SECTION 015416
CONSTRUCTION HOISTING, RIGGING AND CRANE OPERATIONS

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 024116 - Structure Demolition
2. Section 238143 - Air-Source Heat Pumps
3. Section 237300 - Air Handling Units
4. Section 232123 - Hydronic Pumps
5. Section 134813 - Acoustic Equipment Enclosures
6. Section 312316 - Excavation, Trenching, and Backfill

1.2 SUMMARY

A. Scope: All hoisting, rigging and crane operations required to lift, lower, place and remove equipment and materials on this project, including the means, methods, planning, supervision and documentation for safe lifting.

B. Lifting operations include, but are not limited to:

1. Placement of mechanical equipment (outdoor units, AHU sections, pumps, tanks and similar)
2. Removal and disposal of decommissioned plant
3. Lowering of demolition elements
4. Placement of acoustic enclosures/barriers and other heavy plant

C. Lifting is a means-and-methods responsibility of the Contractor; all lift engineering (load weights, crane selection, rigging design) is performed by the Contractor's competent persons.

1.3 DEFINITIONS

A. Lift Plan: documented plan for a lifting operation (or category of routine lifts) defining loads, equipment, rigging, ground conditions, sequence, exclusion zones and personnel; prepared under the responsibility of the appointed person.

B. Critical lift: a lift requiring enhanced planning and approval; a lift shall be treated as critical when any of the following applies: load > 75% of the crane's rated capacity at the working radius; lift over or adjacent to occupied buildings, the public, or live services; tandem (multi-crane) lift; lift near overhead power lines; blind lift; or any lift so designated by the appointed person / CSE.

C. Appointed person: competent person responsible for planning and supervising the lifting operation per UNI ISO 12480-1.

D. Crane operator): operator holding the *"Abilitazione per the Accordo Stato-Regioni 22/02/2012"* for the relevant crane type.

E. Slinger / rigger and signaller (banksman): trained persons who attach/detach the load and direct the operator.

F. SWL / WLL (Safe / Working Load Limit): maximum load an item of equipment or accessory may lift, as marked and certified.

G. Ground bearing pressure: pressure transmitted by crane outriggers/tracks to the ground; compared against the allowable bearing capacity to size mats/cribbing.

H. Exclusion zone: area kept clear of personnel during lifting, covering the lift radius and any drop/swing zone.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
D.Lgs. 81/2008 Tit. III	Use of work equipment - lifting equipment and accessories (Art. 70-73, Allegato V/VI)

D.Lgs. 81/2008 Art. 71	Periodic checks of lifting equipment; Allegato VII inspection intervals
D.M. 11/04/2011	Periodic verification of lifting equipment (INAIL / authorised bodies)
UNI ISO 12480-1	Cranes - safe use - Part 1: general (lift planning, appointed person, signaller)
UNI EN 13000	Cranes - mobile cranes - requirements
UNI EN 14439	Cranes - safety - tower cranes (where used)
UNI ISO 4309	Cranes - wire ropes - care and maintenance, inspection and discard
UNI EN 13414-1/2/3	Steel wire rope slings - safety
UNI EN 1492-1/2	Textile slings - flat woven webbing slings / roundslings - safety
UNI EN 1677-1..6	Components for slings - hooks, links, master links - safety
UNI EN 13155	Cranes - non-fixed load-lifting attachments (below-the-hook devices, spreader beams)
Accordo Stato-Regioni 22/02/2012	Mandatory operator training/abilitazione for mobile, tower and self-erecting cranes
Dir. 2006/42/CE	Machinery Directive - CE marking of cranes and lifting accessories
EM 385-1-1 Section 16	USACE Safety Manual - cranes and rigging; Critical Lift Plan (where contractually invoked)
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Lift Plan: for each critical lift, and a generic lift plan for categories of routine lifts; per UNI ISO 12480-1; submitted before the lifting operation. Minimum content: load identification and weight (with centre of gravity), crane selection and load/radius chart, working radius and configuration, outrigger reactions and ground-bearing assessment with mats/cribbing, rigging arrangement and accessory WLL, exclusion zone and drop/swing zones, maximum permissible wind speed, lift sequence, communication method, and personnel roles.

B. Crane documentation: make/model, capacity and load charts, CE declaration, and current periodic-verification report (D.M. 11/04/2011 / INAIL).

C. Personnel certification: crane operator "*Abilitazione (Accordo Stato-Regioni 22/02/2012)";* appointed person, slinger/rigger and signaller training records.

D. Lifting accessories register: schedule of slings, shackles, spreader beams and below-the-hook devices with WLL, CE marking and inspection/test certificates (current).

E. Method statement and risk assessment: for the lifting operations, coordinated with the project POS/PSC.

F. Insurance: evidence of cover for crane operations and suspended loads.

1.6 QUALITY ASSURANCE

A. Appointed person: competent person per UNI ISO 12480-1 responsible for the planning and supervision of all lifting operations.

B. Crane operators: hold valid *"abilitazione per the Accordo Stato-Regioni 22/02/2012"* for the crane type; medically fit.

C. Slingers/riggers and signallers: trained and designated; only designated persons may attach loads and signal the operator.

D. Where EM 385-1-1 is contractually invoked: comply with Section 16 (cranes and rigging), including the Critical Lift Plan procedure and a designated competent/qualified person for crane and rigging activities.

E. Equipment compliance: all cranes and accessories CE-marked, within current periodic-verification validity, and inspected before use.

PART 2 – EQUIPMENT

2.1 CRANES AND HOISTING EQUIPMENT

A. Type: mobile crane, tower crane, telehandler or hoist appropriate to the load, radius and site constraints; UNI EN 13000 (mobile) / UNI EN 14439 (tower).

B. Rating: rated capacity, at the working radius and configuration, with adequate margin for the load including rigging; load/radius chart available at the crane.

C. Certification and verification: CE-marked; current periodic verification per D.M. 11/04/2011; functional safety devices (load moment indicator/limiter, anti-two-block) operational.

D. Wire ropes: maintained and inspected per UNI ISO 4309; discard criteria observed.

2.2 LIFTING ACCESSORIES

A. Slings: steel wire rope (UNI EN 13414) or textile webbing/roundslings (UNI EN 1492); selected for the load, configuration and sling angle; WLL marked.

B. Components: hooks, shackles, master links and rings per UNI EN 1677; CE-marked, WLL rated, with safety latches on hooks.

C. Below-the-hook devices: spreader/lifting beams and frames per UNI EN 13155; certified, WLL marked, with documented design.

D. Condition: all accessories within current inspection validity, free of defects; defective items removed from service.

PART 3 – EXECUTION

3.1 LIFT PLANNING

A. Prepare and obtain approval of the Lift Plan before the lifting operation; classify each lift as routine or critical per Article 1.3.

B. Determine load weight and centre of gravity; select crane and configuration from the load/radius chart with margin; design the rigging arrangement and verify accessory WLL at the actual sling angles.

C. Assess ground bearing at the crane set-up position; provide outrigger mats/cribbing sized to the outrigger reactions and the allowable ground bearing (coordinate with Section 312316).

3.2 SITE SET-UP AND CONTROL

A. Establish the exclusion zone covering the lift radius and the drop/swing zones; keep personnel and the public clear; schedule lifts over or near occupied or public areas with COR approval and, where required, out of hours.

B. Set up the crane level and on stable ground; deploy outriggers fully on mats; verify safe load indicators are functioning.

C. Maintain safe clearance from overhead power lines, the building and adjacent structures; where clearance cannot be guaranteed, isolate/insulate or use a banksman with a defined approach limit.

D. Define and test the communication method (radio/hand signals) between signaller and operator before lifting.

3.3 LIFTING OPERATIONS

A. Only designated slingers attach the load and only the designated signaller directs the operator; one signaller at a time.

B. Perform a trial lift (load just clear of the ground) to confirm stability, balance and rigging before continuing.

C. Do not exceed the rated capacity; never carry loads over personnel; control tag lines to prevent uncontrolled rotation; never leave a suspended load unattended.

D. Observe the maximum permissible wind speed stated in the Lift Plan and the crane manufacturer's limits; stop lifting in adverse weather (wind, lightning, poor visibility).

E. Stop the operation if any unplanned condition arises and re-assess before resuming.

3.4 INSPECTION AND RECORDS

A. Pre-use inspection of crane and accessories at the start of each shift; record defects and remove defective items from service.

B. Keep on site: crane periodic-verification report, operator licence, accessory register/certificates, and the approved Lift Plan for each lift.

C. Record completed critical lifts; report and investigate any incident or near-miss per the project POS/PSC.

END OF SECTION 015416

SECTION 093013
TILING (PORCELAIN STONEWARE)

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 033000 - Cast-in-Place Concrete
2. Section 024119 - Selective Demolition
3. Section 099123 - Interior Painting
4. Section 232116 - Hydronic Specialties

1.2 SUMMARY

A. Scope: Furnish all labour, materials, and equipment for the supply and installation of porcelain stoneware (gres) floor tiling and associated screeds, skirtings, movement joints and sealants in plant rooms, technical / wet rooms and other areas indicated on the drawings.

B. Work includes:

1. Preparation of the substrate and laying of a new sloped screed (minimum 1% fall) to the floor drain
2. Supply and installation of slip-resistant porcelain stoneware tiles, rating **R11**
3. Coved or square skirtings, edge trims, transition and movement-joint profiles
4. Tile adhesive, grouting and perimeter / movement-joint sealing

C. Tile size, colour and finish to be confirmed with the COR prior to ordering (sample approval).

1.3 DEFINITIONS

A. Porcelain stoneware (gres porcellanato): fully vitrified dry-pressed ceramic tile, group BIa per UNI EN 14411, water absorption E <= 0.5%; high mechanical and chemical resistance.

B. R-rating (R9-R13): slip-resistance classification from the oil-wetted ramp test (DIN 51130); higher number = greater slip resistance. **R11** is required for technical / wet plant rooms.

C. Screed (massetto): levelling / sloping layer between the structural slab and the tile bed; cementitious or pre-mixed, classified per UNI EN 13813.

D. Movement joint: joint that accommodates thermal and structural movement; carried through the tile finish at perimeters, over structural joints, and in fields per UNI 11493-1.

1.4 PERFORMANCE REQUIREMENTS

A. Slip resistance: floor tiles classified **R11** minimum per DIN 51130 / UNI EN 16165 (annex B); certificate required with submittal.

B. Water absorption: E <= 0.5% (group BIa) per UNI EN ISO 10545-3.

C. Breaking strength: modulus of rupture >= 35 N/mm2; breaking strength >= 1300 N (thickness >= 7.5 mm) per UNI EN ISO 10545-4.

D. Deep abrasion (unglazed): <= 175 mm3 per UNI EN ISO 10545-6.

E. Chemical resistance: class UA / ULA (acids and alkalis) per UNI EN ISO 10545-13, suitable for plant-room cleaning agents.

F. Reaction to fire: A1 / A1fl per UNI EN 13501-1.

G. Falls: finished floor laid to a minimum 1% fall to the drain with no ponding.

1.5 APPLICABLE STANDARDS

Key Applicable Standards	
UNI EN 14411	Ceramic tiles - definitions, classification, characteristics (dry-pressed porcelain, group BIa, E <= 0.5%)
UNI EN ISO 10545-1..17	Ceramic tiles - sampling and test methods (water absorption, strength, abrasion,

	slip, chemical)
UNI EN ISO 10545-6	Resistance to deep abrasion for unglazed tiles (porcelain) - <= 175 mm3
DIN 51130 / BGR 181	Slip resistance - ramp test with oil; R-rating R9 to R13 (R11 required for wet plant rooms)
DIN 51097 (A/B/C)	Slip resistance - barefoot wet areas ramp test (where applicable)
UNI EN 16165	Determination of slip resistance of pedestrian surfaces (consolidated method)
UNI 11493-1	Ceramic tiling - design, installation and maintenance rules (Italian practice)
UNI EN 12004	Adhesives for ceramic tiles - classification (cementitious C2 TE S1 min.)
UNI EN 13888	Grout for ceramic tiles (cementitious CG2 WA or reaction-resin RG)
UNI EN 13813	Screed material and floor screeds - properties and requirements
UNI EN 13501-1	Reaction to fire classification (tiles A1 / A1fl non-combustible)
UNI EN 14891	Liquid-applied waterproofing membranes under tiling (where required)
UNI EN 1992-1-1	Eurocode 2 – Design of concrete structures
UNI EN 206	Concrete – specification and performance
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.6 SUBMITTALS

A. Product data and samples: tiles (min. 2 full tiles per type), adhesive, grout, sealant, trims; for COR approval of colour, size and finish before ordering.

B. Test certificates: slip resistance (R11), water absorption, breaking strength, deep abrasion, chemical resistance, reaction to fire.

C. Setting-out / tiling layout drawing: showing falls to drain, tile coursing, movement-joint locations, skirting and trim details.

D. Screed mix design: screed type, class (UNI EN 13813), thickness, curing and maximum residual moisture before tiling.

E. Maintenance data: cleaning and maintenance instructions; attic stock (min. 2% of each tile type, full boxes).

1.7 QUALITY ASSURANCE AND WARRANTY

A. Installer: specialist tiler with documented experience on comparable technical-floor projects.

B. Mock-up / sample area: install a sample area (min. 1 m2) including a movement joint and skirting for COR approval; approved sample becomes the quality benchmark.

C. Warranty: **2 years** against debonding, cracking, lippage and grout failure under normal plant-room use.

PART 2 – PRODUCTS

2.1 TILES

A. Type: through-body / coloured-body porcelain stoneware, dry-pressed, group BIa per UNI EN 14411.

B. Surface finish: matt / structured non-slip, rating **R11** (DIN 51130).

C. Nominal thickness: >= 9 mm for floors (or as required by loading).

D. Format / colour: to be approved by the COR; rectified edges preferred for narrow joints.

2.2 SCREED

A. Material: cementitious screed per UNI EN 13813, minimum class C20-F4; pre-blended product preferred for consistency.

B. Bond: bonded or unbonded as per substrate condition; primer/bonding bridge where bonded.

C. Falls: formed to a minimum 1% slope to the drain.

2.3 ADHESIVE, GROUT AND SEALANT

A. Adhesive: improved cementitious adhesive, class **C2 TE S1** minimum (deformable) per UNI EN 12004; full-bed (buttering/floating) coverage for plant-room floors.

B. Grout: improved cementitious grout class CG2 WA (UNI EN 13888); reaction-resin (RG, epoxy) grout where chemical / hygiene resistance is required at drains and skirtings.

C. Sealant: neutral-cure silicone or polyurethane at movement joints and perimeters; colour to match grout.

2.4 TRIMS AND ACCESSORIES

A. Skirtings: matching tile or coved profile, minimum 100 mm high; sealed at floor junction.

B. Edge / transition profiles: stainless steel or anodised aluminium at exposed edges and material transitions.

C. Movement-joint profiles: proprietary metal/elastomer profiles for field and structural joints.

D. Waterproofing (where indicated): liquid-applied membrane to UNI EN 14891 with reinforced corners and drain collars.

PART 3 – EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify the structural substrate is sound, clean, and free of laitance, oil, and debris (coordinate with demolition of existing flooring/platforms).

B. Confirm drain position and invert level; set out falls before screeding.

C. Verify screed is cured and residual moisture is within the adhesive manufacturer's limit before tiling.

3.2 INSTALLATION

A. Lay screed to falls; cure per manufacturer's instructions before tiling.

B. Apply adhesive with the correct notched trowel; achieve **full bed contact** (no voids) under plant-room floor tiles; back-butter large-format tiles.

C. Maintain uniform joint width; lippage within UNI 11493-1 tolerances; keep tile falls true to the drain with no ponding.

D. Form movement joints at perimeters, over structural joints, at changes of substrate, and in fields per UNI 11493-1; do not bridge with adhesive or grout.

E. Install skirtings and trims; seal floor/wall junctions and around the drain.

3.3 GROUTING AND SEALING

A. Grout after adhesive has cured; tool joints flush; clean tile faces before haze sets.

B. Apply sealant to movement and perimeter joints; tool to a neat profile.

3.4 PROTECTION, TOLERANCES AND ACCEPTANCE

A. Flatness: maximum 2 mm deviation under a 2 m straightedge.

B. Ponding test: flood-test falls to the drain; no standing water after drainage.

C. Protect finished floor from traffic and following trades until grout/sealant fully cured.

D. Final professional cleaning of the tiled surface at completion.

END OF SECTION 093013

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SECTION 099123
INTERIOR PAINTING

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 093013 - Tiling
2. Section 230553 - Identification for HVAC Systems
3. Section 233113 - Metal Ducts

1.2 SUMMARY

A. Scope: Furnish all labour, materials, and equipment for surface preparation, skim coating (rasatura), priming and painting of interior walls and ceilings, including plant rooms and technical rooms (walls and ceilings) and areas disturbed by the works (making good).

B. Work includes:

1. Preparation: cleaning, scraping, filling, sanding, and repair of substrate defects
2. Skim coating (rasatura) to achieve a uniform, smooth substrate
3. Primer / sealer coat appropriate to the substrate
4. Minimum two finish coats of washable interior paint
5. Anti-mould treatment in damp / poorly ventilated technical rooms

C. Colours and sheen to be confirmed with the COR (sample/colour approval).

1.3 DEFINITIONS

A. Skim coat (rasatura): thin levelling layer of filler / skimming compound applied to produce a smooth, uniform surface before priming and painting.

B. Primer (fissativo/aggrappante): coat that consolidates and seals the substrate and promotes adhesion of finish coats.

C. Wet-scrub resistance class (UNI EN ISO 11998): durability rating of the dry film; **Class 1** denotes a washable, hard-wearing coating.

D. VOC: volatile organic compounds; products shall comply with the limits of Dir. 2004/42/CE.

1.4 PERFORMANCE REQUIREMENTS

A. Plant-room and technical areas: washable coating, wet-scrub resistance **Class 1-2** (UNI EN ISO 11998); good opacity (class 1-2 UNI EN 13300).

B. Mould-prone areas: anti-mould / fungicidal paint system, breathable where applied to masonry.

C. VOC: low-VOC, water-borne products compliant with Dir. 2004/42/CE.

D. Adhesion: cross-cut classification <= 1 per UNI EN ISO 2409 on prepared substrates.

E. Steelwork (where painted): corrosion-protection system per UNI EN ISO 12944 appropriate to the corrosivity category (e.g., C3 interior plant room).

1.5 APPLICABLE STANDARDS

Key Applicable Standards	
UNI EN 13300	Water-borne coatings for interior walls/ceilings - classification (gloss, opacity, grain, wet-scrub resistance)
UNI EN ISO 11998	Wet-scrub resistance of coatings (Class 1 = washable/durable)
UNI 8681 / UNI 11021	Classification of paint products and coating systems
Dir. 2004/42/CE	VOC limits in decorative paints and varnishes (Decopaint Directive)
UNI EN ISO 12944-1..9	Corrosion protection of steel by protective paint systems (for metal substrates)

UNI EN 1062 (series)	Coatings and coating systems for masonry and concrete
UNI EN ISO 2409	Cross-cut test - paint adhesion
UNI EN 13501-1	Reaction to fire classification of coatings/linings
UNI EN ISO 7783	Water-vapour transmission of coatings (breathability)
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.6 SUBMITTALS

A. Product data: technical data sheets and safety data sheets for skim compound, primer, finish paint, and anti-mould products; VOC content stated.

B. Colour samples / draw-downs: for COR approval; on-site sample patch (min. 1 m2) per colour/finish before full application.

C. Coating system schedule: substrate type -> preparation -> skim -> primer -> finish coats, with dry-film build and recoat times.

D. Maintenance data: cleaning instructions and attic stock (min. 1 sealed can per colour).

1.7 QUALITY ASSURANCE AND WARRANTY

A. Applicator: experienced decorator; all products of a single manufacturer within each coating system (compatibility).

B. Environmental conditions: apply within the manufacturer's temperature/humidity limits; provide ventilation and dust control.

C. Warranty: **2 years** against peeling, flaking, blistering and premature discolouration.

PART 2 – PRODUCTS

2.1 PREPARATION MATERIALS

A. Fillers / skim compound (rasante): cementitious or ready-mixed interior skimming compound compatible with the substrate and the finish system.

B. Primer / sealer: water-borne consolidating primer for plaster/masonry; adhesion primer for previously painted or smooth surfaces; rust-inhibiting primer for ferrous metal.

2.2 FINISH PAINTS

A. Walls and ceilings (general): water-borne washable interior emulsion, matt/eggshell, UNI EN 13300 opacity class 1-2, wet-scrub Class 1-2.

B. Technical/plant rooms: hard-wearing washable acrylic; anti-mould additive where humidity is expected.

C. Metalwork (where required): primer + finish per UNI EN ISO 12944 for the relevant corrosivity category.

PART 3 – EXECUTION

3.1 PREPARATION

A. Protect floors, equipment, ductwork, panels, labels and fittings; mask or remove escutcheons and hardware.

B. Clean substrates; remove loose/flaking material, efflorescence, grease and dust; treat any mould before skimming.

C. Fill cracks and defects; apply skim coat (rasatura) to achieve a smooth, uniform surface; sand between coats.

D. Do not paint over HVAC identification labels, valve tags, or nameplates (Section 230553).

3.2 APPLICATION

A. Apply primer/sealer suited to the substrate; allow full recoat time.

B. Apply a minimum of **two finish coats** to uniform colour and opacity, free of brush/roller marks, sags and holidays.

C. Paint walls **and ceilings** complete in the areas indicated; make good all areas disturbed by the works to match adjacent finishes.

D. Maintain a wet edge; observe manufacturer's temperature, humidity and ventilation requirements.

3.3 INSPECTION, CLEAN-UP AND ACCEPTANCE

A. Inspect under final lighting; touch up defects; final coat to present a uniform appearance.

B. Remove masking and protection; clean splashes from floors, equipment and glass.

C. Remove and lawfully dispose of paint waste and empty containers; do not discharge washings to drains.

END OF SECTION 099123

SECTION 221316
SANITARY, SEWER, AND HVAC CONDENSATE DRAINAGE PIPING

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FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232116 – Hydronic Specialties
3. Section 237300 – Air Handling Units
4. Section 238216 – Fan-Coil Units
5. Section 238143 – Air-Source Heat Pumps
6. Section 233113 – Metal Ducts
7. Section 230716 – HVAC Thermal Insulation
8. Section 312316 – Excavation, Trenching, and Backfill

1.2 SUMMARY

A. Scope: Furnish and install all gravity drainage piping for the project, comprising:

1. Sanitary waste and vent piping serving plumbing fixtures (WCs, basins, sinks, urinals, floor drains)
2. Building drainage discharge from inside the building envelope to the external sewer connection
3. Site sewer extension from building envelope to public sewer or on-site treatment
4. HVAC condensate drainage from fan-coil units, air-handling units, heat-pump indoor sections, dehumidifiers, and humidifier blowdown
5. Defrost / drip-pan drainage from outdoor heat-pump units
6. Storm/rainwater drainage where indicated on architectural drawings
7. Cleanouts, traps, vents, and inspection access provisions

B. Design code precedence: International Plumbing Code (ICC IPC 2021) is the primary design reference for sizing, slope, materials, and termination of all drainage piping and HVAC condensate disposal (per COR's directive). Italian / European standards (UNI EN 12056 series, UNI EN 752, D.Lgs. 152/2006) apply concurrently; where conflict arises, the more stringent requirement governs.

1.3 DEFINITIONS

A. Sanitary drainage: piping system removing wastewater from plumbing fixtures (greywater + blackwater) to the building sewer connection.

B. Building drain: the lowest piping inside the building envelope that receives discharge from soil, waste, and other drainage pipes and conveys it to the building sewer.

C. Building sewer: the piping extending from the end of the building drain to the public sewer, septic tank, or other approved disposal point.

D. HVAC condensate: water condensed from atmospheric moisture on cooling coils (FCU, AHU, heat pump), or produced during defrost cycles; pH typically 6.5–8 but may be slightly acidic on some materials.

E. Indirect waste pipe: waste pipe that does not connect directly to the sanitary drainage system, but discharges through an air gap into a fixture, receptor, or interceptor that is so connected — per ICC IPC Chapter 8. **HVAC condensate is classified as indirect waste** and shall discharge through an air gap.

F. Air gap: unobstructed vertical distance, through the free atmosphere, between the lowest opening of any pipe supplying water or waste to a receptor and the flood-level rim of that receptor; minimum 25 mm or twice the effective pipe diameter, whichever is greater (ICC IPC 802.2).

G. Trap: fitting providing a liquid seal that prevents back-passage of air and odours without materially affecting flow.

H. Trap seal depth: vertical distance between the dip and the crown weir of the trap; minimum 50 mm, maximum 100 mm (ICC IPC 1002.4 / UNI EN 12056-2).

I. Cleanout: access opening in a drainage piping system used for clearing obstructions.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
ICC IPC 2021	International Plumbing Code – Chapter 3 (General Regulations), Chapter 7 (Sanitary Drainage), Chapter 8 (Indirect/Special Waste), and Section 314 (Condensate Disposal)
ICC IPC Section 314	Condensate Disposal – HVAC equipment condensate piping size, materials, slope, and termination
ICC IPC Section 314.2.3	Condensate drain pipe minimum size based on coil capacity (≤ 20 ton: DN 20; 21–40 ton: DN 25; 41–90 ton: DN 32; 91–125 ton: DN 40; 126–250 ton: DN 50)
UNI EN 12056-1	Gravity drainage systems inside buildings – general and performance requirements
UNI EN 12056-2	Gravity drainage systems inside buildings – sanitary pipework, layout and calculation
UNI EN 12056-3	Gravity drainage systems inside buildings – roof drainage, layout and calculation
UNI EN 12056-5	Gravity drainage systems inside buildings – installation and testing
UNI EN 752	Drain and sewer systems outside buildings – sewer system management
UNI EN 1610	Construction and testing of drains and sewers (trench backfill, joint testing)
UNI EN 877	Cast iron pipes and fittings for sanitary drainage (SML-type)
UNI EN 1329-1	PVC-U piping systems for soil and waste discharge inside building
UNI EN 1451-1	Polypropylene (PP) piping systems for soil and waste
UNI EN 1453-1	Structured-wall PVC-U pipes for soil and waste discharge
UNI EN 12200	PVC-U rainwater piping systems
UNI 9183	Sistemi di scarico delle acque usate – design criteria
D.Lgs. 152/2006	Environmental Code – Part III (water protection, discharge of treated wastewater)
D.M. 37/2008	Building systems – installer qualifications (plumbing systems)
Reg. (UE) 305/2011 (CPR)	Construction Products Regulation – CE marking for piping products
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Drainage layout drawings: plans and isometrics showing all drainage piping; sizes, slopes, cleanouts, vents, traps, and termination points; coordinated with structural and architectural drawings.

B. Product data: pipe and fitting manufacturers' data sheets; CE marking and Declaration of Performance per CPR; material standard compliance (EN 877 / EN 1329 / EN 1451 / EN 1453 / EN 12200).

C. Hydrostatic test plan: plan for water/air testing per ICC IPC 312 and UNI EN 1610.

D. Condensate route drawing: drawing showing the route of every HVAC equipment condensate line from drain pan outlet, through trap, to indirect-waste termination; trap geometry detail.

1.6 QUALITY ASSURANCE

A. Installer: licensed plumbing contractor per **D.M. 37/2008** (impianti idrici e sanitari, lett. d); minimum 5 years' experience on comparable projects.

B. Pipe and fittings: CE marked per CPR (Reg. UE 305/2011); DoP submitted at procurement.

C. Codes governing installation: ICC IPC 2021 is the primary installation code for this project. UNI EN 12056 (inside buildings) and UNI EN 752 (outside buildings) apply concurrently. D.Lgs. 152/2006 governs the quality of any wastewater discharged off-site.

D. No cross-connection between potable water and drainage; backflow protection per Section 232116; air-gap separation per ICC IPC 802.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and fittings in manufacturer's original packaging; protect ends with caps.

B. Store horizontally on level supports; protect from UV (PVC/PP); do not stack above manufacturer's limit.

C. Inspect on delivery for damage, ovalisation, or fitting deformation; reject non-conforming items.

1.8 WARRANTY

A. All drainage piping and fittings: **5 years** from Substantial Completion.

B. HVAC condensate lift pumps: **1 year**.

PART 2 – PRODUCTS

2.1 PIPE MATERIALS — INSIDE BUILDING

A. Cast iron (SML — soil, manhole, lead-free) per EN 877: preferred for vertical stacks in multi-storey buildings and where acoustic performance is required; centrifugal cast or sand cast; with EPDM gaskets and stainless-steel clamps; ≥ 1.5 mm internal epoxy lining for chemical resistance.

1. Diameter range: DN 50 – DN 300
2. Use: vertical waste/soil stacks in occupied buildings (sound absorption), and any application where higher fire performance (A1 non-combustible per EN 13501-1) is required

B. Polypropylene (PP) per EN 1451-1: standard for in-building waste and vent piping where acoustic performance is not the principal criterion; mineral-reinforced PP for sound-attenuating ranges; socket fittings with integrated EPDM lip seal.

1. Diameter range: DN 32 – DN 160
2. Temperature: continuous 90 °C, short-burst 95 °C — suitable for kitchen and dishwasher waste
3. Fire class: B-s1,d0 minimum per EN 13501-1; A2-s1,d0 for sound-rated/fire-rated branches

C. PVC-U per EN 1329-1: acceptable for non-acoustic in-building waste piping, condensate lines, and laboratory waste; socket joints with elastomeric seal or solvent cement; do not use above 60 °C.

1. Diameter range: DN 32 – DN 160
2. Fire class: B-s1,d0 minimum; not used where A2 required

D. Copper per EN 1057 (for condensate only, optional): half-hard tube acceptable for short condensate runs where corrosion resistance and small bore are advantageous (e.g., from FCU drain pan to nearest trap).

2.2 PIPE MATERIALS — OUTSIDE BUILDING (BURIED)

A. Vitrified clay per EN 295: preferred for buried gravity sewer in commercial projects; sulphate-resistant; long life; lockable spigot-socket joints with elastomeric seal.

B. Structured-wall PVC-U per EN 1453-1 or HDPE per EN 12666-1: acceptable for buried sewer lines; minimum SN 8 ring stiffness (or as required by burial depth and traffic load); EN 1610 installation.

C. Reinforced concrete pipe per EN 1916: for large-diameter (DN ≥ 400) buried sewer lines or where traffic loading and durability so require.

D. Cast iron per EN 877 (buried): acceptable for buried sections immediately exiting the building, transitioning to alternative material at the first inspection chamber.

2.3 HVAC CONDENSATE DRAIN PIPING — DEDICATED

A. Code reference: ICC IPC Section 314 (Condensate Disposal). All HVAC condensate piping shall conform to IPC 314 sizing, slope, material, and termination requirements.

B. Material — preferred: PVC-U per EN 1329-1 (Schedule 40 or equivalent wall) or polypropylene (PP) per EN 1451-1; copper EN 1057 acceptable; **galvanised steel is NOT recommended** for condensate (mild acidity attacks zinc coating).

C. Minimum size per ICC IPC 314.2.3 (based on cooling-equipment nominal capacity, USRT = US refrigeration tons; 1 USRT = 3.517 kW):

1. Equipment ≤ 20 USRT (≤ 70 kW): minimum **DN 20** (¾")
2. Equipment 21–40 USRT (74–141 kW): minimum **DN 25** (1")
3. Equipment 41–90 USRT (144–317 kW): minimum **DN 32** (1¼")
4. Equipment 91–125 USRT (320–440 kW): minimum **DN 40** (1½")
5. Equipment 126–250 USRT (443–880 kW): minimum **DN 50** (2")

D. Minimum slope: 1% (10 mm per metre) toward indirect-waste termination per ICC IPC 314.2.2; never level or back-slope.

E. Trap geometry — mandatory: P-trap or U-trap at each drain-pan outlet, with trap depth (water seal) at least equal to the negative static pressure (mm w.g.) the fan develops downstream of the cooling coil + 25 mm safety margin; this prevents the fan suction from holding water in the pan (drain-pan flooding) on draw-through AHU configurations. **No exception** — every drain-pan outlet has its own trap.

F. Vent (where required by IPC 314.2.5): open vent (air-admittance valve or open pipe to atmosphere) upstream of the trap where condensate-line static head could break the trap seal.

G. Termination — indirect waste per ICC IPC 802: condensate pipe shall terminate at an air gap above a tundish, floor drain, mop-sink, hub drain, or approved indirect-waste receptor. **Direct connection to sanitary drainage is NOT permitted.**

H. Insulation: all condensate lines passing through occupied spaces shall be insulated against surface condensation (sweating) per Section 230716 — minimum 13 mm FEF closed-cell elastomeric foam, vapour-tight at all joints.

I. Cleanout / rod-out access: provide cleanout tee at the start of each horizontal condensate run, at every change of direction > 45°, and at maximum 15 m intervals; cleanout caps accessible without dismantling adjacent insulation.

2.4 CONDENSATE LIFT PUMPS (WHERE GRAVITY DRAINAGE IS NOT FEASIBLE)

A. Application per ICC IPC 314.2.4: where the drain-pan outlet elevation does not permit gravity flow to an indirect-waste receptor with the minimum 1% slope, install a condensate lift pump.

B. Type: factory-assembled lift pump unit comprising tank (≥ 0.5 L), float switch, centrifugal or peristaltic pump (≥ 6 L/h at 3 m discharge head), check valve, high-water alarm contacts.

C. Materials: ABS or polycarbonate tank; PP impeller; FKM seal compatible with mild-acid condensate; brass or stainless discharge connection.

D. Electrical: 230 VAC 50 Hz fused supply; volt-free high-water alarm contact wired to BMS via Section 230900; pump fault contact wired to BMS.

E. Safety interlock: high-water level shall interrupt the cooling-coil control loop (close chilled water valve or stop heat-pump compressor) preventing further condensate generation until alarm clears. Wire interlock through Section 230900 DDC.

F. Discharge pipe: soft copper or flexible PE tube; minimum DN 8 (5/16"); rises vertically to maximum 3 m, then to gravity drain with continuous slope; terminate at indirect waste per Article 2.3.

2.5 TRAPS, CLEANOUTS, AND VENTS

A. Traps: every plumbing fixture and floor drain provided with a P-trap (preferred), S-trap or bottle trap as appropriate; trap seal depth 50–100 mm; trap material to match upstream piping.

B. Cleanouts (ICC IPC 708):

1. Every horizontal branch ≥ DN 75: cleanout at upstream terminus
2. Every change of direction > 45°

3. Maximum 30 m intervals on straight runs ≤ DN 150; 22.5 m for DN > 150 (ICC IPC 708.1.5)
4. Every base of soil/waste stack
5. At entrance of building drain to building (within 1.5 m of the wall penetration)

C. **Vents (ICC IPC Chapter 9):** size and arrange vent piping to limit pressure deviation in any plumbing fixture trap to ±25 mm water column; main vent through-roof termination minimum DN 75; cap with rodent screen.

D. **Air-admittance valves (AAV):** acceptable per ICC IPC 917 where through-roof venting is impractical (e.g., island fixtures, retrofit); approved AAV per ASSE 1051; do not use as substitute for primary system vent.

2.6 FLOOR DRAINS AND TUNDISHES

A. **Floor drains:** stainless steel AISI 304 body and grating (AISI 316 in coastal/swimming-pool areas); load class K3 (300 kN) per EN 1253-1 for plant rooms; integral P-trap with self-priming feature where exposed to evaporation.

B. **Trap primer:** install trap primer line on floor drains in mechanical rooms and other areas subject to evaporation; supply from potable water with backflow preventer.

C. **Tundishes / hub drains for HVAC condensate termination:** stainless steel or PP-with-elastomeric-seal tundish with visible air gap, sized for combined condensate and safety-valve discharge flows.

2.7 SUMPS AND LIFT STATIONS (WHERE REQUIRED)

A. **Sewage ejector / lift station:** factory-packaged duplex pump unit in cast-iron or HDPE chamber; alternate-duty pumps; high-water alarm; vent to atmosphere; per ICC IPC Section 712.

B. **Storm-water sump pump (where applicable):** submersible pumps with float control; discharge to building storm-water system; do not connect storm sump discharge to sanitary system.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify structural openings, sleeves, and penetrations are correctly positioned and sized for drainage piping; report discrepancies before commencing installation.

B. Confirm location of building sewer connection, invert level, and minimum cover with site survey before commencing buried drainage works.

C. Verify condensate drain elevation at each HVAC equipment outlet permits gravity drainage with required slope; identify locations requiring lift pumps before equipment installation.

3.2 INSTALLATION — IN-BUILDING DRAINAGE

A. Install all drainage piping per ICC IPC Chapter 7 and UNI EN 12056-5; coordinate with structural and architectural penetrations.

B. **Slope (ICC IPC 704.1):**

1. Building drain and horizontal branches DN ≤ 80: minimum 2% (20 mm/m)
2. Building drain DN 90 – DN 150: minimum 1% (10 mm/m)
3. Building drain DN > 150: minimum 0.8% per ICC IPC Table 704.1; verify per local authority
4. Condensate drain: minimum 1% per ICC IPC 314.2.2

C. **Joints:** elastomeric-seal socket joints (preferred); solvent-cemented joints for PVC-U where elevated temperatures and chemical content allow; mechanical clamp couplings for cast iron (EN 877); never mix jointing methods within a single run.

D. **Hangers and supports:** size and space per Section 230529 and manufacturer's data; cast-iron DN 100: maximum 2.0 m horizontal spacing; PVC-U DN 100: maximum 1.0 m horizontal spacing; sound-attenuating clamps required on vertical stacks within occupied spaces.

E. **Penetrations:** sleeve all drainage pipes through walls, floors, and slabs; fire-stop per Section 078413 at fire-rated barriers; acoustic seal at acoustic-rated barriers; flexible coupling at structural movement joints.

F. Cleanouts (ICC IPC 708): install at all locations specified in Article 2.5; orient access cap toward unobstructed working space; cap with brass plug; thread-lock not permitted.

G. Vent piping: rise to roof penetration at minimum 1:50 slope; terminate not less than 150 mm above roof line and not less than 3 m horizontally from openable windows / air intakes (ICC IPC 904).

3.3 INSTALLATION — HVAC CONDENSATE DRAIN

A. Connect to drain-pan outlet of each FCU, AHU, heat pump, and dehumidifier per equipment manufacturer's instructions.

B. Trap fabrication: P-trap or U-trap immediately at drain-pan outlet; height of trap seal = fan negative static pressure (mm w.g.) + 25 mm; document trap depth in commissioning record.

C. Slope: continuous 1% minimum (10 mm/m) toward indirect-waste termination; no upward sections in gravity portion.

D. Indirect waste termination (ICC IPC 802): terminate at tundish, floor drain, hub drain, or mop-sink with **visible air gap** ≥ 2 × pipe diameter (minimum 25 mm). COR or Owner shall be able to verify air gap during inspection.

E. Insulation: apply 13 mm FEF closed-cell foam over entire condensate run within insulated/occupied spaces; vapour-tight at all joints; do not leave any portion of cold condensate pipe uninsulated within finished ceiling voids.

F. Cleanouts: at start of run, at every change of direction > 45°, every 15 m on straight runs.

G. No connection of condensate drain to roof gutter, rainwater leader, or sanitary stack without air-gapped intermediate receptor.

3.4 INSTALLATION — BURIED SEWER

A. Install per **UNI EN 1610** and ICC IPC Chapter 7; minimum cover 800 mm in landscape, 1000 mm in traffic-loaded areas.

B. Bedding: 150 mm compacted granular fill (sand or 4/8 mm gravel) below pipe; haunching and surround to spring line; selected excavated material as backfill above; warning tape at 300 mm above pipe.

C. Slope: minimum 1% (10 mm/m) for DN ≤ 200; 0.5% acceptable for DN > 200 per local authority.

D. Inspection chambers (manholes): at every change of direction, junction, or invert change, and at maximum 30 m intervals; sizes per UNI EN 476.

E. Connection to public sewer: per local utility authority's approval and connection specification; coordinate elevation and any required backwater valve.

3.5 TESTING

A. Sanitary drainage water test (ICC IPC 312.2): plug downstream end; fill to overflow at highest point or apply 3 m water column at lowest point; maintain ≥ 15 minutes; no visible leakage permitted.

B. Air test (ICC IPC 312.3): alternative to water test; pressurise system to 35 kPa (5 psi); maintain ≥ 15 minutes; pressure drop ≤ 7 kPa permitted.

C. Buried sewer joint test (UNI EN 1610): water-fill test or air-pressure test per EN 1610; document each manhole-to-manhole section result before backfill closure.

D. Condensate drain test: pour 2 L of clean water into each drain pan; verify free flow to indirect-waste termination without backup or overflow; verify trap holds water seal after fan shutdown.

E. Lift pump test: simulate high-water condition with float manually raised; verify pump operation, discharge, alarm signal to BMS, and cooling-coil interlock shut-off.

F. Submit signed test reports for all drainage works before concealment by ceilings, walls, or backfill.

3.6 COMMISSIONING

A. Operate each HVAC cooling unit for minimum 1 hour at design conditions; verify continuous condensate flow at indirect-waste termination; verify trap retains water seal; record observations.

B. Verify lift-pump high-water alarm transmits to BMS supervisor; verify cooling-coil shut-off interlock disables cooling on high-water signal.

C. Photographically document each air-gap termination for the project record.

3.7 IDENTIFICATION

A. Label all drainage piping per Section 230553:

1. Sanitary waste: brown
2. Storm/rainwater: blue with white stripe
3. HVAC condensate: blue (cold-water family) with 'CONDENSATE' text label every 5 m and at each change of direction

B. Tag lift pumps, sumps, and main cleanouts with stainless tag showing function and reference number.

END OF SECTION 221316

SECTION 230519
METERS AND GAUGES FOR HVAC PIPING

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 230523 – General-Duty Valves for HVAC Piping
2. Section 232113 – Hydronic Piping
3. Section 232116 – Hydronic Specialties
4. Section 230900 – Instrumentation and Controls for HVAC
5. Section 232123 – Hydronic Pumps

1.2 SUMMARY

A. Scope: Furnish and install all thermometers, pressure gauges, flow meters, heat meters, and related instrumentation for HVAC hydronic systems as shown on drawings and as specified herein.

B. Included instruments:

1. Dial thermometers – bimetal, gas-actuated, and dial types
2. Pressure gauges – Bourdon tube, diaphragm
3. Differential pressure gauges and indicators
4. Flow meters – electromagnetic, ultrasonic, variable-area
5. Heat meters (energy meters) per MID 2014/32/UE
6. Test points and pressure/temperature test valves
7. Gauge cocks and gauge accessories

C. Design working conditions: max **120°C**, max **16 bar**.

1.3 DEFINITIONS

A. Thermometer: instrument for measuring fluid temperature; types include bimetal, gas-actuated, and resistance (Pt100).

B. Pressure gauge: mechanical instrument converting fluid pressure into pointer rotation on a calibrated dial (Bourdon tube or diaphragm element).

C. Differential pressure gauge: instrument measuring pressure difference between two points; used across coils, strainers, and control valves.

D. Heat meter: assembly of flow sensor + paired temperature sensors + calculator, integrating thermal energy (kWh); subject to MID directive.

E. Test point (Schrader valve): self-sealing valve accepting portable meter probes without system drain-down.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
EN 837-1	Bourdon tube pressure gauges – dimensions, metrology, requirements
EN 837-3	Capsule and diaphragm pressure gauges
EN 13190	Dial thermometers for industrial use
EN ISO 5167-1	Measurement of fluid flow – orifice plates, nozzles, venturi tubes
EN 1434-1	Heat meters – general requirements
EN 1434-2	Heat meters – constructional requirements
EN 1434-4	Heat meters – pattern approval tests

MID 2014/32/UE	Measuring Instruments Directive – heat meters
EN 60529 (CEI 20-37)	Degrees of protection (IP rating)
EN 61000-4-2/-4/-6	EMC immunity requirements
OIML R 75	Heat meters – OIML recommendation
UNI 9196	Plumbing systems – flow meters and gauges
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Product Data: manufacturer's data sheets showing accuracy class, pressure/temperature rating, materials, dimensions, and connection sizes for all instruments.

B. Calibration Certificates: factory calibration certificates for heat meters and flow meters; accuracy traceable to national metrology standards.

C. MID Declaration: conformity declaration per Directive 2014/32/UE for all heat meters.

D. Shop Drawings: piping connection details, tapping locations, thermowell schedules.

E. Operation and Maintenance Manuals: including re-calibration intervals and procedures.

1.6 QUALITY ASSURANCE

A. All pressure gauges: accuracy class **1.6** minimum per EN 837-1.

B. All thermometers: accuracy **±1°C** or better across the stated range.

C. All heat meters: accuracy class **2** minimum per EN 1434-1 and MID; valid type approval certificate required.

D. D.M. 37/2008: installations shall be carried out by licensed firms; declaration of conformity filed per art. 7.

E. Flow meters shall be installed with straight pipe runs as required by manufacturer; minimum 5D upstream, 2D downstream.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver instruments in manufacturer's original packaging with calibration certificates.

B. Protect gauges from mechanical shock; store in dry, temperature-controlled environment.

C. Do not remove protective caps until final installation.

1.8 WARRANTY

A. Standard warranty: **1 year** from date of Substantial Completion.

B. Heat meters: **5 years** product warranty. Note: mandatory periodic metrological re-verification per **D.M. 93/2017** (Italian implementation of MID) is required at **8-year intervals** for heat meters; this is a regulatory requirement independent of the product warranty and shall be scheduled by the Owner's facility manager.

PART 2 – PRODUCTS

2.1 DIAL THERMOMETERS

A. Bimetal thermometers: bi-metallic coil element; stainless steel case, 100 mm dial, adjustable angle neck; connection G½" BSP.

1. Temperature ranges: 0–60°C (chilled water), 0–120°C (heating), 0–160°C (high-temperature)
2. Scale: dual °C/°F; red maximum pointer

3. Accuracy: ±1% of full scale
4. Protection: IP54 minimum

B. Thermowells: stainless steel AISI 316 immersion wells for all dial thermometers; length matched to pipe diameter; threaded connection.

1. Lagging extension where pipe is insulated; length to suit insulation thickness
2. Velocity rating: suitable for fluid velocities in use; anti-vibration design for pump discharge locations

C. Gas-actuated thermometers (remote-reading): capillary length ≤ 1.5 m; stainless steel capillary and bulb; 150 mm dial.

2.2 PRESSURE GAUGES

A. Bourdon tube gauges: EN 837-1; 100 mm dial for mechanical rooms, 63 mm acceptable for limited-access locations.

1. Case: stainless steel or ABS, glycerine-filled for vibrating service
2. Connection: bottom ¼" or ½" NPT/BSP, with isolating cock (gauge cock) and snubber
3. Scale: bar (primary), psi (secondary); choose range so operating pressure falls in 25–75% of full scale
4. Accuracy: class 1.6 per EN 837-1
5. MWP rating: 1.25 × full scale minimum

B. Diaphragm gauges: use for viscous or corrosive fluids (glycol concentrations > 40%), low-pressure (<0.1 bar) applications.

C. Gauge cocks: bronze or stainless; rated PN16 minimum; T-pattern with test point port.

D. Pressure snubbers: sintered stainless steel, PN25, installed between cock and gauge on all pump-connected points.

2.3 DIFFERENTIAL PRESSURE GAUGES AND INDICATORS

A. Diaphragm differential pressure gauges: 100 mm dial; measuring range appropriate to service (strainers: 0–1 bar ΔP, coils: 0–0.6 bar ΔP).

1. Material: wetted parts stainless steel AISI 316
2. Static pressure rating: PN16
3. Accuracy: class 1.6

B. Digital differential pressure transmitters (where BMS-connected): 4–20 mA output; 0.25% accuracy; display in Pa or bar; BACnet/IP or BACnet MS/TP output preferred; HART or Modbus RTU as alternative.

2.4 FLOW METERS

A. Electromagnetic flow meters: for hydronic circuits DN25 and above; no moving parts.

1. Liner: PTFE or PFA; electrodes: high nickel-molybdenum corrosion-resistant alloy (e.g., Ni-Mo-Cr type) or stainless AISI 316
2. Accuracy: ±0.5% of reading
3. Output: 4–20 mA + pulse + BACnet/IP (preferred) or Modbus RTU/TCP (legacy)
4. IP67 minimum; display: local LCD showing flow rate and totalized volume
5. Straight run: 5D upstream, 2D downstream; no valves or elbows in upstream run

B. Ultrasonic flow meters (clamp-on, temporary or permanent): non-intrusive; accuracy ±1% of reading; BACnet/IP or Modbus RTU output.

C. Variable-area (rotameter) flow meters: for small circuits DN15–DN25; stainless steel float and tube; scale engraved on body; for visual indication only.

2.5 HEAT METERS (ENERGY METERS)

A. Assembly: flow sensor + supply/return temperature sensors (PT500 or PT100 matched pairs) + calculator; all from a single manufacturer system.

B. Standard: EN 1434-1 and EN 1434-2; **MID Directive 2014/32/UE** type approval required; OIML R75 recommendation.

C. Flow sensor type: electromagnetic preferred; size to match pipe; insertion type acceptable for DN > 100.

D. Accuracy class: 2 per EN 1434-1.

E. Calculator: DIN rail or wall-mount; display showing: instantaneous flow, supply/return temperatures, power (kW), energy (kWh/GJ), operating hours; BACnet/IP output preferred; M-Bus or Modbus TCP as legacy alternative.

F. Temperature sensor installation: immersion sensors in thermowells, minimum immersion 50 mm; sensors installed in straight flow (not return) and return pipes.

G. Verification: heat meters are subject to mandatory re-verification per Italian metrology regulations; provide documentation for initial calibration traceability.

2.6 TEST POINTS (PETE'S PLUGS / TEST VALVES)

A. Type: self-sealing core valve (Schrader-type) accepting standard portable temperature/pressure probe adaptors.

B. Body: brass or stainless; G¼" or ½" BSP threaded into tee or boss.

C. Installation: at inlet and outlet of every coil, strainer, pump, and heat exchanger; install on both supply and return of each major circuit.

D. Caps: tamper-evident caps with chain; clearly labeled supply/return.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify piping is installed, flushed, and pressure-tested before installing instruments.

B. Confirm that pipe diameters are correct for the specified flow meters.

C. Report any discrepancies to the COR before proceeding.

3.2 INSTALLATION – GENERAL

A. Install all instruments per manufacturer's instructions and drawings; protect from vibration, heat, and mechanical damage.

B. Mount instruments in accessible, well-lit locations; orient dials for easy reading from floor level.

C. Provide isolation valves on each side of flow meters and heat meters to allow in-service removal.

D. Label each instrument with laminated tag: **instrument tag, range, and service**.

3.3 THERMOMETER INSTALLATION

A. Install thermowell first; pressure-test with the piping system before inserting thermometer element.

B. Fill thermowell with thermal compound (heat-transfer paste) before inserting stem.

C. Orient adjustable-angle thermometers for convenient viewing; tighten lock ring after adjustment.

D. Locate thermometers on straight pipe sections; avoid elbows, tees, and areas of turbulent flow.

E. Minimum positions per circuit: supply and return of each air handling unit, each heat pump, each chiller, and each pump suction/discharge.

3.4 PRESSURE GAUGE INSTALLATION

A. Install gauge cock between pipe and gauge; snubber between gauge cock and gauge for pulsating service.

B. Support gauge independently of piping to avoid vibration-induced needle flutter.

C. For pressures below 0.5 bar: use liquid-filled gauges (glycerine); confirm ambient temperature is within gauge rating.

D. Minimum positions: suction and discharge of each pump; inlet and outlet of each pressure-reducing valve and strainer.

3.5 FLOW METER AND HEAT METER INSTALLATION

A. Observe manufacturer's required straight pipe runs; install flow conditioner where insufficient straight run is available.

B. Install bypass spool piece for electromagnetic meters to allow in-service removal.

C. Heat meter temperature sensors: supply sensor on pipe section closest to meter; return sensor on return pipe; cable length per manufacturer.

D. Commission heat meters per EN 1434-4; document zero-flow check and calibration data.

E. Connect BACnet/IP (or M-Bus / Modbus TCP where BACnet is unavailable) to BMS; verify data appears in BMS within 24 hours of commissioning.

3.6 TESTING AND COMMISSIONING

A. **Pressure gauges:** verify reading matches calibrated test gauge ±2%; replace any gauge outside tolerance.

B. **Thermometers:** verify reading matches calibrated reference thermometer ±1°C; document results.

C. **Flow meters:** verify readings agree with BMS within ±2%; document as-installed calibration factor.

D. **Heat meters:** perform functional test per EN 1434-4; submit commissioning report including initial meter reading, date, and technician signature.

3.7 IDENTIFICATION AND LABELING

A. Tag each instrument with stainless steel tag: tag number, range, service description, and installation date.

B. Provide laminated instrument schedule card in mechanical room showing tag numbers, locations, and calibration dates.

C. Mark calibration verification date on each instrument with non-fading ink or sticker.

END OF SECTION 230519

SENSITIVE BUT UNCLASSIFIED

SECTION 230523
GENERAL-DUTY VALVES FOR HVAC PIPING

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232116 – Hydronic Specialties
3. Section 232123 – Hydronic Pumps
4. Section 230519 – Meters and Gauges for HVAC Piping
5. Section 230900 – Instrumentation and Controls for HVAC
6. Section 230716 – HVAC Thermal Insulation

1.2 SUMMARY

A. Scope: Furnish and install all shut-off, isolation, balancing, check, pressure-relief, and control valves for HVAC hydronic systems.

B. Included valve types:

1. Ball valves – full bore and standard bore
2. Gate valves – wedge and parallel gate
3. Globe and stop valves
4. Butterfly valves – wafer and lug body
5. Check valves – spring-loaded and swing type
6. Manual balancing valves with memory stop and measuring ports
7. Pressure-reducing valves (PRV)
8. Pressure-relief / safety valves
9. Automatic balancing valves and PICV (covered also in Section 238216)

C. Design working conditions: max **120°C**, max **16 bar** (PN16); high-pressure service PN25 where noted.

1.3 DEFINITIONS

A. DN (Diameter Nominal — Diamètre Nominal): ISO/EN nominal diameter designation per ISO 6708; does not equal actual inside diameter; expressed without units (e.g., DN 50).

B. PN (Pressure Nominal — Pression Nominale): ISO/EN nominal pressure rating at 20 °C per EN 1333; expressed in bar without units (e.g., PN 16 = 16 bar at 20 °C); derate for higher operating temperatures per manufacturer's pressure–temperature rating curve.

C. Full-bore valve: valve whose bore equals or exceeds the pipe inside diameter; minimal pressure drop.

D. Kv value: flow coefficient expressing flow (m^3/h) of water at 5°C producing 1 bar pressure drop.

E. PICV (Pressure-Independent Control Valve): combines differential pressure regulation, manual balancing, and modulating control in a single body.

F. Memory stop: device on balancing valve stem retaining pre-set open position after closure and re-opening.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
EN 1074-1	Valves for water supply – general requirements
EN 1074-2	Gate and globe valves for water supply
EN 1074-5	Control valves for water supply
EN 12266-1	Industrial valves – testing of metallic valves – pressure tests
EN 12266-2	Industrial valves – testing – functional requirements

EN 13709	Industrial valves – steel globe and globe stop-and-check valves
EN 1092-1	Flanges and their joints – circular flanges for pipes (PN-rated)
EN 558	Industrial valves – face-to-face and end-to-end dimensions
EN 19	Marking of industrial valves
ISO 228-1	Pipe threads – dimensions and tolerances (BSP parallel)
ISO 7-1	Pipe threads – taper threads (BSPT)
EN 1092-2	Flanges – cast iron PN-rated flanges
UNI EN 736-1	Terminology for valves
Dir. 2014/68/UE	Pressure Equipment Directive (PED) – valves PN ≥ 25
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act
D.P.R. 380/2001	Consolidated Building Code

1.5 SUBMITTALS

A. **Product Data:** manufacturer's technical data sheets for each valve type; Kv values, pressure–temperature ratings, body/trim materials, end connections, and dimensions.

B. **PED Declaration of Conformity:** for all valves DN > 25 and PN ≥ 16; CE marking required per Dir. 2014/68/UE.

C. **Valve Schedule:** tabulated list of all valves showing tag number, type, DN, PN, service, and location.

D. **Factory Test Reports:** pressure and leakage test records per EN 12266-1.

E. **Operation and Maintenance Manuals:** including actuator wiring diagrams for all motorized valves.

1.6 QUALITY ASSURANCE

A. Valves PN ≥ 16 and DN > 25: CE marked per PED Directive 2014/68/UE.

B. Leakage class: **EN 12266-1 Class A** (soft-seated), Class B (metal-seated) for isolation valves.

C. Factory pressure test: shell test at **1.5 × PN**; seat test at **1.1 × PN**.

D. Installation by certified firms per **D.M. 37/2008**.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver valves in manufacturer's packaging; keep protective plugs in place until installation.

B. Store off ground, under cover; protect actuators from moisture.

C. Do not use valve bodies as lifting points for heavy actuators; use lifting lugs on actuator where provided.

1.8 WARRANTY

A. All valves: **1 year** from Substantial Completion.

B. Motorized valve actuators: **1 year** including control electronics.

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS – ALL VALVES

A. All valves shall be rated for the service fluid (water/glycol up to 35%), temperature, and pressure of the circuit in which they are installed.

B. Minimum pressure rating: PN16 for all valves; PN25 for valves adjacent to pumps, pressure-reducing stations, or where noted.

C. Marking: per EN 19 – body shall be permanently marked with DN, PN, material designation, flow direction (where applicable), and CE mark.

D. End connections: threaded (ISO 228-1 parallel BSP) for DN ≤ 50; flanged (EN 1092-1, PN16) for DN ≥ 65. Grooved ends permissible where grooved piping system is used.

2.2 BALL VALVES

A. Body material: brass CW617N for DN15–DN50; cast iron GJS-400 or carbon steel WCB for DN65 and above.

B. Ball: stainless steel AISI 316; PTFE seats; blowout-proof stem.

C. Bore: full-bore (a passaggio integrale) for all DN ≥ 32 and all isolation valves; full-bore DN15–DN25 preferred.

D. Handle: stainless steel lever with position indicator; lockable in open/closed position; insulation kit (wing-handle) for insulated pipes.

E. Rating: PN16 minimum; PN25 brass valves for pump circuits.

F. Drain/vent provision: tee-port ball valves with side connection for draining where indicated.

G. Actuated ball valves: see Section 230900 (motorized on/off valves for control) and Section 238216 (fan-coil service valves).

2.3 GATE VALVES

A. Gate valves permitted only for **DN ≥ 65** where low-pressure-drop isolation is required; do not use for throttling.

B. Body: cast iron GGG-40 (EN-GJS-400) ductile iron; resilient-seated wedge gate.

C. Stem: rising stem, stainless steel AISI 316; handwheel with position indicator.

D. Rating: PN16; flanged connections per **EN 1092-2** (cast/ductile iron flanges – matches the iron body) for the valve; **EN 1092-1** (steel flanges) for the mating pipe flanges, with appropriate gasket selection at the interface.

E. Leakage class: EN 12266-1 Class A.

2.4 GLOBE AND STOP VALVES

A. Application: throttling, regulation, and where flow control is required.

B. Body: brass or bronze for DN ≤ 50; cast iron or carbon steel for larger sizes.

C. Disc: renewable PTFE or metal seat; Kv characteristic shall be quoted by manufacturer.

D. Rating: PN16 threaded for DN ≤ 50; PN16 flanged for DN > 50.

2.5 BUTTERFLY VALVES

A. Application: isolation and coarse throttling for DN ≥ 50.

B. Body type: wafer (centerline) for general use; lug body with threaded inserts for end-of-line service.

C. Disc: ductile iron or stainless AISI 316; EPDM or PTFE-lined seat.

D. Shaft: stainless AISI 316; double-eccentric (high-performance) design for DN ≥ 150.

E. Operator: lever lock with 10-position stop for manual; gearbox for DN ≥ 200 or as noted.

F. Rating: PN16; suitable for 120°C with EPDM seat (verify manufacturer data).

G. Motorized butterfly valves: 2-position or modulating actuator; see Section 230900.

2.6 CHECK VALVES

A. Spring-loaded check valves (wafer or inline): preferred type for all horizontal and vertical service.

1. Body: brass (DN ≤ 50) or cast iron/ductile iron (DN > 50)
2. Disc: stainless steel AISI 316; EPDM seal
3. Spring: stainless steel; closing at near-zero differential pressure (silent check – no water hammer)
4. Rating: PN16; cracking pressure < 0.15 bar

B. Swing check valves: use only in horizontal service where noted; DN ≥ 65 with renewable seat and disc.

C. Check valves on pump discharge: spring-loaded wafer type; rated for pump shut-off head; install immediately downstream of isolation valve.

2.7 MANUAL BALANCING VALVES

A. Type: manual circuit-setter type with micrometric handwheel and **memory stop** (position locked on partial opening, closeable without losing set position).

B. Measuring ports: two integral pressure/temperature test ports (Schrader type) upstream and downstream; compatible with portable differential pressure meter.

C. Body: brass or gun-metal; DN15–DN50 threaded; DN65+ flanged or grooved.

D. Kv characteristic: linear; manufacturer to provide flow–opening characteristic tables.

E. Commissioning: all manual balancing valves shall be set and documented during hydraulic commissioning; settings recorded in commissioning report with flow rate, pressure drop, and valve opening at each position.

F. Rating: PN16; suitable for 120°C.

NOTE: Manual balancing valves are used on circuits where PICV are not installed. Where PICV are specified (see Section 238216 and 2.8 below), manual balancing valves on the same sub-circuit may be omitted.

2.8 PRESSURE-INDEPENDENT CONTROL VALVES (PICV)

A. Function: PICV combines in a single body: (a) differential pressure regulator maintaining constant ΔP across the control element, (b) manual preset for maximum flow, and (c) modulating control element (2-way).

B. Accuracy: flow accuracy ±5% of set value across ΔP range **20–400 kPa** (0.2–4.0 bar).

C. Body: brass or stainless steel; sizes DN15 to DN50 threaded; DN65 and above flanged.

D. Actuator: electric (24 VAC/VDC or 230 VAC); 0–10 V or 4–20 mA control signal; spring-return (fail-safe closed).

E. Preset range: factory or field adjustable; minimum 5 preset positions or continuous adjustment via setting ring.

F. Rating: PN25.

G. Commissioning: set preset flow at commissioning per hydraulic design; record in balancing report.

2.9 PRESSURE-REDUCING VALVES (PRV)

A. Type: direct-acting or pilot-operated diaphragm type; adjustable set point.

B. Body: brass for DN ≤ 50; cast iron for DN > 50.

C. Accuracy: outlet pressure ±0.1 bar of set point under flow conditions.

D. Range: adjustable 0.5–6 bar outlet; factory set to design value.

E. Rating: inlet PN16; outlet PN16.

F. Accessories: upstream strainer (100 mesh minimum), upstream isolation valve, downstream pressure gauge, and downstream isolation valve; provide bypass with globe valve for maintenance.

2.10 PRESSURE-RELIEF AND SAFETY VALVES

A. Type: spring-loaded full-lift safety valve per EN ISO 4126-1; sized per the discharge capacity formulas of EN ISO 4126-1 / -7 (water service) or **Raccolta R, Ed. 2009 / s.m.i.** (INAIL) for closed circuits with primary heat generator in Italy; the valve relief capacity (kW or kg/h) shall exceed the maximum heat input to the protected circuit.

B. Set pressure: as per design; maximum 110% of circuit MWP.

C. Body: brass or bronze; stainless steel disc and spring.

D. Discharge: piped to safe drain via tundish; pipe size not less than valve outlet size; no valves on discharge side.

E. Certification: CE marked per PED Directive 2014/68/UE; approved by Notified Body.

F. Sizing reference: EN ISO 4126-1 (general), EN ISO 4126-7 (water-side application), and Raccolta R Ed. 2009 (INAIL) for boiler/heat-generator protection in Italian installations.

2.11 STRAINERS

A. Type: Y-pattern with blowdown valve; stainless steel or bronze body.

B. Screen: stainless steel AISI 316; mesh size 0.8 mm (800 µm) for coil protection; 1.5 mm for pump suction.

C. Rating: PN16; same end connections as connected pipe.

D. Blowdown valve: ½" ball valve on screen chamber; piped to drain.

E. Installation: upstream of pumps, control valves, PICV, heat exchangers, and heat meters; orient screen pocket downward in horizontal runs.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify pipe is installed, supported, and free of construction debris before installing valves.

B. Confirm valve type, size, and pressure rating match drawings and valve schedule.

C. Report discrepancies to COR before proceeding.

3.2 INSTALLATION – GENERAL

A. Install valves with stems in accessible positions; orient for easy operation and reading of position indicators.

B. Do not use valve body as pipe support. Provide independent pipe support within 300 mm of each valve flange.

C. Install flanged valves with gaskets centred on flange face; tighten bolts in cross-pattern sequence.

D. Install threaded valves with PTFE tape or anaerobic sealant; tighten to manufacturer's torque.

E. Observe flow direction arrows on valve bodies; incorrect installation of check valves and globe valves will cause system malfunction.

F. Provide unions on each side of all threaded valves DN ≤ 50 to allow removal without disturbing the piping.

G. Provide isolation bypass (with globe valve) for all PRVs, strainers, and heat meters to allow in-service maintenance.

3.3 BALL VALVE INSTALLATION

A. Install ball valves with stem in the horizontal or upper-quarter positions; vertical stem permitted for insulated pipes with extended handles.

B. Set handle parallel to pipe = open; perpendicular to pipe = closed; verify marking agrees with actual position before insulation.

C. For valves to be insulated: use extended-stem version or insulation kit with wing handle extending through insulation.

3.4 CHECK VALVE INSTALLATION

A. Install spring-loaded check valves in any orientation (horizontal, vertical up-flow); swing check valves horizontal only.

B. Locate pump-discharge check valves immediately downstream of pump isolation valve; minimum 3D straight pipe before any elbow.

3.5 BALANCING VALVE COMMISSIONING

A. Perform hydraulic balancing after system flushing and pressure testing; balancing before final controls commissioning.

B. Measure flow at each terminal using portable differential pressure meter at valve test ports.

C. Set memory stop at final position; record valve opening (% or turns) and measured flow in commissioning report.

D. Submit signed commissioning report with design flows, measured flows, and final valve settings before Substantial Completion.

3.6 PRESSURE-RELIEF VALVE TESTING

A. Test each safety valve by lifting test lever (where present) and confirming operation; document test date.

B. Do not plug, cap, or restrain safety valve discharge during or after commissioning.

C. Confirm discharge pipe is unobstructed and drains to safe location.

3.7 FIELD QUALITY CONTROL

A. Leakage test: all installed valves shall be leak-free at system operating pressure; check after 24-hour soak at design pressure.

B. Actuation test: cycle all motorized valves and PICV through full open–close stroke; verify travel time and fail-safe position.

C. PRV test: verify outlet pressure equals set point ±0.1 bar under flow and no-flow conditions.

3.8 IDENTIFICATION AND LABELING

A. Tag all valves with stainless steel tag: **valve tag number, type, DN, PN, and service**; tag numbers to match drawings and valve schedule.

B. Mark normally-open valves with green indicator; normally-closed with red.

C. Post laminated valve chart in mechanical room showing tag numbers, functions, and normal operating positions.

END OF SECTION 230523

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232116 – Hydronic Specialties
3. Section 233113 – Metal Ducts
4. Section 237300 – Air Handling Units
5. Section 238216 – Fan Coil Units
6. Section 232123 – Hydronic Pumps
7. Section 230716 – HVAC Thermal Insulation
8. Section 230553 – Identification for HVAC Systems

1.2 SUMMARY

A. Scope: Furnish and install all hangers, supports, anchors, guides, seismic braces, and associated hardware for HVAC piping, ductwork, and mechanical equipment.

B. Included work:

1. Pipe hangers and rods for all hydronic piping systems (heating, cooling, condenser water, glycol)
2. Duct hangers, trapeze frames, and lateral braces for rectangular and circular sheet metal ducts
3. Equipment support bases, inertia pads, and anti-vibration mounts for AHUs, pumps, and fans
4. Seismic restraints and lateral bracing per NTC 2018 for all piping ≥ DN 65 and ducts with longest side ≥ 600 mm
5. Pipe anchors, guides, and expansion loops to control thermal movement
6. Insulation protection saddles and shields at all support points on insulated piping

1.3 DEFINITIONS

A. Hanger: support that suspends pipe or duct from overhead structure by means of rods, straps, or chains; carries load in tension.

B. Support: structure that bears pipe or equipment weight from below; carries load in compression; includes floor stands, base plates, and structural frames.

C. Anchor: rigid restraint that prevents pipe movement in all directions; absorbs thermal expansion forces; located at fixed points in expansion loop design.

D. Guide: restraint that allows axial pipe movement but prevents lateral/vertical movement; directs thermal expansion toward expansion loops or flexible joints.

E. Trapeze: horizontal structural member (angle or channel section) spanning between two hanger rods; supports multiple parallel pipes or a wide duct.

F. Seismic brace: lateral restraint system (rod, angle, or sway brace) designed to resist inertial forces from seismic events; required by NTC 2018 §7.2.3.

G. Insulation protection saddle (sella): curved steel plate between pipe support and insulation; prevents crushing of insulation at support points; mandatory on insulated pipes.

H. MSS SP-58 type number: industry-standard catalogue designation for hanger and support components; referenced throughout this Section.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
MSS SP-58	Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation
MSS SP-69	Pipe Hangers and Supports – Selection and Application Guide

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MSS SP-89	Pipe Hangers and Supports – Fabrication and Installation Practices
MSS SP-90	Guidelines on Terminology for Pipe Hangers and Supports
EN 13480-3	Metallic industrial piping – Design and calculation; Annex J – pipe support spacing
UNI EN ISO 3506-1	Mechanical properties of corrosion-resistant stainless steel fasteners – bolts
UNI EN 10025-2	Hot-rolled structural steel products – technical delivery conditions
NTC 2018 §7.2.3	Norme Tecniche per le Costruzioni – non-structural elements (seismic bracing of systems)
Circ. 21/01/2019 n.7	NTC 2018 application instructions
SMACNA HVAC Duct Construction Standards	Duct hanger types, spacing, and loading – Chapter 4 (Hangers and Supports)
EN 12237	Ventilation for buildings – ductwork – strength and leakage of circular sheet metal ducts
D.Lgs. 81/2008	Consolidated Workplace Safety Act
D.P.R. 380/2001	Consolidated Building Code

1.5 SUBMITTALS

A. Shop drawings: hanger and support layout drawings at 1:50 minimum; showing type, location, rod size, and load for each support; seismic brace locations and directions highlighted.

B. Product data: manufacturer's load tables for all hanger types; rod pull-out strength for all insert types; seismic load resistance data for all bracing components.

C. Material certificates: material test reports (MTC) for hanger rods and structural steel; stainless steel grade certification where specified.

D. Anchor approvals: manufacturer's technical approval (ETA or equivalent) for all cast-in or post-installed anchors into concrete.

1.6 QUALITY ASSURANCE

A. All hanger and support components shall be of a recognised manufacturer specialising in pipe support and seismic-restraint systems, with documented experience on comparable HVAC installations and full product certification per the standards listed in this Section.

B. Hanger rod sizes and spacing shall comply with MSS SP-69 Tables and EN 13480-3 Annex J; no field-fabricated rod or strap without COR approval.

C. Seismic bracing design: NTC 2018 §7.2.3; calculations signed and stamped by a registered structural or civil engineer licensed per DM 17/01/2018 – NTC 2018. Installer follows COR-approved drawings and installation instructions; installer shall not modify brace layout without written COR approval.

D. All post-installed anchors into concrete: ETA-approved expansion or chemical anchors; installed per manufacturer's instructions; torque-tested at 10% of installed anchors (minimum 3 per system).

1.7 WARRANTY

A. All hanger and support systems: **1 year** from Substantial Completion.

B. Seismic bracing system: **5 years** — structural integrity of all restraint connections and anchors.

PART 2 – PRODUCTS

2.1 MATERIALS — GENERAL

A. Standard material: carbon steel, hot-dip galvanised (HDG) per EN ISO 1461; minimum coating 45 µm (85 µm for outdoor or humid locations).

B. Stainless steel: AISI 316 (1.4401) for all hangers and rods in contact with stainless steel piping; for outdoor, coastal, or chemically aggressive environments; for pool plant rooms.

C. Threaded rods: DIN 975 / ISO 4029; carbon steel class 4.6 galvanised (standard); class 8.8 galvanised where specified for heavy loads; stainless A4-70 where SS required.

D. Nuts and washers: matching grade and material to rod; double-nut locking at all adjustable rod connections.

E. Slotted strut channel sections (cold-formed steel): zinc-electrogalvanised (minimum 12 µm) for indoor dry; HDG or stainless for all other locations.

F. Dissimilar metals: where copper or stainless steel piping contacts carbon steel support, use dielectric isolation pad (neoprene or EPDM, 3 mm minimum) to prevent galvanic corrosion.

G. Insulating pipe collars and clamps: All pipe clamps, rings, and clevis hangers in direct contact with HVAC piping shall incorporate a continuous elastomeric liner (neoprene, EPDM, or reinforced rubber, minimum 3 mm thickness). Bare metal-to-pipe contact is not permitted on any HVAC service. Purpose: prevent galvanic corrosion at dissimilar-metal interfaces; eliminate thermal bridging and surface condensation at hanger contact points on chilled water, cold glycol, and other sub-ambient circuits; attenuate structure-borne vibration transmission from pipe to building structure. Manufacturer's standard product of a recognised supplier of insulated-clamp / lined-bracket pipe-support systems, subject to COR's approval.

2.2 PIPE HANGER TYPES (MSS SP-58)

A. Type 5 – Clevis hanger: adjustable; standard for horizontal piping up to DN 150; sized per pipe OD including insulation where applicable.

B. Type 9 – Adjustable band hanger: for smaller pipes DN 15–50 where rod hanger is impractical; maximum load per manufacturer's table.

C. Type 12 – Pipe clamp: for close-to-wall horizontal pipe; where vertical rod hanger cannot be used; load limit per manufacturer.

D. Type 26 – Adjustable pipe roll support: for long runs with significant thermal expansion; allows axial pipe movement via steel roller; galvanised steel body; locate at calculated guide points in expansion loop design. Where low-friction sliding support is required (large diameter piping), use PTFE slide plate assembly (separate product; specify PTFE pad minimum 5 mm thick, stainless steel backing) in lieu of Type 26 roller.

E. Type 36 / 37 – Adjustable swivel clevis hanger: two-bolt adjustable clevis; for horizontal piping where angular adjustment is required; not a spring hanger.

F. Type 51 / 54 – Spring hangers: Type 51 = variable spring; Type 54 = constant-load spring; for pump suction/discharge piping and connections subject to vibration or thermal settlement; spring rate and travel calculated by COR; load and travel stamped on unit.

G. Trapeze hanger: fabricated from back-to-back steel angles or slotted strut channel; for multiple parallel pipes ≤ 2 m width; span and section sized per loading calculations.

NOTE: All hanger types shall be adjustable after installation to permit final alignment of piping. One-piece clamps or fixed types without adjustment mechanism are not permitted as primary pipe supports.

2.3 PIPE ANCHORS AND GUIDES

A. Anchors: welded or bolted anchor brackets on pipe; resist axial, lateral, and vertical forces; designed by COR to absorb expansion forces from thermal loops.

B. Guides: allow axial pipe movement only; lateral and vertical movement restrained; spacing per expansion loop design; maximum spacing = 40 × pipe OD.

C. Anchor and guide materials: carbon steel galvanised; welded to pipe with full penetration weld where pipe material allows; bolted type (split collar) for copper and stainless pipe.

2.4 INSULATION PROTECTION SADDLES

A. Requirement: mandatory at every support point on insulated piping; prevents compression of insulation; maintains thermal continuity through support.

B. Material: carbon steel sheet ≥ 3 mm; galvanised or painted; arc-welded saddle enclosing lower 180° of pipe circumference; length ≥ 150 mm (small bore) to 300 mm (large bore); no contact between support structure and pipe.

C. Insulation thickness: saddle height = full insulation thickness + 10 mm clearance; pipe insulation continuous through saddle zone.

D. High-temperature piping (> 60°C): high-density calcium silicate or foam glass insert within saddle to bridge support point.

2.5 DUCT HANGERS AND SUPPORTS

A. Rectangular duct hangers: trapeze type using back-to-back 40×40×4 mm steel angles (or equivalent slotted strut channel) spanning duct width + 50 mm each side; suspended by two threaded rods; rod size per spacing table below.

B. Circular duct hangers: adjustable band hanger or clevis-type ring at diameter; rod size per spacing table.

C. Duct support at AHU connections: independent support within 300 mm of AHU casing; ductwork weight shall not bear on AHU connections.

D. Maximum hanger spacings and minimum rod diameters for ductwork:

Parameter	BACnet Object / Modbus Reg.	R/W	Notes
Duct type / size	Max spacing	Rod Ø min	Notes
Rectangular – longest side ≤ 400 mm	2 400 mm	Ø 8 mm	SMACNA Table 4-1
Rectangular – longest side 401–800 mm	1 500 mm	Ø 10 mm	SMACNA Table 4-1
Rectangular – longest side 801–1500 mm	1 200 mm	Ø 12 mm	SMACNA Table 4-1
Rectangular – longest side > 1500 mm	900 mm	Ø 12 mm + mid-support	SMACNA Table 4-1
Circular / oval – Ø or minor ≤ 500 mm	3 000 mm	Ø 8 mm	SMACNA Table 4-1
Circular / oval – Ø or minor > 500 mm	2 000 mm	Ø 10 mm	SMACNA Table 4-1

2.6 MAXIMUM PIPE HANGER SPACING

A. Hanger spacing shall not exceed the values below; actual spacing may be reduced by the COR where concentrated loads, valves, or fittings require closer support.

Parameter	BACnet Object / Modbus Reg.	R/W	Notes
Nominal pipe size	Steel / GI / Fe (m)	Copper (m)	Pre-insulated (m)
DN 15 - DN 20 (1/2 in - 3/4 in)	2.0 m	1.8 m	2.0 m
DN 25 - DN 32 (1 in - 1-1/4 in)	2.5 m	2.0 m	2.5 m
DN 40 - DN 50 (1-1/2 in - 2 in)	3.0 m	2.5 m	3.0 m
DN 65 - DN 80 (2-1/2 in - 3 in)	3.5 m	3.0 m	3.5 m
DN 100 - DN 125 (4 in - 5 in)	4.0 m	3.5 m	4.0 m
DN 150 (6 in)	4.5 m	--	4.5 m

DN 200 and above (>= 8 in)	5.0 m	--	5.0 m

NOTE: Spacings are for straight horizontal runs of water-filled pipe. Reduce by 20% for vertical runs without intermediate restraints, for steam piping, or for pipes with external insulation > 80 mm thickness. Copper pipe (EN 1057) is not commercially available in HVAC applications above DN 108 (4 in); columns marked '--' indicate copper is not applicable at that diameter. Steel pipe spacing per EN 13480-3 Annex J; copper pipe spacing per MSS SP-69 Table 3 (which governs where more restrictive).

2.7 SEISMIC RESTRAINTS

A. Applicability: all piping ≥ DN 65 and all ductwork with longest side ≥ 600 mm shall be provided with seismic lateral bracing per NTC 2018 §7.2.3.

B. Lateral brace spacing: maximum 6 m centres for piping; maximum 6 m for ductwork; braces at each change of direction.

C. Brace types: four-way (longitudinal + transverse) sway braces using steel angle or rod diagonals; modular factory-engineered seismic-restraint system with valid ETA / ICC-ES approval acceptable in lieu of site-fabricated bracing.

D. Design loads: horizontal seismic force per NTC 2018 §7.2.3 formula Fa = Sa × Wa × γa / qa; seismic coefficient Sa and site parameters (ag, S, Categoria d'uso) defined by the structural engineer for the specific project location. For preliminary design and where project-specific seismic calculation is not yet available, use the conservative estimate Fa = 0.3 × g × W (W = weight of pipe/duct including fluid and insulation); this value shall be confirmed or replaced by the structural engineer's project-specific calculation before detailed design.

E. Anchors: ETA-approved expansion anchors or chemical anchors into concrete structure; anchor design per manufacturer's ETA and seismic load calculations.

F. Seismic isolators for equipment: AHUs, pumps, and fan coils on spring or neoprene mounts to limit seismic force transmission to structure; spring mounts for equipment > 5.5 kW with steel cage housing, NTC 2018 rated.

2.8 ANTI-VIBRATION MOUNTS FOR EQUIPMENT

A. Pumps and fans ≤ 5.5 kW: neoprene anti-vibration pads; Shore A hardness 40–60; minimum 20 mm static deflection under operating load.

B. Pumps and fans > 5.5 kW, AHUs: spring isolators with steel housing/cage; minimum 25 mm static deflection; NTC 2018 seismic rated; natural frequency ≤ 4 Hz.

C. Fan coil units (ceiling suspended): spring hangers rated for FCU weight + service load (including full water content and filter); minimum **25 mm** static deflection; natural frequency ≤ 4 Hz; neoprene-only hangers not permitted for ceiling-suspended FCUs.

D. Inertia bases: reinforced concrete inertia pad, mass = 1.5 × (pump + motor) assembly weight, for all base-mounted pumps > 5.5 kW; spring mounts between inertia base and floor slab.

NOTE: All anti-vibration mounts shall be loaded to 60–80% of rated capacity at operating weight to achieve stated natural frequency. Overloaded or underloaded mounts do not achieve the specified isolation.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify structural elements (beams, slabs, walls) are available and adequate for support loads before installing hangers.

B. Do not attach hangers to metal decking, sprinkler piping, electrical conduit, or other mechanical/electrical systems.

C. Confirm anchor type is appropriate for concrete compressive strength and slab thickness; minimum embedment per ETA.

3.2 INSTALLATION — PIPE SUPPORTS

A. Rod plumb: hanger rods shall be plumb within 1°; angled rods without lateral brace are not permitted.

B. Adjustment: set hanger nuts to maintain designed pipe elevation; re-adjust after system fill and pressurisation.

C. Isolation: install neoprene or EPDM pad between pipe clamp and copper or stainless steel pipe; between galvanised support and copper pipe.

D. Insulated pipe: install insulation protection saddle before closing hanger; do not compress insulation; maintain full insulation thickness at support.

E. Vertical pipe: support at each floor penetration and at maximum 4 m intervals on vertical risers; use riser clamps (MSS SP-58 Type 8) with load transferred to slab.

F. No support to piping itself: piping shall not support the weight of valves, strainers, or instruments without independent support within 300 mm of the fitting.

3.3 INSTALLATION — DUCT SUPPORTS

A. Install trapeze hangers level to ± 2 mm across span; verify duct sits level on trapeze before fastening.

B. Support flexible duct connections at AHU and fan coil independently — do not use flexible connection to carry duct weight.

C. All penetrations through fire-rated floors and walls: provide independent support on each side of penetration; fire-rated collars or intumescent blanket as required.

3.4 INSTALLATION — SEISMIC BRACING

A. Install lateral braces before completing pipe or duct connections; do not wait until system is complete.

B. Four-way braces at maximum 6 m spacing and at all changes of direction ≥ 45°; longitudinal and transverse braces may be combined at the same location.

C. Anchor torque: tighten to manufacturer's specified installation torque; record torque values on installation record.

D. Submit completed seismic brace installation record (Dichiarazione di corretta posa) signed by installer before system commissioning.

3.5 FIELD QUALITY CONTROL

A. Hanger inspection: 100% visual inspection of all hangers before insulation is applied; check rod size, spacing, plumb, and nut tightening.

B. Load test (spot check): 5% of all post-installed anchors to be torque-tested to 120% of installation torque; no pull-out or cracking permitted.

C. Anti-vibration mount check: measure static deflection under operating load; verify within 10% of specified value.

D. As-built record: submit as-built hanger schedule showing actual hanger type, rod size, and spacing at each support point; update seismic brace layout drawing.

END OF SECTION 230529

SECTION 230553
IDENTIFICATION FOR HVAC SYSTEMS

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 233113 – Metal Ducts
3. Section 230529 – Hangers and Supports for HVAC Piping and Equipment
4. Section 230900 – Instrumentation and Controls for HVAC
5. Section 232123 – Hydronic Pumps
6. Section 237300 – Air Handling Units
7. Section 260518 – Low-Voltage Electrical Power Conductors and Cables

1.2 SUMMARY

A. Scope: Furnish and install a complete identification system for all HVAC piping systems, ductwork, mechanical equipment, valves, and control panels.

B. Included work:

1. Pipe labels with colour band, fluid name, flow direction arrow, and pressure/temperature where required
2. Equipment name plates (targhe) for all AHUs, pumps, fan coil units, heat pumps, and major plant items
3. Valve identification tags (targhette valvole) keyed to valve schedule
4. Duct labels at each air terminal and at each major branch
5. Control panel labels and zone identification for BMS field devices
6. Safety and hazard signs at refrigerant plant, gas train, and high-temperature equipment

C. Identification shall be installed **after** pressure testing, flushing, and final painting of piping and equipment, but **before** final inspection and handover.

1.3 DEFINITIONS

A. Equipment tag (targa): permanent stainless steel or anodised aluminium nameplate affixed to each item of mechanical plant; carries tag number, description, and duty data.

B. Valve tag (targhetta valvola): numbered disc (brass, aluminium, or engraved stainless) hung from valve handwheel or stem; cross-referenced to valve schedule in O&M manual.

C. Pipe label (etichetta tubazione): adhesive or banded label showing colour stripe, fluid name, and flow arrow; applied to pipe or pipe insulation at regular intervals and at key locations.

D. Flow arrow: directional arrow on pipe label indicating normal flow direction; both directions shown where flow is reversible.

E. Circuit code: abbreviated service code used consistently throughout drawings, schedules, and tags (e.g., HW = heating water; CHW = chilled water; CW = condenser water; GLY = glycol; DHW = domestic hot water).

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
ANSI/ASME A13.1	Scheme for the Identification of Piping Systems – colour and label requirements
UNI 5634:1965	Pipe identification for fluids – withdrawn; no current regulatory force; cited for historical reference only; superseded in this project by ASME A13.1
UNI EN ISO 20560-1:2021	Identification of contents of piping systems – graphical symbols for labels and signs (current ISO reference)

ISO 7010	Graphical symbols – safety signs – registered safety signs
UNI EN ISO 7000	Graphical symbols for use on equipment – registered symbols
CEI EN 60445	Basic and safety principles – identification of equipment terminals and conductor terminations
CEI 64-8	Electrical systems – conductor identification colours
UNI 7543-1	Colours and safety signs – safety colours
D.Lgs. 81/2008 All. XXV	Safety signage – minimum provisions
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Identification schedule: complete list of all pipes, equipment, valves, and ducts to be identified; tag numbers, circuit codes, label text, and colours; submitted for COR approval before fabrication.

B. Valve schedule (registro valvole): tabulated list of all valves; columns: tag number, service, location, type, size, normal position (open/closed), fail position; to be included in O&M manual.

C. Sample labels and tags: physical samples of each label type and tag material for COR approval before full production.

D. Equipment tag drawings: drawings showing tag content for each major item; submitted concurrently with equipment submittals.

1.6 QUALITY ASSURANCE

A. All labels, tags, and signs shall be produced by a specialist identification manufacturer; field hand-written labels are not acceptable.

B. Tag numbers shall match exactly the numbers shown on Contract drawings, BMS point schedules, and O&M manuals; no variation without COR approval.

C. Colours shall match the project colour schedule (Art. 2.2) and ASME A13.1 where applicable; verify colour under project lighting conditions before full installation.

1.7 WARRANTY

A. All identification materials: **1 year** from Substantial Completion; labels shall not peel, fade, or become illegible under normal plant room conditions within warranty period.

PART 2 – PRODUCTS

2.1 PIPE LABELS

A. Label type: self-adhesive vinyl labels or wrap-around band labels; UV-resistant and chemical-resistant inks; suitable for –20°C to +120°C continuous service.

B. Label size: per pipe / insulation OD:

1. OD ≤ 50 mm: minimum 50 mm × 200 mm label
2. OD 51–150 mm: minimum 70 mm × 300 mm label
3. OD 151–300 mm: minimum 90 mm × 400 mm label
4. OD > 300 mm: stencilled directly on pipe insulation lagging

C. Label content:

1. Background colour band: full width of label, per colour schedule (Art. 2.2)
2. Fluid name: abbreviated circuit code + full Italian description (e.g., 'CHW – Acqua refrigerata')
3. Flow direction arrow: minimum 50 mm tall; black or white for contrast; both arrows for reversible flow
4. Pressure and temperature where required by PED Dir. 2014/68/UE (piping systems > 110°C or > PN16)

D. Label spacing:

1. Straight runs: maximum 5 m between labels in plant rooms; maximum 10 m in ceiling voids
2. At every branch, riser, floor/wall penetration (both sides), valve, and access panel
3. At every change of direction > 45°
4. Minimum one label in each room or zone served

2.2 PIPE COLOUR IDENTIFICATION SCHEDULE

A. The following colour schedule applies to all HVAC piping systems on this project, based on ASME A13.1 and common Italian HVAC practice:

Parameter	BACnet Object / Modbus Reg.	R/W	Notes
Service	Background	Text	RAL approx.
Heating hot water (HW)	Orange	Black	RAL 2010
Low-temp. heating (LTHW)	Orange	Black	RAL 2010
Chilled water – supply (CHW-S)	Blue	White	RAL 5015
Chilled water – return (CHW-R)	Blue	White	RAL 5015
Condenser water (CW)	Grey	Black	RAL 7001
Domestic hot water (DHW)	Orange	Black	RAL 2010
Domestic cold water (DCW)	Green	White	RAL 6024
Glycol / antifreeze circuit	Violet	White	RAL 4005
Compressed air	Pastel blue	Black	RAL 5024
Natural gas (where present)	Yellow	Black	RAL 1021
Drain / condensate	Grey	Black	RAL 7035
Refrigerant (high-pressure side)	Orange	Black	RAL 2004
Refrigerant (low-pressure side)	Light orange	Black	RAL 2003
Fire-protection water	Red	White	RAL 3000

NOTE: Where pipe insulation cladding (lagging) is present, the colour band label is applied to the cladding surface. Self-adhesive labels shall not be applied directly to mineral wool or foam insulation without a vapour-barrier cladding layer. Natural gas (yellow RAL 1021) is the only fluid retaining a yellow label on this project; all water-based services use orange, blue, green, or grey to avoid confusion with the gas hazard colour. Supply air ducts (light blue RAL 5012) are differentiated from compressed air piping (pastel blue RAL 5024) by both RAL shade and label format (duct labels are significantly larger). Condenser water (CW, grey RAL 7001) is intentionally differentiated from domestic cold water (DCW, green RAL 6024) to prevent cross-connection risk.

2.3 EQUIPMENT NAME PLATES (TARGHE)

A. Material: 1.5 mm anodised aluminium (natural or black anodised); or 1.5 mm brushed stainless AISI 304; engraved text filled with black or white enamel.

B. Size: minimum 150 mm × 80 mm; larger as required to accommodate all tag information.

C. Fixing: stainless steel self-tapping screws or rivets to equipment casing; adhesive fixing only where screw fixing would damage equipment warranty.

D. Tag content format:

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Parameter	BACnet Object / Modbus Reg.	R/W	Notes
Field	Content	Example	Status
Line 1 (top)	Equipment tag number	e.g. P-01-HW-001	Mandatory
Line 2	Equipment description (Italian)	e.g. Pompa acqua calda - circuito primario	Mandatory
Line 3	Duty point or capacity	e.g. Q = 8 m3/h H = 18 m 3.0 kW	Mandatory
Line 4 (bottom)	Service circuit code	e.g. HW / LTHW / CHW / CW / GLY	Mandatory

E. Colour coding of tags:

1. Heating system equipment: yellow tag with black text
2. Cooling / chilled water equipment: blue tag with white text
3. Ventilation / AHU equipment: grey tag with black text
4. Domestic water equipment: green tag with white text
5. Refrigerant / heat pump equipment: red tag with white text
6. General / mixed service: aluminium natural anodised tag with black text

2.4 VALVE TAGS (TARGHETTE VALVOLE)

A. Material: 2 mm brass disc or 1.5 mm anodised aluminium disc; minimum Ø 50 mm.

B. Stamped or engraved: tag number per valve schedule; circuit code; normal position (NA = normally open; NC = normally closed).

C. Attachment: stainless steel 'S'-hook to valve handwheel spindle or identification ring on actuated valve; wire attachment not acceptable.

D. Colour:

1. Manual isolation valves: brass (natural) or yellow anodised aluminium
2. Pressure-reducing valves and safety relief valves: red disc
3. Motorised / actuated control valves: blue disc
4. Drain and vent valves: grey disc

E. Valve schedule: provide complete valve schedule in O&M manual; include: valve tag, service, pipe size, type, location description, normal position (open/closed), fail-safe position, and actuator/BMS point reference where applicable.

NOTE: All valves, including drain cocks, automatic air vents, and fill points, shall be tagged. No valve shall be left unidentified at handover. The valve schedule is a mandatory O&M document.

2.5 DUCT LABELS

A. Supply air ducts: label background light blue (RAL 5012); text black; content: 'MANDATA – [zone or AHU tag]'.

B. Return / extract air ducts: label background yellow (RAL 1003); text black; content: 'RIPRESA / ESTRAZIONE – [zone or AHU tag]'.

C. Fresh air intake ducts: label background green (RAL 6024); text white; content: 'ARIA ESTERNA'.

D. Exhaust air ducts: label background grey (RAL 7035); text black; content: 'ARIA ESPULSA'.

E. Label spacing: at each branch from main; at each AHU connection; at each zone served; at every access panel; minimum one label per room or zone served by the duct.

F. Airflow arrow: printed on label; direction of normal flow.

G. Label size: minimum 100 mm × 300 mm for ducts ≥ 200 mm side; label applied to duct or duct insulation lagging; stencilled directly on large ducts > 1000 mm.

2.6 CONTROL PANEL AND BMS FIELD DEVICE LABELS

A. Control panels: engraved panel fascia label; text: panel tag, description, served zone; minimum 10 mm text height; label material per equipment nameplate (Art. 2.3).

B. BMS sensors and actuators: adhesive polyester label on each sensor, transmitter, and actuator; text: BMS point tag (as per BMS point schedule in Section 230900); minimum 12 pt font.

C. VFD / frequency drive: label on door: drive tag, motor it serves, BACnet Device Instance number.

D. Terminal strips: label each terminal with wire number per wiring diagram; CEI EN 60445 compliant numbering.

2.7 SAFETY AND HAZARD SIGNS

A. Refrigerant plant room: ISO 7010 / D.Lgs. 81/2008 mandatory signs: 'RISCHIO ASFISSIA – REFRIGERANTE'; 'VIETATO FUMARE E USARE FIAMME LIBERE'; emergency ventilation switch label.

B. High-temperature piping (> 60°C): 'ATTENZIONE – SUPERFICIE CALDA' warning label per ISO 7010-W017 at accessible locations.

C. Gas (where present): mandatory sign 'GAS – PERICOLO DI ESPLOSIONE / VIETATO FUMARE E USARE FIAMME LIBERE' per D.Lgs. 81/2008 All. XXV (sign text legally required in Italian); non-residential gas systems: UNI 11528; residential gas systems: UNI 7129.

D. Pressurised equipment (PED): pressure vessel CE plate per PED Dir. 2014/68/UE; stamped PS, TS, V, year, and Notified Body number.

E. Emergency stops: red/yellow emergency stop labels per ISO 13850 (safety of machinery – emergency stop) and D.Lgs. 81/2008 All. XXV at each emergency stop push button and at plant room entry points; wording: 'ARRESTO DI EMERGENZA'.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Confirm all piping, ductwork, and equipment painting and insulation is complete before applying identification labels.

B. Verify tag numbers against as-built drawings and BMS point schedules; report and resolve any discrepancies before label production.

3.2 INSTALLATION

A. Surface preparation: clean pipe or duct surface with isopropyl alcohol before applying self-adhesive labels; ensure surface is dry and free of dust, grease, and condensation.

B. Label alignment: apply labels horizontally on horizontal pipes and ducts; readable from the floor or from the main access aisle; labels on vertical pipes shall be readable from below or from the nearest walkway.

C. Insulated pipes: apply labels after final cladding is installed; where cladding is PVC or GRP, apply self-adhesive label directly; where cladding is canvas or mineral wool, use stainless steel banding with label clip.

D. Equipment plates: fix name plates before painting of equipment is complete so that paint does not obscure text; re-apply if plate is painted over.

E. Valve tags: hang tag after valve is installed and before system fill; confirm tag number matches valve schedule before hanging.

3.3 INSPECTION AND ACCEPTANCE

A. 100% check: COR or Clerk of Works to inspect all labels, tags, and signs before handover; sign off on identification checklist.

B. Valve schedule verification: walk all systems with valve schedule; confirm each valve tag is in place, readable, and matches schedule.

C. Illegible or damaged labels: replace before handover; no acceptance of faded, peeling, paint-covered, or incorrectly positioned labels.

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D. Submit completed identification checklist with as-built documentation; include photographic record of each plant room's labelling.

END OF SECTION 230553

SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 230519 – Meters and Gauges for HVAC Piping
2. Section 230523 – General-Duty Valves for HVAC Piping
3. Section 230900 – Instrumentation and Controls for HVAC
4. Section 232113 – Hydronic Piping
5. Section 232123 – Hydronic Pumps
6. Section 233113 – Metal Ducts
7. Section 237300 – Air Handling Units
8. Section 238143 – Air-Source Heat Pumps
9. Section 238216 – Fan-Coil Units
10. Section 134813 – Acoustic Equipment Enclosures

1.2 SUMMARY

A. Scope: Provide complete testing, adjusting, and balancing (TAB) of all HVAC air and water distribution systems, including measurement, verification, balancing, and documentation, by an independent specialist TAB contractor; followed by acceptance testing witnessed by the COR.

B. Included works:

1. Pre-TAB system readiness verification (flushing, leak testing, BMS point checkout)
2. Air-side balancing of all supply, return, and exhaust ductwork to design airflows
3. Waterside balancing of all hydronic circuits (primary, secondary, tertiary, terminal) to design flow rates
4. Fan and pump operating-point verification, SFP/SPP measurement
5. Coil duty verification on representative units
6. Sound and vibration measurement (post-balancing)
7. Final TAB report and as-balanced documentation

C. Procedural reference: UNI EN 12599 (acceptance testing), BSRIA BG 1/2009 (air systems), BSRIA BG 2/2009 (water systems), and CIBSE Commissioning Codes A and W. Where US procedures and tolerances apply, AABC / NEBB / ASHRAE Std. 111 are referenced concurrently.

1.3 DEFINITIONS

A. TAB: Testing, Adjusting, and Balancing — the systematic process of (1) testing equipment performance, (2) adjusting controls and dampers/valves, and (3) balancing flows to design values.

B. Total flow: the sum of all branch / terminal flows in a system; shall equal the design system flow within tolerance.

C. Proportional balancing: technique where all branches of a system are simultaneously adjusted to maintain their designed proportional flow share, regardless of the absolute total.

D. SFP (Specific Fan Power): electrical power consumed by the fan per unit of volumetric airflow, W/(L/s) or W/(m³/s); per Reg. (UE) 1253/2014.

E. SPP (Specific Pump Power): equivalent metric for pumps, W/(L/s) of water moved at design head.

F. TAB Agency: independent specialist firm engaged to perform TAB; **not** the mechanical installation contractor.

G. As-balanced: the final state of the system after all adjustments are recorded; the basis for warranty operation and BMS reference values.

1.4 APPLICABLE STANDARDS

Key Applicable Standards

UNI EN 12599	Ventilation for buildings – test procedures and measurement methods for installed HVAC systems
UNI EN 14336	Heating systems in buildings – installation and commissioning
UNI EN 15378-1	Heating systems and DHW – inspection of boilers and heating systems
UNI EN 16798-17	Energy performance of buildings – Module M5-11 – inspection of ventilation and AC systems
UNI EN ISO 5167	Measurement of fluid flow by means of pressure differential devices
BSRIA BG 49/2024	Commissioning of HVAC systems – best-practice guide
BSRIA BG 2/2009	Commissioning Water Systems – application procedures
BSRIA BG 1/2009	Commissioning Air Systems – application procedures
CIBSE Commissioning Code A	Air distribution systems
CIBSE Commissioning Code W	Water distribution systems
CIBSE Commissioning Code R	Refrigerating systems
AABC National Standards 2016	Total system balance – measurement & verification (US reference for procedures and tolerances)
NEBB Procedural Standards 2019	Testing, Adjusting and Balancing of Environmental Systems
ASHRAE Std. 111-2008(R2017)	Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems
ISO 5801	Fans – performance testing using standardised airways
ISO 10816-3 / ISO 20816-3	Mechanical vibration – evaluation by measurement on non-rotating parts
UNI EN 16430:2014	Fan coil units – testing and rating
UNI EN 14511	Air conditioners and heat pumps – rating
UNI EN 14825	Heat pumps – part load (SCOP/SEER)
UNI EN 15232	Energy performance – impact of controls
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. TAB Agency qualification: company profile; list of completed projects (minimum 5 comparable in the past 5 years); CVs of lead engineer and lead technician; AABC, NEBB, or BSRIA-equivalent certification.

B. TAB Plan (draft): submitted minimum 60 days before TAB start; covers procedures, sequence of operations, instruments to be used (with calibration certificates), point-by-point measurement list, and tolerances.

C. Instrument calibration certificates: for every instrument used during TAB — pitot tubes, anemometers, differential-pressure meters, flow meters, sound level meters, vibration meters, multimeters — calibration not older than 12 months, traceable to national metrology standards.

D. Pre-TAB checklist: signed checklist confirming each prerequisite (flushing complete, leak test passed, BMS controls operational, set-points configured) before TAB commences.

E. Final TAB Report: complete bound report with all readings, system schematics, balanced flow tables, deviation summary, and TAB Agency stamp.

1.6 QUALITY ASSURANCE

A. TAB Agency independence: the TAB Agency shall be an independent third party, with no commercial relationship to the mechanical installation contractor or to the equipment manufacturers used on the project. COR reserves the right to reject any proposed TAB Agency for conflict of interest.

B. Certification: AABC firm certification, NEBB firm certification, or BSRIA TAB certification scheme; alternative accreditation subject to COR approval.

C. Instrument accuracy minimum requirements:

1. Air velocity (hot-wire / vane anemometer): ±3% of reading
2. Air volume by pitot traverse: ±5% of reading
3. Differential pressure (water): ±0.25% full scale
4. Water flow at balancing valve (manufacturer's Kv curve): ±5%
5. Water flow by installed flow meter (verified): ±2%
6. Temperature: ±0.3 °C for water, ±0.5 °C for air
7. Sound level meter: Class 1 per IEC 61672
8. Vibration meter: per ISO 2954

1.7 COORDINATION

A. TAB commencement requires:

1. All HVAC equipment installed and energised
2. Hydronic systems flushed, pressure-tested, and dosed with inhibitor (Section 232113, 232500)
3. Ductwork leakage tested (Section 233113)
4. BMS DDC points checked out (Section 230900)
5. All filters installed in clean condition; no temporary commissioning filters
6. Building substantially complete with weather-tight envelope

B. Conflict resolution: any deviation from design that prevents balancing within tolerance shall be reported to the COR in writing within 24 hours; the TAB Agency does not modify design without written authorisation.

1.8 WARRANTY AND POST-OCCUPANCY

A. Re-balance during warranty: TAB Agency shall return to site once during the warranty period (recommended at 9 months post-handover) to verify that as-balanced flows are maintained and to perform any seasonal re-balance required.

B. Documentation retention: TAB report stored in project O&M manual and on BMS server as PDF.

PART 2 – INSTRUMENTS AND DOCUMENTATION

2.1 TAB INSTRUMENTS

A. Air-side instruments:

1. Pitot-tube and digital manometer for duct traverses (range 0–2500 Pa, 0.5% accuracy)
2. Hot-wire anemometer for low-velocity grilles (0.1–30 m/s)
3. Rotating-vane anemometer for diffuser and grille flow (≥ 80 mm head)
4. Flow hood (powered or unpowered) for terminal device measurement up to 1000 L/s
5. Tachometer (optical and contact) for fan speed verification

B. Water-side instruments:

1. Differential pressure meter with manifold and pressure-test-point fittings (range 0–500 kPa)
2. Portable ultrasonic flow meter (clamp-on, ±1%) as primary verification tool

3. Magnetic flow meter (insertion type) for permanent installations

C. Environmental / safety instruments:

1. Sound level meter Class 1 per IEC 61672 with octave-band analyser
2. Vibration meter per ISO 2954 / ISO 10816-3
3. Multimeter (true RMS, CAT III) for motor current verification
4. Thermal imaging camera (FLIR or equivalent) for trend/qualitative analysis

2.2 DOCUMENTATION FORMATS

A. TAB readings to be recorded on standardised reporting forms (NEBB / AABC standard sheets or equivalent BSRIA forms) for each system, including:

1. System identification (tag, location, design parameters)
2. Equipment performance data (fan/pump speed, current, power, suction/discharge pressure or static pressure)
3. Distribution data (flow at each branch, valve/damper setting, measured ΔP)
4. Terminal device data (flow, valve setting, room temperature observed)
5. Date of measurement, ambient conditions, instrument used, technician initials

B. Final TAB report in PDF and editable spreadsheet format; deposited with COR and uploaded to BMS server documentation folder.

PART 3 – EXECUTION

3.1 PRE-TAB VERIFICATION

A. Before commencing measurements, the TAB Agency shall verify and document the following on the Pre-TAB Checklist:

1. Mechanical installation complete per drawings
2. Ductwork leakage test report submitted and accepted (Section 233113)
3. Hydronic flushing and chemical dosing complete (Sections 232113, 232500)
4. All filters installed, clean, factory specification
5. Fan and pump rotation correct; safety devices operational
6. VFDs commissioned with motor nameplate data loaded (Section 262913)
7. BMS points checkout signed off (Section 230900) — sensors reading correctly, valve/damper actuators stroking through full range
8. All access doors operational; all dampers/valves accessible

B. Deficiencies identified during pre-TAB are reported to the General Contractor; TAB does not proceed until each item is closed.

3.2 AIR-SIDE BALANCING — PROCEDURE

A. Per UNI EN 12599 and BSRIA BG 1/2009:

1. 1. Set all volume control dampers to 100% open
2. 2. Start each AHU and operate at design speed; record initial fan total static pressure, current, and power
3. 3. Perform pitot traverse on each main duct branch using ≥ 24 readings per ISO 3966 / EN 12599 Annex A; calculate volumetric flow
4. 4. Identify the highest-resistance (index) branch; this becomes the design reference
5. 5. Apply proportional balancing: simultaneously close branch dampers to match each branch's ratio of design flow to total
6. 6. Fine-adjust to bring each terminal device within tolerance
7. 7. Adjust fan speed (VFD) to minimum required to satisfy index branch + 10% margin
8. 8. Re-verify all terminals within tolerance; lock damper settings; record

B. Tolerance for air-side balancing per EN 12599 Table 5 / Class B:

1. Total system airflow: −5% / +10% of design

2. Individual zone / terminal: ±10% of design
3. Outdoor air flow (critical): −0% / +10% of design (no less than design)

C. SFP verification: measure fan power and total airflow at final balanced state; calculate SFP; compare to design SFP and Reg. (UE) 1253/2014 minima; report any exceedance.

3.3 WATER-SIDE BALANCING — PROCEDURE

A. Per BSRIA BG 2/2009 and CIBSE Commissioning Code W:

1. 1. Verify pump operating point: measure suction and discharge pressure, calculate developed head, compare to pump curve
2. 2. Verify total system flow by ultrasonic flow meter at pump discharge or by installed flow meter
3. 3. Set all manual balancing valves wide open (or PICVs to maximum preset)
4. 4. Identify the most-hydraulically-remote (index) terminal; this becomes the reference
5. 5. Measure flow at each terminal using ΔP across balancing valve and the manufacturer's Kv chart (or PICV setting verification)
6. 6. Proportionally balance: close branch valves to match design ratios; lock memory stops
7. 7. Adjust VFD set-point (proportional pressure or constant pressure) to minimum required to satisfy index terminal + 10% margin
8. 8. Verify final flows at each terminal; record measured flow, valve opening, ΔP

B. Tolerance for water-side balancing per BSRIA BG 2/2009:

1. Total system flow: ±10% of design
2. Branch and terminal flow: ±10% of design (Class A) or ±15% (Class B) per project category

C. PICV verification: where pressure-independent control valves are installed, verify preset against the design flow chart; measure actual flow at minimum and maximum ΔP across the PICV body to confirm flow independence.

3.4 COIL DUTY VERIFICATION (SAMPLE BASIS)

A. On minimum 10% of installed coils (selected by COR to include all coil types), verify duty:

1. Measure air ΔT across coil (supply and return air temperatures)
2. Measure air volume by flow hood or duct traverse
3. Measure water ΔT across coil (supply and return water temperatures)
4. Measure water flow by ultrasonic flow meter
5. Calculate sensible and latent (cooling) or sensible (heating) duty from each side
6. Compare air-side and water-side duty calculations (energy balance check)
7. Compare to scheduled duty; deviation > 10% triggers further investigation

3.5 ACOUSTIC AND VIBRATION VERIFICATION

A. Sound level measurement at representative occupied positions: with HVAC at full and part-load operation; A-weighted LpA in dB(A) and unweighted octave-band SPL; compared to project NR or NC targets.

B. Outdoor heat-pump LpA at 7 m verification per Section 238143 Article 3.3.

C. Vibration measurement at each pump and fan bearing housing per ISO 10816-3 / ISO 20816-3; maximum 2.8 mm/s RMS for Class II (HVAC) machinery in 'good' band; record three orthogonal axes.

3.6 BMS POINT VERIFICATION (PARALLEL CHECK)

A. For each measurement made by the TAB Agency at a location where the BMS also has a sensor, compare TAB instrument reading against BMS reading; flag deviations > 2× sensor accuracy class for re-calibration by the controls contractor (Section 230900).

B. Verify alarm setpoints with BMS commissioned values: high/low temperature, high/low pressure, filter Δp, flow no-flow.

3.7 TAB REPORT

A. Submit final TAB report within 15 working days of completion; report shall include:

1. Executive summary: systems balanced, tolerance achieved, outstanding issues
2. Equipment data sheets: each pump, fan, coil, AHU as-balanced
3. Distribution tables: each balanced flow with valve/damper setting and reference ΔP
4. Terminal device tables: each grille, diffuser, FCU, and terminal unit
5. SFP and SPP calculations
6. Acoustic and vibration measurements
7. Identified deviations, mitigations, and any items not yet within tolerance with proposed plan to close
8. Instrument calibration certificates appendix
9. Signed and stamped by TAB Agency Project Manager

B. COR review and acceptance of the TAB Report is a precondition for Substantial Completion of HVAC works.

3.8 ACCEPTANCE TESTING (WITH ENGINEER WITNESS)

A. After TAB Report acceptance, conduct witnessed acceptance test:

1. COR selects minimum 10% of balanced terminals at random
2. TAB Agency re-measures in COR's presence
3. All sampled readings shall fall within previously-reported values ±5% of design
4. Any sampled point failing acceptance triggers full re-verification of the affected system at TAB Agency's cost

3.9 SEASONAL RE-BALANCE

A. Where TAB is completed outside the operating season of a given mode (e.g., heating-mode TAB conducted in summer), schedule a seasonal re-balance at the appropriate time of year; coordinated with Owner's facility manager and COR.

B. 9-month return visit during warranty period to verify maintained balance and address any seasonal observation; document any field adjustments in a TAB Addendum filed with the O&M manual.

END OF SECTION 230593

SECTION 230716
HVAC THERMAL INSULATION

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 233113 – Metal Ducts
3. Section 237300 – Air Handling Units
4. Section 232123 – Hydronic Pumps
5. Section 336316 – Pre-Insulated Underground Piping Systems

1.2 SUMMARY

A. Scope: Furnish and install thermal insulation on all HVAC piping, ductwork, and equipment as shown on drawings and specified herein.

B. Included applications:

1. Hydronic piping – heating, chilled water, condenser water, domestic hot water
2. Refrigerant suction and liquid lines (where not factory-insulated)
3. Ductwork – supply, return, and exhaust ducts in unconditioned spaces
4. Air handling unit casings and plenums
5. Equipment – pump casings, valve bodies, expansion vessels (where noted)

C. Design conditions: ambient temperature range –10°C to +40°C; pipe operating temperatures –15°C to +120°C.

1.3 DEFINITIONS

A. Lambda (λ): thermal conductivity [W/(m·K)] of insulation material at declared mean temperature.

B. Mu (μ): water vapour resistance factor; higher μ = better vapour barrier.

C. Reaction to fire class: EN 13501-1 classification (Euroclass A1, A2, B, C, D, E, F); minimum class B-s2,d0 required for all HVAC insulation exposed inside buildings.

D. Cladding: outer protective jacket over insulation; aluminium sheet, PVC, GRP, or self-adhesive aluminium foil laminate.

E. Condensation control thickness: minimum insulation thickness preventing surface condensation; governs cold-pipe insulation design.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
EN ISO 12241	Thermal insulation for building equipment and industrial installations – calculation rules
EN ISO 10456	Building materials and products – thermal performance
EN 13162	Thermal insulation products – factory made mineral wool (MW) products
EN 13163	Thermal insulation products – factory made expanded polystyrene (EPS)
EN 13165	Thermal insulation products – factory made polyurethane foam (PUR/PIR)
EN 13166	Thermal insulation products – factory made phenolic foam (PF)
EN 13167	Thermal insulation products – factory made cellular glass (CG)
EN 14303	Thermal insulation – flexible foam rubber products (FEF)
EN 15499	Thermal insulation – elastomeric foam rubber products

EN 13501-1	Fire classification of construction products – reaction to fire
EN ISO 9229	Thermal insulation – vocabulary
D.Lgs. 311/2006	Amendments to D.Lgs. 192/2005 – energy efficiency in buildings
D.P.R. 59/2009	Energy performance of buildings – implementing regulation
UNI 10847	Thermal insulation for buildings – single layer and multilayer systems on flat roofs
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Product Data: manufacturer's technical data sheets for each insulation type; thermal conductivity (λ) vs. temperature curves, reaction-to-fire classification, vapour resistance (μ).

B. Fire certificates: EN 13501-1 test reports; certificates valid and issued by accredited laboratory.

C. Insulation schedule: tabulated schedule showing pipe or duct service, operating temperature, insulation type, thickness, and cladding for all systems.

1.6 QUALITY ASSURANCE

A. All insulation materials exposed within occupied or accessible spaces: minimum Euroclass **B-s2,d0** per EN 13501-1.

B. Thermal conductivity values used in thickness calculations must be certified by manufacturer and tested per EN 12667 or EN 12939.

C. Cold-pipe insulation must prevent surface condensation under design conditions (indoor RH ≤ 70%, ambient 30°C).

D. D.M. 37/2008: insulation of HVAC piping is part of the plant installation; the licensed installer (impresa abilitata per D.M. 37/2008 lett. c) shall certify compliance.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation in original sealed packaging clearly marked with product name, lambda value, and fire class.

B. Store in dry, covered location; protect from moisture, direct sunlight, and physical damage.

C. Do not compress pre-formed pipe sections during storage.

1.8 WARRANTY

A. All insulation materials and installation: **1 year** from Substantial Completion.

B. Pre-insulated pipe systems (Section 336316) warranted separately.

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Select insulation type based on operating temperature, fire classification requirement, exposure (indoor/outdoor), and vapour control need.

B. All adhesives, sealants, and tapes shall be **compatible** with the base insulation material and rated for the service temperature.

C. No insulation containing HCFC or HFC blowing agents shall be used.

2.2 FLEXIBLE ELASTOMERIC FOAM (FEF) INSULATION

A. Application: chilled water piping, refrigerant lines, cold-water pipes, condensate drains; wherever vapour diffusion control is critical.

B. Standard: EN 14303 and EN 15499.

C. Material: closed-cell nitrile-rubber or EPDM foam; λ ≤ 0.040 W/(m·K) at 0°C; μ ≥ 10,000.

D. Fire class: Euroclass **B-s3,d0** minimum; B-s2,d0 preferred and required in escape routes and plant rooms.

E. Form: pre-formed pipe sections (slit lengthwise) for pipe insulation; sheets/rolls for flat surfaces and ductwork.

F. Joining: all longitudinal seams and butt joints sealed with manufacturer's contact adhesive; no gaps, voids, or bridged seams.

G. Thickness – chilled water piping: minimum per condensation calculation; typical values:

1. DN15–DN25: 25 mm
2. DN32–DN65: 32 mm
3. DN80–DN150: 40 mm
4. DN > 150: 50 mm or per thermal calculation

H. Cladding outdoors: aluminium foil facing (factory) or GRP cloth and vapour-barrier paint; FEF not left exposed to UV outdoors without protection.

2.3 MINERAL WOOL (MW) INSULATION

A. Application: heating piping (>60°C), AHU casings, ductwork in fire-rated shafts; where non-combustibility (A1/A2) is required.

B. Standard: EN 13162.

C. Material: glass wool or rock wool; λ ≤ 0.040 W/(m·K) at 50°C mean temperature; fire class **A1** (non-combustible).

D. Form: pre-formed pipe sections with integrated foil facing (glass wool) or jacketed rock wool sections.

E. Jacket: aluminium self-adhesive foil tape or aluminium sheet cladding.

F. Thickness – heating pipes (80–120°C):

1. DN15–DN25: 40 mm
2. DN32–DN65: 50 mm
3. DN80–DN150: 60 mm
4. DN > 150: 80 mm or per thermal calculation

G. Vapour barrier: not required for hot-pipe service; foil facing for appearance and mechanical protection only.

H. Finishing for exposed surfaces: aluminium sheet cladding (0.6 mm minimum); stainless steel banding at 400 mm centres.

2.4 POLYURETHANE / POLYISOCYANURATE (PUR/PIR) FOAM INSULATION

A. Application: complex geometries, flat surfaces, equipment insulation; where thin profile and low λ are needed.

B. Standard: EN 13165.

C. Material: rigid closed-cell PUR/PIR foam; λ ≤ 0.028 W/(m·K) at 10°C; fire class **B-s2,d0** minimum.

D. Form: factory-made pipe sections or boards with factory facings; spray-applied PUR only where noted on drawings.

E. Finishing: aluminium foil facing or aluminium sheet cladding; no exposed foam permitted in finished spaces.

2.5 CELLULAR GLASS (CG) INSULATION

A. Application: pipes in contact with soil or embedded in concrete (pre-insulated systems excluded); cryogenic service.

B. Standard: EN 13167.

C. Material: closed-cell glass foam; λ ≈ 0.038 W/(m·K) at 10°C; **completely vapour-proof** (μ = ∞); fire class **A1**.

D. Joining: bitumen or hot-applied adhesive; joints staggered; sealed with bituminous mastic.

2.6 DUCTWORK INSULATION

A. Supply air ducts in unconditioned spaces: 50 mm mineral wool blanket, foil-faced, secured with pins and speed-clips at 300 mm centres; seams sealed with aluminium tape.

B. Return and exhaust ducts (unconditioned): 25 mm mineral wool blanket, foil-faced.

C. Chilled-water supply ducts / supply air in humid zones: 25 mm FEF sheet, all seams glued; vapour barrier maintained.

D. Fire-rated ducts: ductwork in fire shafts shall have non-combustible (A1 class) insulation; verify fire resistance period required with fire engineer.

E. Duct casing – external: apply insulation after leak test; use self-adhesive FEF or MW blanket with aluminium facing; cladding with 0.6 mm aluminium sheet in mechanical rooms.

2.7 VALVE AND FITTING INSULATION

A. Insulate valve bodies, flanges, and fittings with removable / reusable insulation jackets (soft fabric-covered PUR) on valves DN ≥ 50.

B. Smaller fittings (elbows, tees, DN < 50): preformed FEF or PUR mitre-cut sections; glued and taped; no gaps.

C. Leave valve stems, actuators, and gauge connections accessible; do not insulate over handwheels or actuators.

D. Safety valve bodies and discharge pipes: not insulated; leave bare for visual inspection.

2.8 CLADDING AND FINISHES

A. Aluminium sheet cladding: 0.6 mm thickness; smooth or corrugated; secured with stainless steel banding.

B. Self-adhesive aluminium foil tape: minimum 50 mm wide; for sealing FEF and MW joints in plant rooms.

C. PVC cladding: permitted in dry, unexposed locations only; not for outdoor or high-humidity applications.

D. Outdoor service: use aluminium cladding or GRP jacketing; seal all seams with silicone sealant to prevent water ingress.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Install insulation only after piping and ductwork have been pressure-tested, cleaned, and accepted.

B. Pipe surface must be clean, dry, and free of corrosion before insulation is applied.

C. Ambient temperature during application: FEF adhesive above +10°C; MW not below –5°C.

3.2 INSTALLATION – PIPING INSULATION

A. Install pre-formed pipe sections with longitudinal seam on the upper quadrant or on opposite sides for symmetry; glue all seams continuously.

B. Butt joints: staggered 100 mm minimum from pipe fittings and hangers; sealed with adhesive and tape.

C. Hangers: use over-insulation hangers or pre-insulated support shields; do not compress insulation at support points.

D. Penetrations: seal annular space between insulation and sleeve with mineral wool packing (hot pipes) or FEF with vapour-barrier sealant (cold pipes).

E. Flanges: insulate after pressure test; removable boxes or split shells acceptable at flanges requiring periodic maintenance access.

F. Continuity: insulation shall be continuous through hangers, sleeves, and penetrations; no thermal bridges.

3.3 VAPOUR BARRIER INTEGRITY (COLD PIPE)

A. All cold-pipe insulation is a **vapour barrier system**: any puncture, gap, or bridged seam will cause condensation and insulation failure.

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B. Pipe hangers: use hanger inserts (same material, same or greater density) glued into the insulation; no metal-to-pipe contact through insulation.

C. End caps: install manufacturer-approved end caps at valves, flanges, and equipment connections; no raw foam exposed.

D. After insulation complete: inspect under raking light for surface imperfections; repair any visible defects before cladding.

3.4 DUCTWORK INSULATION

A. Install insulation after ductwork leak test (Section 233113); start at AHU connections and work toward terminals.

B. Secure blanket insulation with mechanical pins at maximum 300 mm grid; apply before adhesive sets.

C. Seal all seams, corners, and overlaps with 75 mm aluminium tape; apply with roller for full adhesion.

D. Finish exposed ductwork insulation in plant rooms with aluminium sheet cladding; snap-lock or S-joint seams.

3.5 FIELD QUALITY CONTROL

A. Thickness verification: sample-check insulation thickness at 10% of all pipe segments; measure with calibrated pin probe; record results.

B. Vapour barrier inspection: inspect all cold-pipe insulation seams with damp-test kit or visual inspection in humid conditions after 48 hours; no condensation on surface permitted.

C. Thermal imaging (optional): infrared survey of insulated piping at design conditions to verify no thermal bridges.

D. Submit field quality control report listing checked locations, measured thicknesses, and any deficiencies corrected.

3.6 PROTECTION AND LABELING

A. Where insulated pipes are subject to mechanical damage (floor level, accessible areas): protect with 1.5 mm aluminium sheet or GRP jacket.

B. Label insulated pipes per Section 232113 colour coding; apply labels over outer cladding, not directly on insulation.

END OF SECTION 230716

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SECTION 230900
INSTRUMENTATION AND CONTROLS FOR HVAC

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232123 – Hydronic Pumps
3. Section 237300 – Air Handling Units
4. Section 238143 – Air-Source Heat Pumps
5. Section 238216 – Fan-Coil Units
6. Section 230519 – Meters and Gauges for HVAC Piping
7. Section 260518 – Low-Voltage Electrical Power Conductors and Cables

1.2 SUMMARY

A. Scope: Design, supply, install, program, commission, and demonstrate the complete Building Automation and Control System (BACS) for all HVAC systems.

B. BACS functional scope:

1. DDC (Direct Digital Control) field controllers for all AHUs, pumps, heat pumps, fan-coil units
2. Central supervisor workstation and BMS server
3. Sensor and actuator networks (wired and/or wireless)
4. Alarms, trending, scheduling, and energy monitoring
5. BACnet/IP integration to client's enterprise network and BACnet MS/TP field bus
6. Integration of legacy Modbus RTU/TCP field devices where BACnet is unavailable

C. BACS efficiency class: minimum **Class B** per EN 15232-1; Class A where noted.

1.3 DEFINITIONS

A. DDC controller: Direct Digital Controller; microprocessor-based unit executing control sequences and communicating via open protocols.

B. BMS (Building Management System): supervisory software layer; collects data, handles alarms, provides graphical user interface.

C. BACnet: open communication protocol per EN ISO 16484-5 / ASHRAE 135; used for supervisor-to-controller and controller-to-controller communication.

D. Modbus RTU/TCP: open serial/TCP protocol (IEC 61158/61784); accepted as legacy alternative for field devices that do not support BACnet; full register map required.

E. SCOP/SEER: seasonal efficiency indicators per EN 14825; BMS shall record and display energy data enabling calculation.

F. PID: Proportional–Integral–Derivative control loop; standard control algorithm for temperature, pressure, and flow regulation.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
EN ISO 16484-2	BACS – hardware (BACnet/IP, BACnet MS/TP)
EN ISO 16484-5	BACS – data communication protocol (BACnet)
ASHRAE 135	BACnet communication protocol
IEC 61158	Industrial communication networks – fieldbus (Modbus)
IEC 61784	Communication profile families – Modbus RTU/TCP

EN 15232-1	Energy performance – impact of BACS (efficiency classes A–D)
EN 12098-1	Controls for heating systems – electronic optimisers
EN 14511	Rating of heat pumps and chillers – test conditions
EN 60730-1	Automatic electrical controls – general requirements
EN 60870-5-104	Telecontrol equipment and systems
EN 61000-4	EMC immunity – ESD, radiated, conducted
EN 60529	IP protection rating
EIA-485	RS-485 electrical standard for Modbus RTU
EN 15500-1	Electronic individual zone control equipment – HVAC
CEI 64-8	Electrical systems – user installations (≤ 1000 V)
UNI EN 60364	Electrical systems in buildings (series)
CEI EN 60529	Degrees of protection (IP rating)
IEC 61158 / 61784	Modbus RTU/TCP fieldbus
ASHRAE 135	BACnet communication protocol
EIA-485	RS-485 electrical interface standard
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act
D.P.R. 380/2001	Consolidated Building Code

1.5 SUBMITTALS

A. System Architecture Drawing: showing all controllers, network segments, field devices, and communication protocols.

B. Point List (I/O Schedule): complete list of all physical and virtual points; tag, description, controller, I/O type, range, engineering units.

C. Control Sequences (Sequence of Operations): narrative and/or logic diagrams for each controlled system.

D. Modbus Register Maps: for every field device (heat pumps, fan-coil controllers, VFDs, energy meters); including data types, scaling, and polling intervals.

E. BACnet Object List: for BACnet-capable devices; BTL certification or PICS document.

F. BMS Graphic Screens (draft): floor plans and system diagrams showing all monitored points.

G. Commissioning Plan: describing point-by-point checkout, loop tuning, alarm testing, and network performance testing.

H. O&M Manual: including system architecture, controller programming backup, user guide, and maintenance schedule.

1.6 QUALITY ASSURANCE

A. DDC controllers shall comply with **EN 60730-1** (automatic electrical controls).

B. BACnet devices shall carry **BTL (BACnet Testing Laboratories)** certification or equivalent EU conformity; PICS document required.

C. Modbus devices shall include factory-tested register map; provide evidence of field device interoperability.

D. BACS contractor shall have minimum **5 years** experience with BACnet systems of comparable size.

E. Installation by qualified electricians; certification per **D.M. 37/2008** where applicable.

F. EMC: all control equipment shall meet EN 61000-4 immunity requirements.

1.7 WARRANTY

A. Hardware: **1 year** from Substantial Completion; software updates: **1 year** included.

B. On-call support response: maximum 4 hours for BMS server failure; 8 hours for field controller replacement.

PART 2 – PRODUCTS

2.1 DDC FIELD CONTROLLERS

A. General-purpose controllers (GPC): for AHUs, heat pumps, pump stations; minimum 16 universal inputs (UI), 8 binary outputs (BO), 8 analogue outputs (AO).

1. Power supply: 24 VAC or 24 VDC; voltage range ±15%
2. Communication: BACnet MS/TP (RS-485) + optional BACnet/IP Ethernet port
3. Modbus RTU master port: RS-485, supporting ≥ 32 slave devices per port
4. On-board memory: stores at least 24 hours of point trend data independently of supervisor
5. Operating temperature: 0–55°C; humidity 10–90% RH non-condensing
6. Protection: IP30 minimum; DIN-rail or panel-mount

B. Zone / Room controllers (VAV/FCU): compact DDC for individual fan-coil units or VAV boxes; BACnet MS/TP or Modbus RTU communication.

C. Programmable logic: controllers shall be freely programmable (IEC 61131-3 or graphical tool); control sequences not locked into firmware.

2.2 BMS SUPERVISOR AND SERVER

A. Software: open BACnet/IP supervisor; certified for ASHRAE 135 / EN ISO 16484-5; graphical SCADA-style interface.

B. Server hardware: industrial PC or virtual machine; UPS-backed; RAID storage for trend data (minimum 3 years at 5-minute intervals).

C. Database: SQL or equivalent; exportable to CSV/Excel for energy reporting.

D. Alarm management: configurable alarm priorities; email/SMS notification; acknowledgement logging with user and timestamp.

E. Trending: all analogue points trended at minimum 15-minute intervals; all alarms logged with timestamp.

F. Scheduling: time-based and calendar-based scheduling for all equipment; holiday programme.

G. Energy dashboard: display and report kWh, COP/SCOP, degree-days, heating/cooling energy by system.

H. Remote access: HTTPS web browser access (TLS 1.2 or higher); role-based user permissions.

2.3 SENSORS

A. Temperature sensors:

1. Duct and pipe immersion: Pt100 or Pt1000; accuracy ±0.3°C at 20°C; range –30 to +150°C
2. Room sensors: Pt1000 combined with humidity and optional CO_2; accuracy ±0.5°C
3. Outdoor sensors: Pt100; radiation shield; IP54 enclosure

B. Humidity sensors: capacitive thin-film; accuracy ±3% RH at 20°C; range 0–100% RH; duct or room mount.

C. CO_2 sensors: NDIR dual-beam; range 0–2000 ppm; accuracy ±50 ppm + 3% of reading; auto-calibration (ABC).

D. **Pressure differential transmitters:** 4–20 mA output; silicon membrane; accuracy 0.25% FS; ranges: 0–500 Pa (duct), 0–200 kPa (hydronic).

E. **Flow switches (duct/pipe):** paddle or differential pressure type; adjustable set point; Form C relay output; IP54.

2.4 ACTUATORS

A. **Damper actuators:** 24 VAC/VDC or 230 VAC; spring-return (fail-safe) or non-spring; torque sized for damper area + 25% margin; 0–10 V position feedback.

B. **Modulating valve actuators:** 24 VAC/VDC; 0–10 V or 4–20 mA command; spring-return fail-safe open or closed as noted; position feedback 0–10 V.

C. **On/Off valve actuators:** 24 VAC/VDC; spring-return; running time ≤ 120 s for full stroke; auxiliary switch for BMS feedback.

D. **VFD (Variable Frequency Drive) integration:** all pump and AHU fan VFDs shall communicate via **BACnet/IP or BACnet MS/TP** as the standard protocol; Modbus RTU accepted as legacy alternative. BMS reads speed, current, fault status, and energy.

2.5 BACnet/IP FIELD INTEGRATION

A. **BACnet/IP is the standard field protocol** per ASHRAE 135 / EN ISO 16484-5. All field devices (DDC controllers, FCU controllers, VFDs, heat pumps, AHUs) shall support BACnet/IP natively or via BACnet MS/TP gateway.

B. **BACnet/IP:** Ethernet 10/100 Mbps; RJ-45; each device as unique BACnet Device with configurable Device Instance; services: ReadProperty, WriteProperty, SubscribeCOV, Who-Is, I-Am, ReadPropertyMultiple.

C. **BACnet MS/TP (RS-485 alternative):** where Ethernet is not available at field device level; baud rate 76 800 or 38 400 bps; daisy-chain topology; 120 Ω termination at bus ends; max 32 devices per segment; max 1 200 m segment length.

D. **Modbus RTU/TCP (legacy integration):** permitted for existing field devices or where BACnet is not available from the manufacturer; Modbus RTU on RS-485 (EIA-485); 9600–19200 baud; 8N1 frame; address 1–247; Modbus TCP port 502; FC01–FC04, FC06, FC16; polling ≤ 10 s critical, ≤ 60 s trend.

NOTE: The table below is a representative data point list. In BACnet implementations these map to BACnet objects; in Modbus implementations to register addresses. Final object lists / register maps are submitted by the BACS contractor during shop drawing review.

Parameter	BACnet Object / Modbus Reg.	R/W	Notes
Room Temperature	AI-1 / HR 40001	R	BACnet AI present_value °C; Modbus °C × 10
Setpoint – Heating	AV-1 / HR 40002	R/W	BACnet AV °C; Modbus °C × 10
Setpoint – Cooling	AV-2 / HR 40003	R/W	BACnet AV °C; Modbus °C × 10
Operating Mode	MV-1 / HR 40004	R/W	BACnet Multi-state Value (1=Off, 2=Heat, 3=Cool, 4=Auto, 5=Vent); Modbus equivalent
Fan Speed Command	MV-2 / HR 40005	R/W	BACnet MV (1=Auto, 2=Low, 3=Med, 4=High, 5=Max); Modbus equivalent
Supply Air Temperature	AI-2 / HR 40006	R	BACnet AI °C; Modbus °C × 10
Return Air Temperature	AI-3 / HR 40007	R	BACnet AI °C; Modbus °C × 10
Outdoor Temperature	AI-4 / HR 40008	R	BACnet AI °C; Modbus °C × 10 (from

			weather station)
Pump 1 Run Status	BI-1 / DI 10001	R	BACnet BI (0=Off, 1=Run); Modbus equivalent
Pump 1 Start/Stop	BO-1 / CO 00001	R/W	BACnet BO (0=Stop, 1=Start); Modbus equivalent
Pump 1 Fault	BI-2 / DI 10002	R	BACnet BI (0=OK, 1=Fault); Modbus equivalent
Chiller/HP Enable	BO-2 / CO 00002	R/W	BACnet BO (0=Off, 1=Enable); Modbus equivalent
Chiller/HP Fault	BI-3 / DI 10003	R	BACnet BI (0=OK, 1=Fault); Modbus equivalent
Valve Position – Zone 1	AO-1 / HR 40010	R/W	BACnet AO 0–100%; Modbus equivalent (0–10V)
ΔP Pump	AI-5 / IR 30001	R	BACnet AI kPa; Modbus kPa × 10
Energy Meter	AI-6 / IR 30002	R	BACnet AI kWh totalised; Modbus integer kWh
CO_2 Level – Zone 1	AI-7 / IR 30003	R	BACnet AI ppm; Modbus ppm
Alarm Status	BI-4…BI-n / HR 40020	R	BACnet: discrete BI per alarm; Modbus: bitmask (b0=highT, b1=lowT, b2=highP…)
BMS Date/Time Sync	AV-3 / HR 40030	W	BACnet: DateTime property of Device object; Modbus: EPOCH seconds (32-bit, 2 regs)
Software Version	CSV-1 / IR 30100	R	BACnet CharacterString Value; Modbus packed e.g. 0105 = v1.5

2.6 WIRING AND NETWORK CABLING

A. BACnet/IP cable (primary): Cat6 UTP or F/UTP; in dedicated metallic conduit, separate from power cables; connect to building LAN or dedicated BACnet VLAN.

B. BAS / BACnet MS/TP cable (RS-485): single-pair shielded twisted-pair instrumentation cable, AWG 22 (≈ 0.33 mm² conductor), low-capacitance construction (≤ 50 pF/m between conductors), characteristic impedance 100–120 Ω, with foil + braid shield and drain wire, suitable for RS-485 / BACnet MS/TP service — **unless otherwise specified by the equipment manufacturer**; drain shield bonded at one end only (at the BMS supervisor end); maximum segment length 1 200 m per RS-485 standard.

C. Modbus RTU cable (legacy): same specification as the BAS / BACnet MS/TP cable above.

D. Sensor wiring: shielded 2-wire for Pt100/1000; shielded twisted pair for 4–20 mA transmitters; segregate from 230 VAC wiring throughout.

E. All field control wiring in metallic conduit or trunking; see Section 260534.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify mechanical and electrical installations are complete before installing controls.

B. Confirm correct location of all sensor tapping points per approved shop drawings.

C. Report missing tapping points or incorrect sensor locations to COR before proceeding.

3.2 INSTALLATION – GENERAL

A. Mount DDC controllers in dedicated control panels or in equipment-integrated panels; panels IP54 minimum in plant rooms.

B. Label all terminals, cables, and field devices with permanent wire markers matching the I/O point list.

C. Provide DIN rail terminal blocks for all field wiring terminations; no wiring directly to controller terminals in accessible locations without terminals.

D. Install all sensor wells (temperature), pressure tappings, and flow switches per manufacturer instructions; verify correct orientation.

3.3 COMMISSIONING

A. Point-by-point checkout: verify every physical I/O point by simulation or physical actuation before loading final control sequences.

B. Control loop tuning: tune all PID loops under normal operating conditions; record P/I/D parameters in commissioning report.

C. Alarm testing: trigger each alarm condition and verify correct alarm message, priority, and notification.

D. Setback/scheduling test: verify heating setback, night cooling, and holiday mode operate correctly.

E. Modbus integration test: confirm all Modbus slave devices respond; verify register values match physical measurements.

F. BACnet integration test: verify all objects appear correctly in supervisor; trend all key points for 48 hours before handover.

G. Energy metering: confirm kWh data is being logged and is exportable.

3.4 TRAINING

A. Provide minimum **8 hours** of on-site operator training; include: system overview, daily operation, alarm response, manual override, and scheduling.

B. Provide minimum **4 hours** of engineer-level training for BMS maintenance and programming.

C. Training materials: printed and digital manuals; video recording of training session (where client agrees).

3.5 DOCUMENTATION AT HANDOVER

A. Submit complete as-built point list (I/O schedule).

B. Submit controller programme backup files (all versions).

C. Submit BMS graphic screen files and database backup.

D. Submit signed commissioning reports for all systems.

E. Submit O&M manual in both printed and digital (PDF) format.

END OF SECTION 230900

SECTION 232113
HYDRONIC PIPING

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Applicable Italian and European standards listed in the Standards Table are incorporated herein by reference. Where conflicts exist, the more stringent requirement shall govern.

C. Related Sections:

1. Section 230523 – General-Duty Valves for HVAC Piping.
2. Section 230529 – Hangers and Supports for HVAC Piping and Equipment.
3. Section 230716 – HVAC Thermal Insulation.
4. Section 230553 – Identification for HVAC Systems.
5. Section 232116 – Hydronic Specialties.
6. Section 232123 – Hydronic Pumps.
7. Section 336316 – Pre-Insulated Underground Piping Systems.

Key Applicable Standards	
UNI EN ISO 21003	Multilayer piping systems for hot and cold water
UNI EN 10255	Non-alloy steel tubes – threaded ends
UNI EN 10217-1	Welded steel tubes for pressure purposes – non-alloy steel
UNI EN 10216-1	Seamless steel tubes for pressure purposes – non-alloy steel
UNI EN ISO 1127	Stainless steel tubes – dimensions and tolerances
UNI EN 10217-7	Welded stainless steel tubes for pressure purposes
UNI EN 1057	Copper and copper alloys – seamless round copper tubes
UNI EN ISO 4427	Plastics piping systems – PE pipes for water supply (PE, HDPE, PEAD)
UNI EN 13480	Metallic industrial piping – pressure piping series
EN 1092-1	Flanges and their joints – steel flanges
EN 10242	Threaded pipe fittings in malleable cast iron
EN 1254-1/2	Copper and copper alloy fittings – compression and capillary
EN 1514-1	Flanges and their joints – gaskets
ISO 228-1	Pipe threads – dimensions and tolerances (Rp/BSPP)
ISO 7-1	Pipe threads for pressure-tight joints (Rc/R)
UNI EN 14336	Heating systems – installation and commissioning
UNI EN 12828	Heating systems in buildings – design
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005	Energy performance of buildings
Dir. 2014/68/UE (PED)	Pressure equipment

1.2 SUMMARY

A. Section Includes:

1. Multilayer composite piping (PE-RT/Al/PE-RT or PE-X/Al/PE-X), including standard and full-bore systems.
2. Galvanized steel piping.
3. Black steel piping.
4. Stainless steel piping.
5. Copper piping.
6. Polyethylene piping (PE / HDPE / PEAD).
7. Fittings, joints, gaskets, and flanges for all piping materials.
8. Pressure testing and commissioning of hydronic piping systems.

B. Applications: heating, cooling, and combined hydronic distribution systems for HVAC, operating with water or water-glycol mixtures.

1.3 DEFINITIONS

A. Hydronic Piping: Closed-circuit piping systems conveying heated or chilled water for HVAC terminal units and air-handling equipment.

B. Multilayer Composite Pipe: Three-layer pipe consisting of an inner plastic layer (PE-RT or PE-X), an aluminium interlayer bonded with adhesive, and an outer plastic layer (PE-RT or PE-X), per EN ISO 21003.

C. Full-Bore Fitting: A fitting whose internal bore at the connection point equals or exceeds the internal bore of the pipe, producing no flow restriction at the joint. Required for all multilayer piping with internal diameter exceeding 26 mm (DN > 26 internal).

D. DN: Nominal diameter. Unless otherwise stated, DN refers to the **internal (bore) diameter** for multilayer piping, and to the nominal pipe size per applicable EN standard for steel and copper.

E. MWP: Maximum Working Pressure, as rated for the piping system.

F. PED: Pressure Equipment Directive 2014/68/EU.

1.4 ACTION SUBMITTALS

A. Product Data: For each pipe material and fitting type:

1. Manufacturer's data sheets, certifications, and dimensional tables.
2. Pressure-temperature rating curves at design operating conditions.
3. For multilayer piping: confirmation of full-bore compliance for all fittings used on pipes with internal diameter > 26 mm, with bore measurement data.
4. Material compliance certificates per applicable EN standard.
5. Jointing method and installation instructions, including tool calibration records for press-fit systems.

B. Shop Drawings: Piping layout plans and sections at 1:50 minimum scale, indicating pipe sizes, materials, slopes, drain and vent points, expansion loops, and anchor/guide locations.

C. Coordination Drawings: BIM or 2D drawings coordinating piping with structure, ductwork, electrical conduit, and architectural elements; issued before rough-in.

D. Welding Qualifications: Welding procedure specifications (WPS) and welder qualification records per EN ISO 15614-1 for steel piping.

1.5 INFORMATIONAL SUBMITTALS

A. CE Declaration of Conformity per PED 2014/68/EU for all pressure piping and fittings where applicable.

B. Material test certificates (EN 10204 type 2.2 minimum, type 3.1 for PED-category II and above) for steel and copper piping.

C. Pressure test reports, signed by installer and witnessed by Owner's representative.

D. As-built piping drawings, updated to reflect installed conditions, submitted within 30 days of system commissioning.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Piping and fitting manufacturers shall be ISO 9001 certified and hold third-party certification for the applicable product standard (EN ISO 21003, EN 10255, EN 1057, etc.).

B. Installer Qualifications: Hydronic piping installer shall hold valid license per D.M. 37/2008 for thermal/hydraulic building systems and demonstrate experience on at least three comparable projects in the past five years.

C. Press-Fit Tool Certification: Contractors using press-fit jointing systems shall use tools certified and calibrated by the fitting manufacturer. Tool calibration records shall be available on request.

D. Welding: All welding on steel piping shall be performed by qualified welders per EN ISO 9606-1 and to qualified procedures per EN ISO 15614-1.

E. Regulatory Compliance: All piping systems shall comply with D.M. 37/2008, D.Lgs. 192/2005 and s.m.i., and PED 2014/68/EU as applicable to the operating pressure and temperature.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver piping in original manufacturer's packaging or bundled with end caps in place. Inspect for damage on delivery.

B. Store piping horizontally on level supports at maximum 1.5 m spacing, off the ground. Protect from UV radiation (multilayer and PE piping), mechanical damage, and contamination.

C. Protect pipe ends with factory-supplied caps or field-installed plugs at all times until connection.

D. Do not use damaged or kinked multilayer piping; kinking causes permanent delamination of the aluminium layer.

1.8 WARRANTY

A. Multilayer Piping System: Minimum ten (10) years manufacturer's system warranty covering pipe, fittings, and jointing method against defects in materials and workmanship, when installed with the manufacturer's approved tools and fittings.

B. Steel, Copper, and Stainless Piping: Minimum one (1) year manufacturer's warranty against defects in materials and workmanship.

PART 2 – PRODUCTS

2.1 GENERAL PIPING REQUIREMENTS

A. Design Conditions: Unless otherwise noted on drawings, piping systems shall be rated for:

1. Maximum working pressure (MWP): 10 bar (1 000 kPa).
2. Maximum operating temperature: 95 °C for heating circuits; 25 °C for chilled water circuits.
3. Minimum operating temperature: 2 °C (non-freeze conditions); -10 °C for systems with glycol mixture as indicated.

B. Water-Glycol Mixtures: Where antifreeze protection is required, piping materials, fittings, and seals shall be compatible with ethylene glycol or propylene glycol solutions up to 40% by volume. Confirm compatibility with pipe and fitting manufacturer.

C. Pipe Sizing: Internal diameters and wall thicknesses shall be selected per the project hydraulic design. Default velocity limits (where not otherwise specified on drawings): **1.5 m/s** in distribution mains and **2.0 m/s** in terminal-unit connections (typical comfort/noise-sensitive applications); up to **2.5 m/s** acceptable in large plant-room mains DN ≥ 150 where pressure drop optimisation governs and noise is not a concern (CIBSE Guide C). Velocities ≤ 1.0 m/s permitted for low-flow trim circuits. In all cases verify Reynolds number, noise generation, and erosion–corrosion limits for the selected pipe material.

D. Slope: All horizontal piping shall be installed with a minimum slope of 3 mm per metre toward low points (drain valves) and rising toward high points (automatic air vents), unless otherwise indicated.

E. Pipe Material Selection: Use the material specified on the drawings for each system and location. Where no material is specified, the following hierarchy applies:

1. Concealed indoor distribution up to DN 50 (internal ≤ 50 mm): multilayer composite.
2. Exposed or plant-room distribution: black steel or galvanized steel as indicated.
3. Fan-coil unit and terminal connections: multilayer composite or copper.
4. Underground service: PE / HDPE / PEAD or pre-insulated (see Section 336316).

2.2 MULTILAYER COMPOSITE PIPING

A. Standard: UNI EN ISO 21003-2 (pipe) and UNI EN ISO 21003-3 (fittings). System class 2 (95 °C / 10 bar) as minimum, or class 5 (95 °C / 10 bar) where indicated.

B. Construction:

1. Inner layer: PE-RT (polyethylene of raised temperature resistance) or PE-X (crosslinked polyethylene), per EN ISO 21003.
2. Intermediate layer: aluminium tube, butt-welded or overlap-welded, bonded to inner and outer layers with compatible adhesive.
3. Outer layer: PE-RT or PE-X, colour-coded per manufacturer's system (typically blue for cold, red for hot).

C. Pressure-Temperature Rating:

1. Minimum: 10 bar at 95 °C continuous service.
2. Test pressure per EN ISO 21003: 1.5× MWP, minimum 15 bar, for 1 hour with no leakage or permanent deformation.

D. Full-Bore Requirement for DN > 26 (Internal):

1. For all multilayer pipes with an **internal diameter exceeding 26 mm**, only **full-bore** fitting systems shall be used.
2. Full-bore fittings shall have an internal bore at the pipe connection equal to or greater than the internal bore of the connected pipe, with no restriction ring, insert, or sleeve reducing the flow cross-section.
3. Standard compression or insert fittings that reduce the internal bore are **not permitted** for pipe sizes with internal diameter > 26 mm.
4. Acceptable full-bore jointing systems: manufacturer's press-fit full-bore fittings (e.g. with EPDM or HNBR O-ring seal) or approved equivalent, confirmed in writing by the COR prior to procurement.

5. For pipe with internal diameter ≤ 26 mm, standard press-fit or compression fittings with internal support sleeve are permitted.

E. Bending: Minimum bending radius per manufacturer's data. Use spring bender or mandrel for cold bending; do not heat multilayer pipe for bending.

F. Expansion: Compensate for thermal expansion with manufacturer-calculated expansion loops, lyres, or axial compensators. Do not rely on changes of direction alone without calculation.

G. Oxygen Diffusion Barrier: All multilayer pipe used in closed heating circuits shall incorporate an oxygen diffusion barrier layer (EVOH or equivalent) per EN ISO 21003, to prevent corrosion of system components.

H. Marking: Each pipe length shall bear permanent factory marking at intervals ≤ 1 m indicating: manufacturer, standard, dimension (OD × wall), material, system class, and production date.

2.3 GALVANIZED STEEL PIPING

A. Standard: UNI EN 10255 (medium series minimum), hot-dip galvanized per EN ISO 1461 inside and outside.

B. Application: Domestic cold water service, make-up water lines, compressed air distribution, and other non-return-water services as indicated. **Not permitted** for closed heating circuits with water temperature above 60 °C (risk of zinc dissolution and system contamination).

C. Joints:

1. DN ≤ 50: screwed joints with ISO 7-1 taper threads (Rc/R), PTFE tape or anaerobic thread sealant; malleable iron fittings per EN 10242, hot-dip galvanized.
2. DN > 50: flanged joints per EN 1092-1, PN16; or grooved mechanical couplings of a recognised manufacturer.

D. Cutting and Threading: Cut with pipe cutter or hacksaw; ream cut ends. Thread with machine-cut threads per ISO 7-1; apply zinc-rich paint or cold galvanizing compound to all cut, threaded, and abraded surfaces.

2.4 BLACK STEEL PIPING

A. Standard: UNI EN 10255 (medium or heavy series) for screwed applications; UNI EN 10217-1 or UNI EN 10216-1 for welded applications.

B. Application: Primary heating and cooling distribution mains, plant-room piping, and all applications where welded construction is required or where temperatures exceed 60 °C.

C. Minimum Wall Thickness: Per EN 10255 medium series for DN ≤ 100; schedule per EN 10217-1 for DN > 100, selected for MWP with safety factor ≥ 1.5 per EN 13480.

D. Joints:

1. DN ≤ 50: screwed (ISO 7-1) or socket-weld; butt-weld also acceptable at all sizes.
2. DN > 50: butt-welded (preferred), flanged PN16 per EN 1092-1, or grooved mechanical couplings where dismantling is required.
3. Welding: continuous fillet or butt weld per EN ISO 15614-1; full penetration on pipes DN > 50 or MWP > 6 bar.

E. Surface Treatment: Factory or field-applied rust-inhibiting primer (two coats minimum) on all exterior surfaces not subsequently insulated. Interior surfaces: clean and free of mill scale, oil, and debris before system filling.

F. Dielectric Isolation: Install dielectric unions or flanges at all connections between steel and copper piping to prevent galvanic corrosion.

2.5 STAINLESS STEEL PIPING

A. Standard: UNI EN ISO 1127 (seamless) or UNI EN 10217-7 (welded), grade AISI 304 (1.4301) as minimum; AISI 316L (1.4404) where indicated or for chemically treated water systems.

B. Application: Chilled water systems, solar thermal, chemical water treatment circuits, food-grade or sanitary applications, and any location where corrosion resistance superior to carbon steel is required.

C. Joints:

1. Press-fit fittings with EPDM (heating/cooling) or HNBR (oil-resistant) O-ring seals; fittings per EN ISO 1127 or manufacturer's system standard.
2. Orbital or TIG butt-weld (preferred for DN > 54 or MWP > 6 bar); full penetration, purged with argon backing gas.
3. Flanged PN16 per EN 1092-1 for dismantling points.

D. Passivation: After installation and pressure testing, flush and passivate system per ASTM A380 or equivalent procedure; obtain manufacturer's recommendation in writing.

2.6 COPPER PIPING

A. Standard: UNI EN 1057, half-hard (R250) or hard (R290); minimum wall thickness Table X or Y as appropriate for operating pressure.

B. Application: Fan-coil unit connections, induction unit connections, terminal piping in concealed ceiling voids, and other applications as indicated.

C. Joints:

1. Capillary brazed (preferred): silver-phosphorus alloy (CP105 or equivalent per EN 1044); fittings per EN 1254-1.
2. Compression fittings per EN 1254-2: permitted for DN ≤ 28 in accessible locations only.
3. Press-fit fittings per EN 1254-2 with EPDM or HNBR O-ring: acceptable at all accessible sizes.
4. Soldered joints (tin-lead solder) are **not permitted** in potable water or heating systems above 110 °C.

D. Bending: Use proprietary bending spring or machine; minimum bending radius 3.5× OD for hard tube, 2.5× OD for half-hard tube.

E. Dielectric Isolation: See Article 2.4 — install dielectric unions at all connections to ferrous piping.

2.7 PE / HDPE / PEAD PIPING

A. Standard: UNI EN ISO 4427-2 (PE 80 or PE 100); SDR rating selected for MWP with safety factor per EN ISO 4427.

B. Application: Underground cold water make-up and drainage service within building site boundary; above-ground service where UV-stabilized grade is specified and UV exposure is limited. Not for primary HVAC water distribution above ground unless specifically indicated.

C. Colour Coding: Black (with or without blue stripes for water service); manufacturer's standard.

D. Joints:

1. Electrofusion (EF) fittings per EN 12201-3: preferred for all buried service and DN > 63.
2. Butt fusion per EN 12201 for straight runs DN ≥ 90.
3. Mechanical compression fittings per EN 1254-3: permitted for above-ground accessible service DN ≤ 63.

E. Transition to Metal Piping: Use manufacturer-supplied PE-to-steel or PE-to-copper transition fittings; no direct threading of PE pipe.

2.8 FITTINGS, FLANGES, AND GASKETS

A. General: Fittings shall be compatible with the connected pipe material and rated for the same MWP and temperature as the pipe. Do not mix fitting systems from different manufacturers within the same piping system without written COR approval.

B. Malleable Iron Fittings (Steel Screwed Piping): EN 10242, hot-dip galvanized for galvanized piping; black for black steel.

C. Steel Flanges: EN 1092-1, PN16 as standard; raised face (type B) unless flat face (type A) required by connected equipment.

D. Gaskets: Full-face or ring-type EPDM, NBR, or PTFE-enveloped spiral-wound gaskets per EN 1514-1, selected for fluid and temperature service.

E. Copper Fittings: EN 1254-1 (capillary) or EN 1254-2 (compression/press-fit); matching pipe OD series.

F. Multilayer Fittings: Manufacturer's proprietary system fittings, compatible with pipe series; press-fit type strongly preferred. See Article 2.2 for full-bore requirements.

G. Dielectric Unions: Bronze body, rated PN16, suitable for 95 °C service; installed between all ferrous and non-ferrous pipe connections.

2.9 PIPE HANGERS AND SUPPORTS

A. Pipe hangers, supports, anchors, guides, and expansion devices shall comply with Section 230529 – Hangers and Supports for HVAC Piping and Equipment.

B. Multilayer piping shall be supported at maximum intervals per EN ISO 21003 and manufacturer's published data, accounting for operating temperature (reduced intervals at elevated temperature). Minimum support intervals at 95 °C are typically 60–70% of the cold-service interval; confirm with manufacturer.

C. Insulated piping shall be supported with insulation protection shields (saddles) of sufficient length to prevent compression of insulation at support points.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that rough-in sleeves, penetrations, and structural supports are correctly positioned before commencing installation.

B. Confirm that pipe materials, sizes, and pressure ratings shown on drawings match those delivered to site. Do not install substitute materials without written COR approval.

C. Inspect all pipe lengths and fittings for damage, corrosion, or defects; reject and replace any non-conforming items.

3.2 INSTALLATION — GENERAL

A. Install all hydronic piping per manufacturer's instructions, approved shop drawings, D.M. 37/2008, and applicable UNI EN standards.

B. Pipe Routing: Route piping as shown on drawings; maintain required clearances from electrical equipment (minimum 150 mm), structure, and other services. Avoid routing above electrical panels or switchgear.

C. Slope and Drainage: Pitch all horizontal runs ≥ 3 mm/m toward drain valves. Install automatic air vents at all system high points; drain valves (DN 20 minimum) at all low points.

D. Expansion: Account for thermal expansion in all piping materials. Install expansion loops, lyres, or axial compensators as shown on drawings. Fix anchors and guides per structural engineer's details.

E. Penetrations: Sleeve all piping through walls, floors, and ceilings with steel or PVC sleeves, minimum one pipe diameter larger than insulated pipe OD. Seal annular space with fire-stopping material per Section 078413 at fire-rated barriers; with flexible sealant elsewhere.

F. Isolation Valves: Install isolation ball valves at all branch take-offs, at all equipment connections, and at intervals not exceeding 30 m on distribution mains, to allow sectional isolation without draining the system.

3.3 INSTALLATION — MULTILAYER PIPING

A. Cut pipe square with a pipe cutter or fine-tooth saw; deburr and calibrate cut end with manufacturer's calibration/deburring tool before fitting assembly.

B. Full-Bore Systems (Internal DN > 26):

1. Assemble press-fit full-bore fittings using the manufacturer's calibrated press tool and jaw set. Verify jaw size matches pipe OD and fitting series.
2. Inspect O-ring position and condition before pressing; replace any damaged or displaced O-ring.
3. Unpressed fittings shall be identified with a waterproof marker and inspected before pressure testing; all fittings must be pressed before test.
4. Record press-tool serial number and calibration date in the commissioning log.

C. Standard Systems (Internal DN ≤ 26):

1. Install compression fittings by inserting the internal support sleeve fully into the pipe end before assembly.
2. Tighten compression nuts to manufacturer's specified torque; do not over-tighten.

D. Bending: Use appropriate bending spring, mandrel, or bending machine per manufacturer's minimum radius table. Do not apply heat. Discard any pipe showing kinks, white stress marks, or delamination.

E. Support Intervals at Operating Temperature: Follow manufacturer's temperature-corrected support table. At 70 °C, maximum support intervals are typically reduced by 20–30% from ambient-temperature values.

3.4 INSTALLATION — STEEL PIPING

A. Screwed Joints: Apply PTFE tape (minimum 3 wraps) or anaerobic thread sealant to male threads only; assemble to hand-tight plus 2–3 turns with pipe wrench. Do not use hemp or lead-based sealants.

B. Welded Joints: Tack-weld in at least four positions before completing root pass. Perform visual inspection of all welds; radiographic or ultrasonic testing where required by PED or as indicated on drawings.

C. Flanged Joints: Align flanges without forcing piping; insert all bolts before tightening. Tighten bolts in diametrically opposite sequence (cross-pattern) to uniform torque per EN 1591-1.

D. Galvanic Protection: Apply cold galvanizing compound or zinc-rich paint to all cut, threaded, and field-welded surfaces of galvanized piping immediately after working.

3.5 INSTALLATION — STAINLESS STEEL PIPING

A. Cleanliness: Handle, cut, and install stainless steel piping using tools dedicated exclusively to stainless steel. Do not use carbon steel wire brushes, grinding discs, or any tool previously used on carbon steel; ferrous contamination causes crevice corrosion.

B. Cutting: Orbital saw, plasma cutter, or fine-tooth hacksaw; remove all burrs and sharp edges with a stainless-dedicated deburring tool before fitting assembly.

C. Welding process: TIG (GTAW – Gas Tungsten Arc Welding) is the required process for all pressure-boundary welds on stainless steel HVAC piping. Orbital TIG is preferred for DN > 54 or for automated production runs. MIG/GMAW is permitted only for non-pressure structural attachments (anchor brackets, guides).

D. Filler material: ER308L for AISI 304 / 304L; ER316L for AISI 316 / 316L; matching or one grade higher in alloying content than base metal; per AWS A5.9 / EN ISO 14343.

E. Argon backing gas (purging): Mandatory for all pressure-boundary butt welds. Purge the pipe bore with 99.99% pure argon from weld start until completion and cooling to < 300 °C; maintain oxygen content ≤ 0.1% (1 000 ppm) measured at the purge outlet before striking arc. Welds made without purging, or showing internal oxidation ('sugaring'), shall be rejected and the pipe section replaced.

F. Welder qualification: Welders performing stainless steel pressure welds shall be qualified per EN ISO 9606-1 (process 141 – TIG; material Group 8 – austenitic stainless) for the applicable thickness range. Submit qualification records before commencing work.

G. Post-weld cleaning: Remove heat tint from the weld zone using a stainless-dedicated wire brush or approved pickling paste (citric or phosphoric acid base); neutralise completely and flush thoroughly with clean water.

H. Passivation: After pressure testing of each system section, passivate per ASTM A380 (citric acid preferred) or equivalent approved procedure; verify pH-neutral discharge before final system fill.

3.6 INSTALLATION — COPPER PIPING

A. Clean pipe and fitting surfaces with fine abrasive cloth and apply flux before brazing.

B. Braze with silver-phosphorus alloy (CP105 or equivalent); heat uniformly with propane/oxygen torch; apply filler at joint gap (not at torch point).

C. After brazing, remove flux residue by flushing with clean water; inspect all joints before insulating.

D. Do not apply flame directly to press-fit fittings or within 100 mm of previously assembled press joints.

3.7 FLUSHING AND CLEANING

A. Before connecting to system equipment (pumps, heat exchangers, boilers, chillers, fan coils), flush all piping with clean mains water at maximum available pressure until discharge runs clear, per BSRIA BG 29 or UNI EN 14336.

B. Install temporary strainers (mesh ≤ 0.8 mm) at all equipment inlet connections during flushing; clean after flushing and before final commissioning.

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C. For systems requiring chemical cleaning or passivation (black steel systems), perform chemical cleaning and neutralisation before introducing system water. Dispose of chemicals per applicable environmental regulations.

D. After flushing and prior to commissioning, dose system water with inhibitor and biocide per Section 232500 – HVAC Water Treatment.

3.8 FIELD QUALITY CONTROL — PRESSURE TESTING

A. Hydrostatic Pressure Test:

1. Test all completed piping systems hydrostatically at 1.5× MWP, minimum 10 bar (1 000 kPa), for not less than 60 minutes.
2. Isolate all equipment not rated for test pressure (pumps, expansion vessels, pressure relief valves, sensors) before testing.
3. Test medium: clean water, de-aerated where possible.
4. Accept/reject criterion: no visible leakage and pressure drop ≤ 0.1 bar over 60 minutes.
5. Record test pressure, duration, start/end pressure readings, date, and witness name; submit signed test report.

B. Multilayer Piping — Additional Test: After hydrostatic test, inspect all press-fit joints visually for deformation or O-ring extrusion. Any deformed fitting shall be replaced.

C. Pneumatic Test: Pneumatic pressure testing is permitted only where system cannot be filled with water (e.g., risk of frost damage); requires written approval from COR. Test pressure: 1.1× MWP maximum; safety precautions per EN 13480-5.

3.9 IDENTIFICATION

A. Identify all piping per Section 230553 – Identification for HVAC Systems.

B. Mark pipe material, fluid, flow direction, and pipe reference number at all branches, valves, penetrations, and at maximum 5 m intervals on straight runs.

C. Colour-code insulation jacketing or pipe identification bands per project colour schedule:

1. Heating supply: red / orange.
2. Heating return: red / orange with return stripe.
3. Chilled water supply: blue.
4. Chilled water return: blue with return stripe.
5. Make-up / domestic cold water: green.

END OF SECTION 232113

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SECTION 232116
HYDRONIC SPECIALTIES

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232123 – Hydronic Pumps
3. Section 232500 – HVAC Water Treatment
4. Section 230523 – General-Duty Valves for HVAC Piping
5. Section 238143 – Air-Source Heat Pumps

1.2 SUMMARY

A. Scope: Furnish and install all hydronic system accessories and specialties including expansion vessels, air separators, dirt separators, backflow preventers, filling stations, deaerators, and system fill/drain provisions.

B. Included items:

1. Closed diaphragm expansion vessels
2. Air separators and automatic air vents
3. Dirt separators and magnetic filters
4. Backflow preventers and filling groups
5. Pressure-relief safety valves (not covered in Section 230523)
6. System drain cocks, air vents, and commissioning connections
7. Flexible pipe connectors (anti-vibration hoses)

1.3 DEFINITIONS

A. Type BA backflow preventer: verifiable reduced-pressure-zone backflow preventer per EN 1717 / EN 13959; protects against fluid risk categories 3 and 4; consists of two independently-closing check valves and a middle zone maintained at lower pressure than supply; testable via four test cocks.

B. Fluid risk category (EN 1717): category 3 = fluid posing a slight health hazard (HVAC heating/chilling circuits with inhibitors); category 4 = fluid posing a significant health hazard; category 5 = toxic/radioactive. Category 3 and 4 circuits require minimum Type BA protection.

C. Filling station: pre-assembled unit connecting potable water supply to the closed HVAC circuit; includes isolation valves, Y-strainer, cartridge softener, Type BA backflow preventer, pressure reducer, and water meter.

D. Closed expansion vessel: pressure vessel with internal flexible diaphragm; accommodates thermal expansion of system water without opening to atmosphere; prevents dissolved oxygen ingress.

E. Microbubble deaerator: tangential-flow separator using velocity reduction to allow dissolved gas bubbles to coalesce and be vented; removes both free and dissolved air from circulating water.

F. Magnetic filter: in-line device using high-strength neodymium magnets to capture ferrous particles (magnetite, iron oxide) from circulating water; prevents boiler/heat exchanger fouling.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
EN 1717	Protection against pollution of potable water – backflow prevention requirements
EN 13959	Backflow prevention devices – Type BA – verifiable, reduced pressure zone
EN 1567	Pressure reducing valves – combined pressure reducing valves
EN 13831	Closed expansion vessels with built-in diaphragm for installation in water

EN 14868	Protection of metallic materials against corrosion – potable water
EN 12828	Heating systems in buildings – design of water-based heating systems
EN 14336	Heating systems in buildings – installation, commissioning, and operation
EN ISO 4126-1	Safety devices for protection against excessive pressure – safety valves
EN 1092-1	Flanges and their joints – PN-rated steel flanges
EN 10255	Steel tubes for screwed fittings
UNI 8065	Water treatment in HVAC thermal systems
D.M. 37/2008	Building systems – art. 1 lett. c (thermal plants)
D.M. 174/2004	Materials in contact with water intended for human consumption (potable water materials)
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act
D.P.R. 380/2001	Consolidated Building Code

1.5 SUBMITTALS

A. Product data: technical data sheets for all specialties; pressure, temperature, and volume ratings.

B. PED declarations: CE marking per Dir. 2014/68/UE for all pressure vessels (expansion vessels, separators).

C. Backflow preventer certification: EN 1717 / EN 13959 Type BA conformity; type approval certificate from accredited body; D.M. 174/2004 material compliance for DHW-connected devices.

D. Factory test records: hydraulic test certificates for expansion vessels.

E. Softener data: cartridge water softener technical data sheet; resin capacity and replacement schedule.

1.6 QUALITY ASSURANCE

A. All pressure vessels: CE marked per PED Directive 2014/68/UE; test certificate from Notified Body.

B. Backflow preventers: EN 1717 Type BA is mandatory for all connections between HVAC closed circuits and potable water supply, regardless of fluid risk category; annual test and certification required by qualified plumber.

C. DHW / potable water circuits: all materials in contact with potable water (backflow preventer body, seals, softener cartridge) shall comply with **D.M. 174/2004**; manufacturer's attestation required.

D. D.M. 37/2008: installation by licensed firm; filing of declaration of conformity (dichiarazione di conformità) with local authority.

1.7 WARRANTY

A. All items: **1 year** from Substantial Completion.

B. Expansion vessel diaphragm: **5 years** from date of manufacture.

PART 2 – PRODUCTS

2.1 CLOSED EXPANSION VESSELS

A. Standard: EN 13831; CE marked per PED 2014/68/UE.

B. Construction: carbon steel shell, factory-welded; butyl-rubber or EPDM diaphragm; pre-charged with nitrogen; replaceable diaphragm preferred for vessels > 80 L.

C. **Rating:** maximum allowable pressure (PS) ≥ circuit safety valve set pressure; minimum **6 bar**; temperature rating ≥ 120°C.

D. **Connection:** ¾" or 1" BSP threaded (vessels < 80 L); flanged PN16 for vessels ≥ 80 L.

E. **Pre-charge pressure:** factory-set to 0.5 bar below system static pressure; field-adjustable via Schrader valve.

F. **Sizing:** total acceptance volume calculated per EN 12828, Section 7; include 10% safety margin on calculated vessel size.

G. **Colour:** red RAL 3000 for heating circuits; blue RAL 5015 for chilled water circuits.

H. **Accessories:** isolating valve on vessel connection (full-bore ball valve PN16); filling valve for nitrogen re-charge; pressure gauge on vessel connection.

NOTE: Expansion vessel must be connected on the suction (low-pressure) side of circulation pumps, between pump suction and the system fill point. Incorrect location causes loss of static pressure control.

2.2 AIR SEPARATORS AND AUTOMATIC AIR VENTS

A. **Automatic microbubble deaerators:** tangential-flow or coalescing-media type; removes dissolved and free air from circulating water.

1. Body: cast iron or carbon steel, with internal coalescing media
2. Connection: screwed or flanged to match pipe size; sized for system flow velocity 0.3–1.0 m/s through separator
3. Air vent outlet: 3/8" or 1/2" BSP; connects to automatic float vent or manual ball valve to atmosphere
4. Drain: 1/2" BSP ball valve at base
5. Rating: PN16; 120°C

B. **Automatic air vents:** float-operated, self-sealing at pressure; install at all high points of circuit.

1. Body: brass; maximum pressure PN10; temperature ≤ 110°C
2. Install with isolating valve below vent (¼" ball valve) to allow replacement without drain-down
3. Use stainless steel float version for circuits above 90°C or with inhibitor concentrations > 20%

C. **Manual air vents:** coin-operated type at terminal units and radiators; not used on main distribution piping.

2.3 DIRT SEPARATORS AND MAGNETIC FILTERS

A. **Combination deaerator/dirt separator:** single unit combining microbubble deaeration and dirt separation; preferred for primary circuit of chiller and heat pump plants.

1. Capture particle size: ≥ 50 µm; magnetic rod for iron particles (magnetite)
2. Body: cast iron or carbon steel; flanged PN16; blowdown valve 1/2" BSP
3. Rating: PN16; 120°C

B. **Magnetic filters:** installed on pump suction and on return connections to heat pumps, chillers, and heat exchangers.

1. Magnet: neodymium, minimum 10,000 Gauss; captures ferrous particles including magnetite
2. Body: brass or stainless; inline with union connections; cleanable without system shutdown (using isolation valves)
3. Installation: blowdown port piped to drain; purge at commissioning and every 6 months thereafter

C. **Side-stream filtration (optional):** cartridge filter 25–50 µm on side-stream pump (1–5% of main flow); for systems with known high particulate load.

2.4 BACKFLOW PREVENTERS AND FILLING GROUPS

A. **Backflow preventer — mandatory type:** EN 1717 **Type BA** (verifiable reduced-pressure-zone backflow preventer per EN 13959) is the **only permitted type** for all connections between HVAC closed circuits and potable water supply. Type BA provides positive protection against fluid risk categories 3 and 4 (inhibited water, glycol circuits).

1. Size: DN15 standard (filling circuits); DN20 or DN25 for larger systems or higher make-up flow

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2. Body: brass, dezincification-resistant (DZR); EPDM seals; materials comply with D.M. 174/2004 for potable water contact
3. Test ports: four test cocks for annual verification by qualified plumber
4. Inlet pressure rating: PN10 minimum; maximum inlet pressure: 10 bar
5. Discharge port: piped to visible drain funnel (tundish); not to closed drain

B. **DHW applications:** where the filling group serves a domestic hot water (DHW) circuit or is supplied from a branch shared with potable water, all wetted components shall additionally comply with **D.M. 174/2004** (minimum); manufacturer's written compliance statement required at submittal.

C. **Complete filling station — mandatory assembly in order:**

1. 1. Upstream isolating ball valve (flanged or union-end; full-bore; lockable)
2. 2. Y-strainer 500 µm mesh; blow-down valve; before the BA disconnector to protect its seals
3. 3. Cartridge water softener: cation-exchange resin; capacity sized for system fill volume × 3; replaceable cartridge with shutoff valve for in-service replacement
4. 4. Type BA backflow preventer per EN 1717 / EN 13959
5. 5. Pressure-reducing valve: set to system static fill pressure + 0.5 bar; factory-set and field-adjustable
6. 6. Downstream isolating ball valve (full-bore; lockable); ensures BA device is replaceable without draining system
7. 7. Pressure gauge (63 mm dial; range 0–6 bar) downstream of PRV
8. 8. Water meter (pulsed output for BMS monitoring of make-up water consumption)

NOTE: Isolation valves on both sides of the BA backflow preventer are mandatory to allow annual testing and device replacement without draining the system. The Y-strainer upstream of the BA device protects the check valve seats from particle damage. The cartridge softener protects heat generators and heat exchangers from scale. All three elements (strainer, softener, BA device) must be enclosed between the two isolation valves.

D. **Inhibitor dosing port:** provide chemical dosing connection (3/8" ball valve and hose fitting) downstream of the fill station for inhibitor addition at commissioning and re-dosing during maintenance.

E. **Automatic filling valves:** float or pressure-controlled; for systems with continuous make-up water demand; must include EN 1717 Type BA protection upstream even on automatic filling valves.

NOTE: Per EN 1717 and D.M. 174/2004, it is mandatory to install a Type BA backflow preventer on all connections to the potable water network feeding closed non-potable HVAC circuits. Annual test and certification by a qualified plumber is required; test report retained in the system O&M file.

2.5 PRESSURE-RELIEF SAFETY VALVES (SUPPLEMENTAL)

A. Where not covered under Section 230523, provide safety valves per **EN ISO 4126-1 / -7** and (where applicable to a primary heat generator in Italy) **Raccolta R, Ed. 2009 (INAIL)**, on all closed-circuit sections that could be isolated trapping water under heat input.

B. Minimum one safety valve per heat-generating plant (heat pump, boiler, solar panel array).

C. Set pressure: not greater than 110% of circuit MWP; minimum 3 bar for heating circuits.

D. Discharge pipe: minimum same bore as valve outlet; terminate over funnel drain; no valves on discharge side.

2.6 FLEXIBLE PIPE CONNECTORS

A. **Application:** suction and discharge of all pumps; connections to heat pumps, chillers, and AHUs.

B. **Type:** stainless steel braided flexible hose with EPDM or stainless inner element; minimum 300 mm usable length.

C. **Rating:** PN16; 120°C; maximum deflection angle per manufacturer.

D. **End connections:** screwed (DN ≤ 50) or flanged (DN > 50); stainless steel end fittings.

E. **Vibration isolation:** flexible connectors do not replace pipe spring hangers; provide independent pipe supports within 300 mm of each connector.

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2.7 SYSTEM DRAIN COCKS AND COMMISSIONING CONNECTIONS

A. Provide ¾" or 1" full-bore ball valve drain cocks at all low points of hydronic circuits.

B. Connect drain cocks to drain pipe or provide hose-thread adapter; cap when not in use.

C. Provide commissioning filling and flushing connections (2" or DN50 with ball valve and hose coupling) at main circuit headers.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Confirm piping is installed and pressure-tested before installing specialties.

B. Verify expansion vessel charging pressure before connection; adjust if transit may have altered factory pre-charge.

3.2 INSTALLATION

A. Expansion vessels: mount on rigid bracket, not on flexible pipe; support weight independently of the pipe.

1. Orient vessels per manufacturer (horizontal or vertical as rated); do not invert non-rated vessels
2. Install isolating valve directly at vessel connection; do not insulate the vessel
3. Install with minimum 300 mm straight pipe between vessel and pump suction

B. Deaerators/separators: install in largest pipe section available; horizontal with top air vent connection; blowdown to drain.

C. Automatic air vents: install at each system high point; provide access panel where concealed in ceiling.

D. Backflow preventers: install horizontally with test cocks accessible; upstream strainer mandatory.

E. Flexible connectors: install in line with pipe axis; do not bend or twist at installation; restrain to prevent pipe movement transferring to equipment.

3.3 COMMISSIONING AND TESTING

A. Expansion vessel: verify pre-charge pressure with system cold and completely drained; adjust if needed; record pre-charge pressure in commissioning report.

B. Air purging: operate all automatic air vents during first system fill; purge each high point manually if automatic vents do not open within 30 minutes.

C. Backflow preventer testing: annual test and certification by qualified plumber; first test at commissioning; certify with test report per EN 1717.

D. Safety valves: test by lifting test lever; confirm discharge and reseating; record in commissioning report.

E. Make-up water: record meter reading at commissioning; excessive make-up water after commissioning indicates leakage or air ingestion problem.

END OF SECTION 232116

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SECTION 232123
HYDRONIC PUMPS

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232116 – Hydronic Specialties
3. Section 230523 – General-Duty Valves for HVAC Piping
4. Section 230900 – Instrumentation and Controls for HVAC
5. Section 260518 – Low-Voltage Electrical Power Conductors and Cables
6. Section 262913 – Motor-Control Centers
7. Section 015416 – Construction Hoisting, Rigging and Crane Operations

1.2 SUMMARY

A. Scope: Furnish and install all circulating and service pumps for HVAC hydronic systems; including primary/secondary circuit pumps, heating/cooling distribution pumps, and condenser water pumps.

B. Included pump types:

1. Inline glandless wet-rotor circulator pumps
2. Inline circulator pumps – dry-rotor with mechanical seal
3. End-suction close-coupled centrifugal pumps
4. End-suction base-mounted centrifugal pumps
5. Twin-head (double) pump units
6. Variable-speed pumps with integrated or remote VFD

C. Design conditions: **up to 120°C** fluid temperature, **PN16** minimum casing rating.

1.3 DEFINITIONS

A. BEP (Best Efficiency Point): point on pump curve at maximum hydraulic efficiency; pump shall be sized so design duty falls between 70–110% of BEP flow.

B. EEI (Energy Efficiency Index) — for glandless wet-rotor circulators: EU ecodesign metric per Reg. (CE) 641/2009 amended by Reg. (UE) 622/2012; minimum requirement **EEI ≤ 0.23** for all glandless circulators placed on the EU market since January 2015.

C. MEI (Minimum Efficiency Index) — for water pumps (rotodynamic, dry-rotor, end-suction, multistage): EU ecodesign metric per **Reg. (UE) 547/2012**; minimum requirement **MEI ≥ 0.40** for all water pumps placed on the EU market since January 2015. MEI and EEI are **not interchangeable**: EEI applies to glandless circulators only, MEI applies to dry-rotor water pumps only.

D. NPSH (Net Positive Suction Head): minimum absolute head at pump inlet to prevent cavitation; system NPSH_available must exceed NPSH_required + 0.5 m margin.

E. VFD (Variable Frequency Drive): electronic speed control; enables pump to track variable-flow system curve; required for primary distribution pumps > 1.1 kW.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
EN ISO 9906	Rotodynamic pumps – hydraulic performance acceptance tests – Grades 1, 2, 3B
EN 809	Pumps and pump units for liquids – general safety requirements
EN ISO 5199	Technical specifications for centrifugal pumps – class II
EN 16297-1/2/3	Pumps – rotodynamic pumps – glandless circulators (EU ErP regulation)
Reg. (CE) 641/2009 + Reg. (UE)	Ecodesign for glandless standalone circulators – EEI ≤ 0.23

622/2012	
Reg. (UE) 547/2012	Ecodesign for water pumps (rotodynamic, end-suction) – MEI ≥ 0.40
EN 60034-1	Rotating electrical machines – rating and performance
EN 60034-30-1	Motor efficiency classes – IE1 to IE5
IEC 60947-4-1	Low-voltage switchgear – contactors and motor starters
EN 13480-5	Metallic industrial piping – inspection and testing
Dir. 2006/42/CE	Machinery Directive – pump assemblies
Dir. 2014/68/UE	Pressure Equipment Directive – pump casings PN ≥ 16
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act
D.P.R. 380/2001	Consolidated Building Code

1.5 SUBMITTALS

A. Product data: manufacturer's technical data sheets; pump curve (H-Q), efficiency curve (η-Q), NPSH_required curve, power curve (P-Q); all at design speed.

B. Pump schedule: tabulated list of all pumps with tag, duty point (flow m³/h, head m), motor kW, speed, efficiency at duty, MEI/EEI index, and VFD information.

C. Motor data: motor efficiency class (IE3 minimum), power factor, starting current, insulation class.

D. VFD data: technical data sheets for variable frequency drives; harmonic distortion analysis (THDi) where required.

E. Vibration isolation schedule: pad type, frequency rating, and static deflection for each pump set.

F. Factory test reports: hydraulic acceptance test per EN ISO 9906 Grade 2 for pumps > 5.5 kW.

G. CE declarations: per Machinery Directive 2006/42/CE and PED 2014/68/UE.

1.6 QUALITY ASSURANCE

A. Pump hydraulic performance: acceptance per EN ISO 9906 Grade 2 (flow tolerance ±8%, head tolerance +6%/−3%, power tolerance +4%).

B. Motors: IE3 efficiency class minimum per EN 60034-30-1; IE4 where noted.

C. Glandless wet-rotor circulators: **EEI ≤ 0.23** per Reg. (UE) 622/2012. Dry-rotor water pumps: **MEI ≥ 0.40** per Reg. (UE) 547/2012. Both classes shall carry energy efficiency labelling.

D. Pumps > 5.5 kW: factory hydraulic acceptance test; test certificate to be submitted before delivery.

1.7 WARRANTY

A. All pumps: **1 year** from Substantial Completion.

B. Wet-rotor circulator bearings: **3 years**.

PART 2 – PRODUCTS

2.1 GLANDLESS WET-ROTOR CIRCULATORS

A. Application: heating and chilled water circuits up to DN50; fan-coil unit primary circuits; secondary distribution loops.

B. Construction: stainless steel impeller and rotor shaft; graphite or ceramic plain bearings lubricated by pumped fluid; no shaft seal or stuffing box.

C. Body: cast iron GJL-200 or brass; flanged or screwed connections; PN10 minimum.

D. **Variable speed:** continuously variable speed control; integrated or remote controller; proportional-pressure or constant-pressure control mode.

E. **Energy efficiency: EEI ≤ 0.23** per Reg. (UE) 622/2012 (glandless circulator ecodesign requirement); permanent magnet (EC) motor required to achieve EEI compliance.

F. **Communication: BACnet/IP or BACnet MS/TP** as standard for BMS integration; Modbus RTU as legacy alternative; RS-485 or Ethernet port.

G. **Display:** integrated LCD or LED showing speed, flow (estimated), power (W), and fault codes.

H. **Twin-head circulators:** parallel-mounted dual-head units for duty/standby redundancy on critical circuits; automatic changeover on lead pump fault.

2.2 DRY-ROTOR INLINE CENTRIFUGAL PUMPS

A. **Application:** larger heating/chilled water circuits DN65–DN150; condenser water; secondary distribution.

B. **Construction:** close-coupled to IE3 motor; mechanical seal (SiC/SiC EPDM for heating; PTFE-rated seal for glycol ≥ 30%); PN16 casing.

C. **Body:** cast iron GJS-400 (ductile) or stainless; flanged PN16 EN 1092-1.

D. **Impeller:** closed type; stainless AISI 316 or engineering plastic for smaller sizes.

E. **Speed control:** integrated VFD for all pumps > 1.1 kW; external VFD for pumps > 11 kW (see Section 262913).

F. **BMS interface:** 4–20 mA speed command or BACnet/IP command; digital run status and fault output; BACnet/IP or BACnet MS/TP for integrated VFDs.

2.3 END-SUCTION BASE-MOUNTED CENTRIFUGAL PUMPS

A. **Application:** primary plant circuits, chiller condenser water, large distribution circuits.

B. **Construction:** horizontal end-suction, top-discharge; back-pull-out casing design; separate IE3 motor frame-mounted on common base plate.

C. **Casing:** cast iron or ductile iron; flanged PN16; impeller clearance adjustable without disturbing pipe connections.

D. **Mechanical seal:** single mechanical seal SiC/SiC EPDM; replaceable without draining casing.

E. **Base plate:** welded structural steel; hot-dip galvanised; levelling bolts and grouting provisions; integral drip tray for oil and seal water collection.

F. **Coupling:** flexible elastomeric coupling; coupling guard per Machinery Directive.

G. **VFD:** external wall-mounted or MCC-mounted; see Section 262913; BACnet/IP or BACnet MS/TP communication to BMS.

H. **Vibration isolation:** spring anti-vibration mounts on base plate; installed on inertia block (mass 1.5× pump+motor assembly) for pumps > 5.5 kW.

2.4 VARIABLE FREQUENCY DRIVES (VFD) FOR PUMPS

A. **Required for:** all distribution pumps > 1.1 kW; all primary plant pumps.

B. **Control modes:** constant pressure, proportional pressure (preferred), constant speed.

C. **Input:** 400 V 3-phase; output frequency 0–50 Hz; soft-start ramp 5–30 s.

D. **Protection:** IP55 if wall-mounted in plant room; IP20 if MCC-mounted.

E. **Communication: BACnet/IP or BACnet MS/TP** as standard (ASHRAE 135 / EN ISO 16484-5); Modbus RTU as legacy alternative; read: speed %, current A, power kW, fault code; write: speed command, enable/disable.

F. **Harmonics:** VFDs > 15 kW shall include input filter (DC choke or line reactor) limiting THDi ≤ 10% at PCC.

NOTE: Pump VFDs installed in the MCC are specified in Section 262913. Integrated VFDs (factory-fitted in pump unit) are specified here.

2.5 PUMP ACCESSORIES

A. Suction strainer: Y-type stainless steel 800 µm mesh; flanged PN16; blowdown valve; pressure tapping for ΔP measurement.

B. Isolation valves: flanged ball or butterfly valves on suction and discharge; DN-matched to pump connections.

C. Discharge check valve: spring-loaded wafer check valve immediately downstream of discharge isolation valve.

D. Flexible connectors: stainless braided hose 300 mm length on suction and discharge; Section 232116.

E. Pressure/temperature test points: Schrader-type on suction and discharge; Section 230519.

F. Pressure gauges: 100 mm dial on suction and discharge; Section 230519.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify piping is installed and flushed (Section 232113) before pump installation.

B. Confirm suction pipe minimum straight length: 5D for base-mounted pumps; 3D for inline pumps.

C. Verify electrical supply is correct voltage and that circuit breaker and VFD are properly rated.

3.2 INSTALLATION

A. Base-mounted pumps: level base plate to ±0.1 mm/m; grout under base plate with non-shrink grout; allow grout to cure before pipe connection.

B. Alignment: check motor-to-pump coupling alignment after grouting and after pipe connection; re-align if needed; record alignment readings.

C. Pipe loads: pipe flanges shall not impose loads on pump casing beyond manufacturer's allowable nozzle loads; use pipe supports within 300 mm of each flange.

D. Anti-vibration mounts: install per manufacturer's instructions; do not over-compress; provide flexible pipe connectors on both suction and discharge.

E. Suction strainer: install in correct flow direction; blowdown valve plumbed to drain.

F. Motor direction: check rotation direction before starting; incorrect rotation on three-phase motors causes damage; verify by momentary jog start only.

3.3 START-UP AND COMMISSIONING

A. Flush system per Section 232113 before starting pumps; remove and clean strainer screens after first 48 hours of operation.

B. Initial start: open all isolating valves; prime pump if necessary; start at minimum speed (VFD); check for unusual noise, vibration, or leakage.

C. Bearing temperature: monitor motor and pump bearing temperature for first 4 hours; must not exceed motor manufacturer's limits.

D. Performance test: measure suction pressure, discharge pressure, and motor current at design duty point; confirm flow rate using installed flow meter; compare to pump curve; document results.

E. VFD commissioning: set acceleration/deceleration ramps; program proportional-pressure setpoint; configure BACnet/IP communication (Device Instance, network settings); test BMS read-back of speed and power.

F. Duty/standby changeover: test automatic changeover on lead pump fault; verify standby pump starts within 5 seconds.

3.4 FIELD QUALITY CONTROL

A. Vibration: measure vibration velocity (mm/s RMS) at bearing housings after commissioning; maximum 2.8 mm/s for base-mounted pumps per ISO 10816-3.

B. Noise: verify noise does not exceed specified levels at 1 m from pump; recheck after VFD speed adjustment.

C. Seal inspection: no dripping from mechanical seal permitted; slight leakage during first hours of operation acceptable; reseal or replace if persistent after 48 hours.

3.5 IDENTIFICATION

A. Tag each pump with stainless steel tag: tag number, duty point (flow and head), motor kW, and service.

B. Apply rotation arrow on pump body/casing.

C. Label VFD panel with pump tag and emergency stop location.

END OF SECTION 232123

SECTION 232500
HVAC WATER TREATMENT

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232116 – Hydronic Specialties
3. Section 232123 – Hydronic Pumps
4. Section 238143 – Air-Source Heat Pumps
5. Section 237300 – Air Handling Units

1.2 SUMMARY

A. Scope: Provide complete HVAC water treatment programme including: pre-commission flush and clean, chemical water treatment for all closed circuits, and glycol antifreeze where required.

B. Covered systems:

1. Closed heating circuits (hot water, low-temperature heating)
2. Closed chilled water circuits
3. Condenser water (open or closed)
4. Glycol / antifreeze systems (heat pump evaporator circuits, outdoor coils)

C. Water treatment shall conform to **UNI 8065:2019** and BSRIA BG 50/2013 throughout the service life of the system.

1.3 DEFINITIONS

A. Inhibitor: chemical additive that forms a protective film on metal surfaces; prevents corrosion of steel, copper, aluminium, and cast iron in closed circuits.

B. Biocide: chemical that kills or inhibits growth of bacteria, algae, and biofilm; prevents Legionella in open circuits.

C. pH: measure of acidity/alkalinity; optimal range for closed circuits: **7.5–9.0** (UNI 8065).

D. TDS (Total Dissolved Solids): measure of ion concentration; high TDS promotes scale and corrosion.

E. Hardness: calcium and magnesium ion concentration; expressed as $CaCO_3$ mg/L; scale risk above 200 mg/L.

F. Inhibitor concentration: percentage by volume; must be maintained within manufacturer's specified range; verified by test kit or laboratory analysis.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
UNI 8065:2019	Water treatment in HVAC thermal systems for civil use
UNI 8065 Tab.1	Water quality parameters – closed heating systems
UNI 8065 Tab.2	Water quality parameters – chilled water / cooling
EN 14868	Protection of metallic materials against corrosion – closed heating systems
BSRIA BG 29/2012	Pre-commission cleaning of pipework systems
BSRIA BG 50/2013	Water treatment for closed heating and cooling systems
EN 14336	Heating systems in buildings – installation, commissioning, and operation
EN 12828	Heating systems in buildings – design
EN 1717	Protection against pollution of potable water

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D.Lgs. 152/2006	Environmental Code – discharge of treated water
CIBSE TM54	Evaluating operational energy performance
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Water Treatment Programme: written programme prepared by water treatment specialist; covering: flush procedure, fill water quality, chemical products to be dosed, target parameters, monitoring frequency, and top-up protocol.

B. Chemical product data: manufacturer's safety data sheets (SDS per REACH Regulation EC 1907/2006); dosage instructions; compatibility with system materials.

C. Pre-commission flush report: signed report confirming flush completion; before-and-after water analysis; debris collected during flush.

D. Initial fill water analysis: laboratory analysis of fill water confirming parameters within UNI 8065 limits before chemical dosing.

E. Annual maintenance reports: water analysis results and corrective actions; submitted annually during warranty and service contract periods.

1.6 QUALITY ASSURANCE

A. Water treatment programme to be designed by a **qualified water treatment specialist** with minimum 5 years HVAC experience.

B. All chemicals shall be approved by the specialist for the system materials (copper, aluminium, steel, stainless steel) present.

C. Glycol/antifreeze products: HVAC-grade, non-toxic where required by local regulations; inhibited propylene glycol or mono-ethylene glycol; not automotive antifreeze.

D. Disposal of flush water and spent chemical solutions per D.Lgs. 152/2006 (environmental discharge regulations).

1.7 WARRANTY

A. Water treatment materials and programme: **1 year** minimum; extendable via annual service contract.

B. Corrosion protection guarantee: maintain inhibitor concentrations within specification; record in maintenance log.

PART 2 – PRODUCTS

2.1 FILL WATER REQUIREMENTS

A. Fill water shall meet the following minimum quality requirements per UNI 8065:2019 before chemical dosing:

1. pH: 7.0–8.5
2. Total hardness: ≤ 150 mg/L as $CaCO_3$
3. Chloride (Cl^-): ≤ 50 mg/L for steel circuits; ≤ 200 mg/L for stainless steel
4. Conductivity: ≤ 700 µS/cm
5. Turbidity: ≤ 0.5 NTU
6. Iron (total): ≤ 0.1 mg/L
7. TDS: ≤ 500 mg/L

B. Where mains water does not meet fill water requirements, treat by softening, deionisation, or reverse osmosis before use.

C. Do not use untreated river or groundwater as fill water.

2.2 CORROSION INHIBITORS – CLOSED CIRCUITS

A. Heating circuits: molybdate/nitrite-free or organic (carboxylate/azole) inhibitor package; compatible with all metals present (copper, steel, cast iron, aluminium alloys).

1. Dosage: as per manufacturer's specification; typically 2–5% v/v initial dose
2. Target concentration: maintained within ±1% of specified value; tested with field test kit
3. Top-up: dose inhibitor proportionally when make-up water is added

B. Chilled water circuits: corrosion inhibitor + antifungal agent; molybdate-based or organic; pH stabilised at 8.0–9.0.

C. Compatible materials: inhibitor package must be certified compatible with: copper tube EN 1057, multilayer (PE-X/Al) pipe, galvanised steel, carbon steel, AISI 304/316, cast iron, and brass valves.

D. Mixed-metal circuits: aluminium and copper must not be present in the same circuit without specialist-approved inhibitor package; verify before dosing.

NOTE: Use of domestic (automotive) antifreeze products as corrosion inhibitors is strictly prohibited. These products contain silicates not compatible with most HVAC metals and can form insulating scale on heat transfer surfaces.

2.3 GLYCOL / ANTIFREEZE

A. Type: inhibited mono-ethylene glycol (MEG) or inhibited propylene glycol (MPG); HVAC-grade with corrosion inhibitor package; not automotive grade.

B. Application: heat pump evaporator circuits, outdoor coil circuits, or any system where freezing risk exists.

C. Concentration: sized per design minimum ambient temperature + 5°C safety margin:

1. –5°C design minimum → 25% MEG (freeze protection –13°C)
2. –10°C design minimum → 30% MEG (freeze protection –18°C)
3. –15°C design minimum → 35% MEG (freeze protection –24°C)
4. –20°C design minimum → 40% MEG (freeze protection –30°C)

D. Mixing: blend glycol with treated water before system fill; never add glycol to undrained system.

E. Propylene glycol: use where non-toxicity is required (potable water zones, food processing proximity); same concentration table applies.

F. Verification: measure concentration with refractometer at commissioning and annually; adjust if outside ±3% of target.

G. Inhibitor: glycol product must include integrated corrosion inhibitor package; if not, add separate inhibitor per 2.2.

2.4 BIOCIDES – OPEN AND CONDENSER WATER CIRCUITS

A. Application: condenser water open cooling towers and evaporative circuits; not required for closed circuits.

B. Legionella prevention: biocide programme per **Accordo Stato-Regioni 7 maggio 2015, Rep. 79/CSR** (Guidelines for the Prevention and Control of Legionellosis) and ECDC/WHO guidelines.

C. Biocide types: alternating oxidising (sodium hypochlorite) and non-oxidising (isothiazolinone or DBNPA); rotation to prevent resistance.

D. Dosing: automatic dosing pumps with timer/flow-proportional control.

E. Monitoring: pH, conductivity, and free chlorine (for hypochlorite) measured daily; microbiological sampling quarterly; Legionella culture test twice annually.

NOTE: Legionella risk assessment and open-circuit water treatment programme must be prepared by a specialist and comply with Italian health authority requirements (ASL/AUSL notifications where required).

2.5 DOSING EQUIPMENT

A. Chemical dosing pots (pot feeder): on closed circuits; minimum 3 L volume; top-loaded with valved inlet/outlet; fill with pre-mixed inhibitor solution.

B. Automatic dosing pumps: on large systems (> 5000 L circuit volume) and condenser water circuits; peristaltic type; adjustable dose rate; 4–20 mA input from conductivity sensor.

C. Blowdown control: conductivity-controlled solenoid blowdown valve on condenser circuits; reject water when TDS exceeds setpoint.

D. Chemical storage: dedicated locked chemical store; secondary containment; ventilation; SDS sheets posted.

2.6 WATER ANALYSIS TESTING KITS

A. Provide the following test kits for use by maintenance personnel:

1. pH strips or digital pH meter (accuracy ±0.1)
2. Inhibitor concentration test kit (compatible with specified inhibitor product)
3. Refractometer for glycol concentration (dual MEG/MPG scale)
4. Total hardness colorimetric test kit
5. Chloride test strips

PART 3 – EXECUTION

3.1 PRE-COMMISSION CLEANING (FLUSHING)

A. Procedure: per BSRIA BG 29/2012 and Section 232113 Article 3.7.

B. Sequence:

1. Fill system with clean mains water; check for leaks under filling pressure
2. Circulate at maximum velocity (minimum 1.5 m/s in main pipes) for minimum 1 hour; flush through temporary bypass (not through coils or heat exchangers)
3. Drain, inspect and clean strainer screens; repeat flush until water runs clear (turbidity < 10 NTU)
4. Final fill with treated water meeting 2.1 parameters; add corrosion inhibitor
5. Sample flush water – collect sample for laboratory analysis before disposal

C. Coil protection: during flush, bypass all coils, heat exchangers, and terminal units with flow-through temporary connections; connect coils only after flush water is clean.

D. Commissioning strainers: install temporary fine mesh (100 µm) commissioning strainers on coil inlets for first 2 weeks of operation; remove and clean weekly.

E. Submit signed flush report before final system commissioning.

3.2 SYSTEM FILL AND CHEMICAL DOSING

A. Fill system slowly to avoid air pockets; open all automatic air vents; vent high points manually.

B. Record fill volume (from meter at filling station); compare to system volume from design.

C. Add inhibitor via dosing pot or directly to system via commissioning connection; circulate for minimum 2 hours before sampling.

D. Take water sample after circulation; analyse for inhibitor concentration, pH, hardness, and chloride; confirm all parameters within specification.

E. For glycol circuits: add glycol concentrate to partially filled system; circulate 4 hours; verify concentration with refractometer.

F. Document: fill date, fill volume, chemicals added (product name, batch number, quantity), and initial analysis results.

3.3 ONGOING MAINTENANCE PROGRAMME

A. Closed circuits – monitoring frequency:

1. Monthly: pH, inhibitor concentration (field test kit)
2. Quarterly: full analysis by accredited laboratory – pH, conductivity, TDS, hardness, chloride, iron, copper, inhibitor concentration, bacteria count
3. Annually: review of programme by water treatment specialist; adjust inhibitor type or dose if required

B. Corrective actions: if any parameter is out of specification, identify cause, correct, and re-test within 7 days; document all corrective actions in maintenance log.

C. Make-up water: record volume of make-up water added monthly; excessive make-up (> 5% of circuit volume/month) indicates leakage; investigate and repair.

D. Water treatment log: maintain written log of all test results, chemical additions, and corrective actions; available for inspection at all times.

END OF SECTION 232500

SECTION 238143
AIR-SOURCE HEAT PUMPS

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 232113 – Hydronic Piping
2. Section 232116 – Hydronic Specialties
3. Section 232123 – Hydronic Pumps
4. Section 232500 – HVAC Water Treatment
5. Section 230900 – Instrumentation and Controls for HVAC
6. Section 134813 – Acoustic Equipment Enclosures
7. Section 262913 – Motor-Control Centers
8. Section 232300 – Refrigerant Piping
9. Section 221316 – Sanitary, Sewer, and HVAC Condensate Drainage Piping
10. Section 230593 – Testing, Adjusting, and Balancing for HVAC
11. Section 015416 – Construction Hoisting, Rigging and Crane Operations

1.2 SUMMARY

A. Scope: Furnish and install air-source heat pump (ASHP) units, complete with refrigerant circuit, waterside connections, electrical connections, and BMS interface.

B. Applications:

1. Space heating – low-temperature hydronic circuits (LT-ASHP) at 45–55°C leaving water
2. Space cooling – chilled water circuits at 7–12°C leaving water (reversible units)
3. Combined heating and cooling (simultaneous or seasonal reversible)
4. Domestic hot water preparation (DHW boost to 55–65°C where scheduled)

C. All heat pumps shall be **reversible air-to-water type** unless otherwise noted; refrigerant per EN 378 and F-Gas Reg. UE 517/2014.

1.3 DEFINITIONS

A. COP (Coefficient of Performance): ratio of heating output (kW) to electrical input (kW) at rated conditions (EN 14511 A7/W35).

B. SCOP (Seasonal COP): weighted seasonal efficiency in heating mode per EN 14825; EU ecodesign benchmark.

C. SEER (Seasonal Energy Efficiency Ratio): weighted seasonal efficiency in cooling mode per EN 14825.

D. GWP (Global Warming Potential): CO_2-equivalent per kg of refrigerant; F-Gas regulation (Reg. UE 2024/573) phases down high-GWP refrigerants on a date-and-category schedule; on this project R410A is banned for heat pumps and a low-GWP refrigerant is mandatory regardless of charge (project refrigerant policy — Article 1.6).

E. Defrost: reverse-cycle or hot-gas defrost cycle; removes ice from outdoor coil; causes temporary reduction in heating capacity.

F. LWT (Leaving Water Temperature): water temperature leaving the heat pump condenser (heating) or evaporator (cooling).

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
EN 14511-1/2/3/4	Air conditioners, liquid chilling packages and heat pumps – ratings and testing
EN 14825	Air conditioners, liquid chilling packages and heat pumps – testing at part load (SCOP, SEER)

EN 16147	Heat pumps with electrically driven compressors – testing and requirements for DHW heat pumps
EN 12102-1	Acoustics – sound power level of heat pumps
EN ISO 4871	Acoustics – declaration and verification of noise emission values
EN 60335-2-40	Household and similar electrical appliances – heat pumps and air-conditioners
EN 61000-3-2	EMC – limits for harmonic current emissions
EN 60529	Degrees of protection (IP rating)
Reg. (UE) 813/2013 + amendments	Ecodesign – space heaters including heat-pump space heaters (ηs, SCOP minima)
Reg. (UE) 814/2013	Energy labelling – space heaters and combination heaters
Reg. (UE) 206/2012	Ecodesign – air conditioners and comfort fans (EER, COP minima)
Reg. (UE) 517/2014	F-Gas regulation (in force; partially superseded by Reg. (UE) 2024/573)
Reg. (UE) 2024/573	New F-Gas regulation in force from 11 March 2024 – stricter HFC phase-down and GWP limits
EN 378-1/2/3/4	Refrigerating systems and heat pumps – safety and environmental requirements
D.P.R. 146/2018	Implementation of Reg. (UE) 517/2014 in Italy (replaces D.P.R. 43/2012)
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act
D.P.R. 380/2001	Consolidated Building Code
Dir. 2014/68/UE (PED)	Pressure equipment

1.5 SUBMITTALS

A. Performance data: manufacturer's selection data for each unit; rated capacity (kW) and COP at EN 14511 conditions (A7W35 heating; A35W7 cooling); SCOP and SEER; part-load performance curve.

B. Acoustic data: sound power level (LWA) in octave bands per EN 12102-1; site noise impact assessment if required by planning conditions.

C. Refrigerant data: refrigerant type, GWP, charge mass per unit; F-Gas compliance declaration.

D. BACnet/IP data: PICS document and BACnet object list for BMS integration; see Article 2.8. Modbus register map as supplementary document where applicable.

E. Electrical data: electrical connection diagram; fuse/MCB sizing; inrush current; power factor; harmonic spectrum.

F. CE declarations: Machinery Directive, EMC Directive, F-Gas; PED 2014/68/UE for refrigerant circuit.

G. Foundation/fixing details: loadings on structure; vibration isolator specification; anchor bolt layout.

1.6 QUALITY ASSURANCE

A. Ecodesign (legal minimum): ηs ≥ legal minimum per Reg. (UE) 813/2013 as amended; for LT-ASHP this corresponds to SCOP ≈ 3.1 at average climate / W35. **Project specification (above legal minimum): SCOP ≥ 4.0 at A7/W35 (average climate, low-temperature heat pump)** measured per EN 14825; SEER ≥ 5.0 in cooling mode for reversible units. The product selected shall exceed these project values, not merely the legal minimum.

B. Refrigerant — R410A banned (see Section 232300 Article 1.6 for the project master policy):

1. **R410A banned:** R410A (and other high-GWP A1 HFCs) shall **NOT** be used for air-source heat pumps on this project, irrespective of per-circuit charge.
2. **Required refrigerants:** low-GWP A2L — **R32 (GWP 675, preferred), R454B (GWP 466)**, R1234ze or equivalent; or R290 (A3) where suitable. For per-circuit charge > 6.5 kg, implement the EN 378-3 additional safety measures and Italian fire-prevention (CPI) obligations applicable to the flammable refrigerant; these are deemed included in the Contractor's scope.
3. **R290 (propane, A3):** if specifically selected, follow EN 378-3 strict requirements (charge-per-room-volume limits, mechanical ventilation of plant enclosure, EN 378-3 warning signage, F-Gas A3-certified technicians only).
4. **Contractor shall submit** with the equipment shop drawings the calculated per-circuit refrigerant charge (factory pre-charge + field pipework additional charge) and confirmation that the selected refrigerant complies with this policy (R410A not accepted).

C. F-Gas compliance: refrigerant management system per Reg. (UE) 517/2014 and Reg. (UE) 2024/573; equipment logbook per **D.P.R. 146/2018** (Italian implementation of F-Gas regulation, which replaces D.P.R. 43/2012); leak testing schedule; only F-Gas-certified technicians may handle refrigerant.

D. Noise: unit LWA ≤ specified limit per acoustic study; units adjacent to noise-sensitive areas shall have additional attenuation (screens, barrier walls per Section 134813).

E. Frost protection: all heat pumps operating below 5°C ambient shall include anti-freeze provisions (glycol circuit or electric trace on waterside piping).

1.7 WARRANTY

A. Complete unit: **3 years** from Substantial Completion.

B. Compressor: **5 years** from date of manufacture (compressor unit warranty by compressor OEM).

C. Refrigerant charge: free-of-charge top-up for normal leakage within warranty period (defined as < 10% of charge per year).

PART 2 – PRODUCTS

2.1 GENERAL CONFIGURATION

A. Air-source heat pump type: outdoor-mounted air-to-water unit; monoblock or split configuration; single- or multi-compressor; all refrigerant contained within the outdoor unit (monoblock) or with refrigerant connections to indoor hydraulic module (split).

B. Compressor: scroll or rotary (smaller units); variable speed (inverter-driven) compressor preferred for efficiency at part load and wide operating range.

C. Operating range – heating: outdoor air –20°C to +43°C; leaving water up to 60°C (high-temperature heat pump) or 55°C (standard LT-ASHP).

D. Operating range – cooling: outdoor air +15°C to +46°C; leaving water 5°C minimum.

E. Refrigerant circuit: EN 378 compliant; factory-charged (monoblock); all safety devices (pressure relief, high/low pressure switches, motor protection).

F. Protection: IP44 minimum for outdoor unit; IP54 for units in high-humidity or coastal environments.

2.2 OUTDOOR UNIT (OUTDOOR AIR HEAT EXCHANGER)

A. Coil: aluminium fins on copper tubes; copper or aluminium headers; coated fins for corrosive environments (coastal / urban pollution): hydrophilic or epoxy coating; B-type salt spray EN ISO 9227 ≥ 500 h.

B. Fan: axial fan(s); minimum IE3 motor efficiency (inverter-driven where applicable); propeller guard per Machinery Directive.

C. Defrost: automatic, cycle-based or demand-based defrost; hot-gas or reverse-cycle; include defrost drip tray with drain; insulated base pan.

D. Acoustic louvres/baffles: factory-optional acoustic kit; mandatory where unit is within 5 m of property boundary or noise-sensitive receiver.

2.3 REFRIGERANT CIRCUIT

A. **Compressor:** inverter-driven scroll; BLDC permanent magnet motor; minimum 40% speed turndown; crankcase heater; vibration mounts.

B. **EEV (Electronic Expansion Valve):** stepper-motor type; BMS-readable position; enables refrigerant flow optimisation and improved part-load COP.

C. **Safety devices:** high-pressure switch (manual reset) + high-pressure transducer; low-pressure switch; crankcase heater; motor thermal protection; refrigerant leak detector port (optional).

D. **Refrigerant type and charge:** per manufacturer's design for the unit model; clearly labelled on unit nameplate; logbook provided.

2.4 HYDRAULIC MODULE (WATER SIDE)

A. **Built-in hydraulic module (where applicable):** includes plate heat exchanger, circulating pump, expansion vessel, safety valve, air separator, flow switch, and pressure gauge; all factory-assembled and tested.

B. **Plate heat exchanger:** brazed stainless steel AISI 316; material rated for water/glycol concentrations up to 50% (manufacturer capability); **for this project glycol concentration is capped at 40% v/v** per Section 232500 and UNI 8065 to balance freeze protection with viscosity, pumping power, and heat-transfer penalty; insulated against condensation on cooling side.

C. **Anti-freeze:** internal electric heater or glycol circuit option for leaving water minimum –10°C (glycol solution in evaporator when applicable).

D. **Water-side connections:** DN32–DN65 flanged or BSP threaded; supply and return clearly marked; drain/vent provisions.

E. **Pressure:** MWP 10 bar; factory tested at 15 bar.

2.5 ELECTRICAL

A. **Power supply:** 400 V ± 10%, 3-phase, 50 Hz; single-phase for units < 3 kW only.

B. **Controls voltage:** 24 VAC or 24 VDC for BMS interface and sensors.

C. **Inrush current:** inverter drive limits inrush to ≤ 1.5× FLA; document maximum demand current for electrical sizing.

D. **EMC:** compliance with EN 61000-3-2 (harmonics); EMC filter on inverter output.

E. **Protection:** IP54 electrical enclosure for compressor inverter and control board.

2.6 ACOUSTIC PERFORMANCE

A. **Measurement standard:** EN 12102-1; sound power level LWA measured in free-field conditions.

B. **Sound pressure at distance:** maximum **LpA ≤ 55 dB(A) at 7 m** from unit perimeter under daytime full-load operation; maximum **LpA ≤ 45 dB(A) at 7 m** during night low-noise mode (22:00–07:00). Compliance verified during commissioning per Article 3.3.

NOTE: The 55/45 dB(A) at 7 m limits are project specification acceptance criteria for product selection and commissioning. Site regulatory compliance at the actual noise receptor is governed by D.P.C.M. 14/11/1997 (acoustic zone class per municipal plan) and must be verified by an acoustic study where required by planning conditions.

C. **Units with cooling capacity ≥ 100 kW:** mandatory low-noise/silenced configuration; **EC (electronically commutated) outdoor fans required**; acoustic louvres and baffles factory-installed; product data sheet shall demonstrate LpA ≤ 55 dB(A) at 7 m at full fan speed.

D. **Low-noise mode:** all inverter-driven units shall operate in reduced-noise mode (night setback) during 22:00–07:00; BMS-schedulable via BACnet/IP command; typical LWA reduction 5–8 dB(A) from full-speed.

E. **Maximum sound power:** per acoustic study or as noted on drawings; comply with D.P.C.M. 14/11/1997 (current Italian noise limits) and L. 447/1995.

F. **Acoustic screens:** Section 134813 specifies acoustic barriers where heat pump is ≤ 5 m from openable windows of habitable rooms.

2.7 CASCADES AND LEAD/LAG CONTROL

A. Where multiple heat pump units are installed in parallel:

1. Lead/lag rotation: automatic, time-based or equal-hours control; interval set in BMS
2. Modular loading: BMS activates additional units based on load demand
3. Sequencing logic: first unit at 100% before starting second; last unit at minimum before switching off
4. Fault transfer: immediate switchover to standby unit on lead unit fault alarm

2.8 BACnet/IP COMMUNICATION INTERFACE

A. All heat pump units shall natively support **BACnet/IP** (ASHRAE 135 / EN ISO 16484-5) as the **standard BMS protocol**. BACnet MS/TP (RS-485) is acceptable as a secondary field-bus option. Modbus RTU/TCP is accepted as a legacy alternative only where BACnet is not available from the manufacturer.

B. BACnet/IP requirements: Ethernet RJ-45; 10/100 Mbps; static or DHCP IP; BTL certification or equivalent; PICS document submitted; minimum object types AI, AO, BI, BO, AV, BV; services ReadProperty, WriteProperty, SubscribeCOV, Who-Is, I-Am.

NOTE: The table below lists the minimum data points for BMS integration. Column headers reflect parameter names and R/W status applicable to both BACnet (object properties) and Modbus (register types). Final BACnet object instances and Modbus register addresses are confirmed from the manufacturer's PICS / register map documentation during shop drawing review.

Parameter	BACnet Object / Modbus Reg.	R/W	Notes
Unit Enable/Disable	CO 00001	R/W	0=Off, 1=Enable
Operating Mode	HR 40001	R/W	0=Off,1=Heating,2=Cooling,3=Auto,4=Defrost
Heating Setpoint (°C×10)	HR 40002	R/W	e.g. 450 = 45.0°C leaving water
Cooling Setpoint (°C×10)	HR 40003	R/W	e.g. 70 = 7.0°C leaving water
Leaving Water Temp (°C×10)	IR 30001	R	Measured value
Entering Water Temp (°C×10)	IR 30002	R	Measured value
Outdoor Air Temp (°C×10)	IR 30003	R	Measured value
Compressor 1 Status	DI 10001	R	0=Off, 1=Running
Compressor 2 Status	DI 10002	R	0=Off, 1=Running
Defrost Active	DI 10003	R	0=Normal, 1=Defrost
Unit Fault	DI 10004	R	0=OK, 1=Fault
Fault Code	IR 30010	R	Integer fault code (see O&M manual)
Current Power Draw (kW×10)	IR 30004	R	e.g. 352 = 35.2 kW
COP (×100)	IR 30005	R	e.g. 320 = COP 3.20
Energy Input (kWh)	IR 30006	R	Totalised, resets at midnight
Pump Enable Output	CO 00002	R/W	BMS to enable/disable waterside pump
Anti-legionella Active	DI 10005	R	1 when pasteurisation cycle running

EEV Opening (%)	IR 30007	R	0–100% electronic expansion valve
Refrigerant Pressure High	IR 30008	R	kPa
Refrigerant Pressure Low	IR 30009	R	kPa

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify structural slab or steel frame is designed for heat pump weight plus wind load and seismic load per NTC 2018.

B. Confirm clearances around unit meet manufacturer's minimum requirements for airflow and maintenance access.

C. Verify refrigerant line lengths (for split units) are within manufacturer's limits; elevation differences within allowable range.

3.2 INSTALLATION

A. Foundation and level: install on reinforced concrete pad (minimum 150 mm) or steel frame per structural drawings; level to ±2 mm/m; fix to structure with anti-vibration mounts.

B. Anti-vibration isolation: seismic spring mounts with steel housing/cage; rated for equipment weight plus wind and seismic loads per NTC 2018 seismic zone; minimum static deflection 25 mm; cage prevents lateral displacement under seismic or wind event; certified for both vertical and horizontal load combinations. Neoprene-only pads not permitted.

C. Clearances: maintain manufacturer's minimum air inlet, discharge, and maintenance clearances; no obstructions within discharge air stream.

D. Drainage: drain condensate and defrost water from base pan to storm drain or collection point; do not allow pooling under unit.

E. Refrigerant lines (split units): insulate suction line fully; liquid line insulation per ambient conditions; pressure test leak-tight before refrigerant charging; only certified F-Gas technician to handle refrigerant.

F. Water connections: use flexible connectors at heat pump nozzles; isolation valves within 500 mm of unit; magnetic filter on return connection.

3.3 COMMISSIONING

A. Pre-commissioning checks: electrical insulation test; supply voltage; refrigerant charge (check superheat and subcooling); waterside flow and temperature.

B. Winter performance test (heating mode): conduct at outdoor ambient ≤ 7°C (or the coldest available conditions during the commissioning period); measure outdoor air temperature, leaving water temperature (LWT), entering water temperature, and electrical input power; calculate COP; compare to manufacturer's rated value at EN 14511 conditions A7/W35 (or A2/W35 if ambient allows); record deviation; document in commissioning report.

C. Summer performance test (cooling mode): conduct at outdoor ambient ≥ 25°C (or the warmest available conditions during the commissioning period); measure outdoor air temperature, LWT, entering water temperature, and electrical input power; calculate EER; compare to manufacturer's rated value at EN 14511 conditions A35/W7 (chilled water) or A35/W12; record deviation; document in commissioning report.

NOTE: If seasonal tests cannot be completed during a single commissioning visit due to weather conditions, the tests shall be split: heating-mode test completed during winter, cooling-mode test during summer. Both reports must be submitted before final acceptance. Contractor to agree the testing schedule with the COR at project outset.

D. Defrost test: simulate defrost by reducing outdoor temperature setpoint or blocking coil; verify defrost cycle initiates, completes, and unit returns to normal operation.

E. Noise measurement: measure LpA at 7 m from unit perimeter (and at 1 m for record); compare to LpA ≤ 55 dB(A) limit specified in Article 2.6; measure during daytime and confirm night low-noise mode achieves ≤ 45 dB(A) at 7 m; record all values in commissioning report.

F. BACnet commissioning: verify BACnet/IP discovery (Who-Is / I-Am); confirm all objects listed in Article 2.8 are readable/writable from BMS; verify alarm integration and COV subscriptions.

G. F-Gas documentation: record refrigerant type, charge mass, technician certificate number, and commissioning date in equipment logbook.

3.4 F-GAS MANAGEMENT

A. Maintain F-Gas logbook per **D.P.R. 146/2018** (Italian implementation of Reg. (UE) 517/2014, replacing D.P.R. 43/2012) and the new Reg. (UE) 2024/573 for each heat-pump unit.

B. Leak testing schedule (charge expressed as CO_2-equivalent tonnes per Reg. (UE) 517/2014):

1. 5 – < 50 t CO_2-eq: annual leak check
2. 50 – < 500 t CO_2-eq: every 6 months (or 12 months if automatic leak detection installed)
3. ≥ 500 t CO_2-eq: every 3 months (or 6 months with automatic leak detection); fixed automatic leak detection mandatory

C. All refrigerant work by F-Gas certified technicians (categoria I, II, III, IV per D.P.R. 146/2018 depending on charge and task); record in logbook with certificate number and date.

D. No venting of refrigerant to atmosphere; recovery cylinder mandatory for any refrigerant removal; recovered refrigerant disposed via authorised waste channel.

END OF SECTION 238143

SECTION 260518
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 260534 – Raceways and Boxes for Electrical Systems
2. Section 262913 – Motor-Control Centers
3. Section 230900 – Instrumentation and Controls for HVAC
4. Section 232123 – Hydronic Pumps
5. Section 238143 – Air-Source Heat Pumps

1.2 SUMMARY

A. Scope: Furnish and install all low-voltage power cables, control cables, and signal cables for HVAC mechanical and electrical systems.

B. Standard cable types:

1. Power and control cables **FG16OM16** – 0.6/1 kV, HEPR insulation compound 16, rubber outer sheath OM16, halogen-free; **standard for all HVAC power and control circuits**
2. Flexible cables **H07RN-F** – 450/750 V, EPR insulated, polychloroprene outer sheath; final connections to motors and equipment within LFMC
3. Fire-resistant cables **FTG10(O)M1** – circuit integrity ≥ 90 min in fire conditions; safety-critical circuits only
4. Data/signal cables – Cat6 F/UTP for BACnet/IP; **AWG 22 single-pair shielded low-capacitance twisted-pair instrumentation cable for BAS / BACnet MS/TP** unless otherwise specified by equipment manufacturer; shielded twisted pair for sensors

NOTE: FG16OR and FG16R (HEPR insulation, PVC outer sheath) are permitted only as substitution where FG16OM16 is not commercially available in the required configuration; written approval from the COR is required before substitution. FG16OR is not standard and shall not be used as the default cable type.

NOTE: All cables installed in building construction works must carry CPR marking (Reg. (UE) 305/2011) with declared Euroclass per EN 50575. The minimum required Euroclass depends on the installation location — see Article 1.6.

1.3 DEFINITIONS

A. FG16OM16: CEI 20-13; standard cable for all HVAC power and control circuits; F = copper conductor; G = elastomeric insulation; 16 = HEPR (Hard Ethylene Propylene Rubber) compound 16, conductor temperature 90 °C; O = multicore unarmoured; M = rubber outer sheath; 16 = rubber compound M16, oil-resistant, halogen-free, flexible to −40 °C; 0.6/1 kV. Advantages over FG16OR: halogen-free rubber sheath (no HCl in case of fire); better resistance to ageing and chemicals in plant rooms; greater flexibility at low temperatures.

B. FG16OR / FG16R: CEI 20-13 (CPR designation); CPR-era renaming of pre-CPR types FG7OR and FG7R; F = copper conductor; G = elastomeric insulation; 16 = HEPR compound 16 (updated CPR classification of the former EPR 7 compound); O = multicore unarmoured; R = PVC compound R outer sheath; 0.6/1 kV; acceptable substitute where FG16OM16 is not available.

C. H07RN-F: harmonised European flexible cable (CENELEC HD 22.4 S4 / EN 50525-3-21); H = harmonised type; 07 = 450/750 V rated voltage; R = vulcanised elastomeric (EPR/EPDM) insulation; N = polychloroprene (neoprene) outer sheath; F = fine-strand flexible class 5 copper conductor per EN 60228; for final connections from LFMC conduit to motor terminal boxes and equipment.

D. FTG10(O)M1: CEI 20-45 fire-resistant cable; mineral-insulated or fire-resistant EPR; LSOH outer sheath; maintains circuit integrity ≥ 90 min per IEC 60331; required for safety-critical circuits.

E. CPR (Construction Products Regulation): Reg. (UE) 305/2011 requires all cables permanently installed in building structures to carry CE marking with declared Euroclass fire performance. Mandatory in all EU member states since 1 July 2017.

F. CPR Euroclass: fire classification per EN 13501-6 / EN 50575; classes from Aca (best — non-combustible) down to Fca (no performance declared). Sub-classes: s1/s2/s3 (smoke), d0/d1/d2 (flaming droplets), a1/a2/a3 (acidity of gases).

G. DoP (Declaration of Performance): mandatory document from cable manufacturer declaring the Euroclass and other CPR performance characteristics; required at submittal.

H. Sheathed cable: cable with an overall outer jacket enclosing all conductors; provides mechanical protection, chemical resistance, and identification; mandatory for single-core cables > 6 mm² on cable tray.

I. CCA (Copper Clad Aluminium): not permitted; all conductors shall be annealed copper per EN 60228.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
CEI 64-8	Electrical systems – user installations at nominal voltage ≤ 1000 V
CEI 20-13	Cables with elastomeric insulation and sheath – FG16R/FG16OR/FG16OM16 family (CPR designations)
CEI 20-38	Rubber-insulated cables – nominal voltage 450/750 V (H07RN-F)
CEI 20-22	Cables not propagating fire in bunched installations – IEC 60332-3
CEI 20-35	Flame non-propagation test – IEC 60332-1
CEI 20-37	Gas emission – halogen-free (zero-halogen) cables
CEI 20-45	Fire-resistant cables – IEC 60331
EN 60228	Conductors of insulated cables – cross-section classes (class 2 solid, class 5 flexible)
EN 50525-2-31	Electric cables – general applications – halogen-free thermoplastic insulated
EN 50525-3-21	Electric cables – rubber insulated – H07RN-F flexible cables
IEC 60502-1	Power cables with extruded insulation – rated voltages 1 kV to 30 kV
Reg. (UE) 305/2011	Construction Products Regulation (CPR) – mandatory CE marking for cables in buildings
EN 50575	Power, control, and communication cables – CPR fire performance classification
EN 13501-6	Fire classification of construction products – cables (Euroclass Aca to Fca)
CEI 64-8	Electrical systems – user installations (≤ 1000 V)
UNI EN 60364	Electrical systems in buildings (series)
CEI EN 60529	Degrees of protection (IP rating)
IEC 61158 / 61784	Modbus RTU/TCP fieldbus
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Cable schedule: listing each cable run; tag number, from/to, cable type, CPR Euroclass, conductor size (mm²), length, routing, and conduit reference.

B. Product data: manufacturer's data sheets for each cable type; voltage rating, insulation compound, fire performance Euroclass, temperature rating, and bending radius.

C. DoP (Declaration of Performance): mandatory for every cable type per Reg. (UE) 305/2011; declaring CPR Euroclass per EN 50575; submitted before procurement.

D. Test certificates: fire performance (IEC 60331/60332), halogen content (CEI 20-37) from accredited laboratory; traceable to EN 50575 / EN 13501-6.

E. Cable drawings: single-line diagram showing power distribution; block diagram showing control and BMS wiring.

1.6 QUALITY ASSURANCE AND CPR REQUIREMENTS

A. CPR mandatory marking: all cables shall be CPR-marked per Reg. (UE) 305/2011; Euroclass per EN 50575 / EN 13501-6 declared on cable sheath and in DoP. Cables without valid CPR marking shall not be installed.

B. Minimum Euroclass by installation zone:

1. Escape routes, stairwells, corridors used for evacuation: **B2ca-s1,d1,a1** minimum
2. Plant rooms, technical risers, general HVAC areas: **Cca-s1,d1,a1** minimum
3. Fire-resistant circuits (FTG10(O)M1): **B2ca-s1,d0,a1** or **Aca** minimum per local fire authority requirements
4. Class Eca and Fca: NOT permitted in any permanent building installation

C. Conductor material: annealed copper class 2 (rigid) or class 5 (flexible) per EN 60228; no aluminium conductors for cross-sections < 25 mm²; no CCA.

D. CEI 64-8 compliance: installation methods, cable sizing, overcurrent protection coordination.

E. Installation by qualified electricians; certification per D.M. 37/2008 for all HVAC electrical connections.

1.7 WARRANTY

A. All cables and accessories: **1 year** from Substantial Completion.

PART 2 – PRODUCTS

2.1 POWER CABLES — FG16OM16 (STANDARD)

A. Type FG16OM16 — standard for all HVAC power circuits: CEI 20-13; 0.6/1 kV; copper class 2 conductor; HEPR insulation compound 16 (90°C conductor temperature); rubber outer sheath compound OM16 (oil-resistant, halogen-free, flexible to –40°C); unarmoured for conduit/tray installation.

1. Conductor sizes: 1.5, 2.5, 4, 6, 10, 16, 25, 35, 50, 70, 95 mm² multi-core and single-core as designed
2. Temperature rating: +90°C conductor; –40°C installation; outer sheath oil-resistant (IEC 60811)
3. CPR Euroclass: minimum **Cca-s1,d1,a1** per EN 50575; DoP from manufacturer required

B. Type FG16OR (substitution only — not standard): CEI 20-13; HEPR compound 16 insulation; PVC outer sheath compound R (CPR-era renaming of the pre-CPR FG7OR designation); permitted only where FG16OM16 is not commercially available in the required size or core count; written COR approval required before use.

1. CPR Euroclass: minimum Cca-s1,d1,a1 per EN 50575
2. Limitation: PVC outer sheath releases halogen gases (HCl) in fire; not acceptable in escape routes, areas requiring LSOH cables, or as a default cable type

C. Type FG16R (armoured — specific applications only): CEI 20-13; HEPR insulation + galvanised steel wire armour (CPR-era renaming of the pre-CPR FG7R designation); for direct burial, exposed external runs, or where additional mechanical protection is required; COR approval required.

D. Minimum conductor sizes:

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1. Lighting circuits: 1.5 mm² minimum
2. Power socket circuits: 2.5 mm² minimum
3. Motor feeders: FLA × 1.25 per CEI 64-8; minimum 2.5 mm²
4. Main distribution feeders: sized by voltage drop; maximum 3% feeder to board; 5% total

E. Single-core cables > 6 mm² — sheathing rule:

1. On cable tray: single-core conductors > 6 mm² **shall be of the sheathed type** (FG16OM16 or FG16OR single-core with overall outer sheath); bare insulated conductors on open tray are not permitted above 6 mm²
2. In metallic conduit (EMT/IMC/RMC): sheathed cables are **strongly preferred**; individual insulated conductors without overall sheath are acceptable inside fully enclosed metallic conduit only

NOTE: The sheathing requirement for single-core cables > 6 mm² provides mechanical protection against installation damage, abrasion in conduit, oil exposure, and rodent damage in plant rooms. FG16OM16 single-core with rubber sheath is the standard solution for distribution feeders and motor circuits. FG16OR single-core (ex FG7OR) is acceptable as alternative.

2.2 FLEXIBLE CABLES — H07RN-F (EQUIPMENT FINAL CONNECTIONS)

A. Type H07RN-F: CENELEC HD 22.4 S4 / EN 50525-3-21; 450/750 V; EPR rubber insulation; polychloroprene (neoprene) outer sheath; flexible class 5 copper conductors; for final connections from LFMC conduit termination to motor terminal box and HVAC equipment.

1. Voltage: 450/750 V
2. Temperature: –25°C to +60°C continuous; peak +85°C
3. Use: within LFMC flexible conduit at equipment connection (see Section 260534 Art. 2.3); length ≤ LFMC length
4. CPR Euroclass: minimum Eca-s2; DoP from manufacturer required
5. Conductor sizes: 1.5 to 35 mm² as required for motor FLA

B. Not for: fixed conduit runs, cable trays, or any routed installation; H07RN-F is exclusively for the equipment connection point within LFMC flexible conduit.

C. Slack: leave 200 mm slack at equipment connection box to allow maintenance disconnection without disturbing the conduit system.

2.3 FIRE-RESISTANT CABLES

A. Application: fire alarm circuits, emergency lighting, smoke damper actuators, fire pump circuits, pressurisation fans, emergency ventilation, and all circuits required to function under fire conditions.

B. Type FTG10(O)M1: CEI 20-45; fire-resistant EPR insulation; copper class 2 conductor; LSOH outer sheath (CEI 20-37 zero-halogen); circuit integrity ≥ **90 minutes (FE90)** per IEC 60331-11.

1. CPR Euroclass: **B2ca-s1,d0,a1** minimum; Aca where required by local fire authority
2. Flame retardant: IEC 60332-1 (single) and IEC 60332-3 (bundle)
3. Minimum size: 1.5 mm² for control circuits; 2.5 mm² for power circuits under fire conditions

C. Colour code: red outer sheath for all fire-resistant cables; maintain red consistently throughout project.

D. Segregation: fire-resistant cables in dedicated metallic conduit or cable tray; do not share raceway with standard cables.

2.4 LSOH / HALOGEN-FREE CABLES

A. Application: underground car parks, tunnels, public areas, escape routes, and locations where halogen gas release in fire endangers occupants or sensitive equipment.

B. Type: CEI 20-37 Class 1 (zero-halogen content); CEI 20-35 (flame retardant); LSZH outer sheath.

C. CPR Euroclass: minimum **Cca-s1,d1,a1** for general areas; **B2ca-s1,d1,a1** for escape routes.

D. Note: FG16OM16 rubber-sheathed cables inherently have low halogen content; verify manufacturer's halogen declaration against CEI 20-37 limits when using FG16OM16 in LSOH-required areas.

2.5 CONTROL AND SIGNAL CABLES

A. Multi-core control cables: FG16OM16 multi-core; 0.6/1 kV; 0.75, 1.0, 1.5 mm² per core; for valve and damper actuators, sensor wiring, and 230 V control circuits. FG16(O)R multi-core only as COR-approved substitution where FG16OM16 is unavailable in the required core count.

1. Number of cores: as required; minimum 20% spare cores in each cable
2. Screen: overall aluminium/polyester tape screen with drain wire for control cables in VFD-noisy environments
3. CPR Euroclass: minimum Cca-s1,d1,a1

B. BACnet/IP network cable (standard): Cat6 F/UTP or S/FTP; 250 MHz bandwidth; in dedicated metallic conduit segregated from 230 V power cables; connect to building BACnet VLAN or dedicated BMS LAN.

C. BAS / BACnet MS/TP cable (RS-485 field bus): single-pair shielded twisted-pair instrumentation cable, AWG 22 (≈ 0.33 mm² conductor), low-capacitance construction (≤ 50 pF/m between conductors), characteristic impedance 100–120 Ω, with foil + braid shield and drain wire, suitable for RS-485 / BACnet MS/TP service — **unless otherwise specified by the equipment manufacturer**; drain shield bonded at one end only (at the BMS supervisor end); maximum segment length 1 200 m per RS-485 standard.

D. Modbus RTU cable (legacy): same specification as the BAS / BACnet MS/TP cable above; use only where BACnet is unavailable from the field device manufacturer.

E. 4–20 mA analogue signal: shielded twisted pair 0.5–1.0 mm²; screen drained at receiving end only.

2.6 CABLE IDENTIFICATION AND MARKING

A. Colour coding — Italian CEI 64-8 standard:

1. Phase L1: brown; Phase L2: black; Phase L3: grey (3-phase circuits)
2. Neutral (N): blue
3. Protective earth (PE): green/yellow
4. Control 230 VAC: any colour except green/yellow and blue
5. Control 24 VAC/VDC: violet or grey recommended
6. Fire-resistant circuits: red outer sheath

B. CPR marking: all cable sheaths shall display CPR Euroclass marking (e.g., Cca-s1,d1,a1), CE mark, EN 50575 reference, and manufacturer name; visible without unsheathing.

C. Cable markers: heat-shrink or clip-on markers at each end and at all junction boxes; marker shows cable tag number matching cable schedule.

D. Core markers: insulated bootlace ferrules at each core end; core number per cable schedule.

2.7 CABLE ACCESSORIES

A. Cable glands: IP-rated per enclosure IP rating; nickel-plated brass or stainless steel; nylon only for light-duty indoor dry locations; ATEX certified in classified hazardous areas.

B. Terminations: crimped compression lugs for conductors ≥ 10 mm²; insulated bootlace ferrules for all stranded conductor ends ≤ 6 mm²; no bare strands; no soldering as primary connection method.

C. Junction boxes: IP54 minimum in plant rooms; DIN rail terminal blocks; earth bar; size to allow 150 mm cable loop inside.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify conduits and metallic trunking (Section 260534) are installed, secured, and clean before pulling cables.

B. Confirm cable type and CPR Euroclass match the approved cable schedule and installation zone.

C. Verify segregation between power and signal/BACnet cables from conduit installation stage.

3.2 INSTALLATION

A. Cable fill: maximum 40% of conduit cross-sectional area (single cable); 33% for three or more cables per CEI 64-8.

B. Bending radius: minimum 8× cable diameter for FG16OM16 and FG16OR; 10× for armoured cables (FG16R); 5× for data cables.

C. Cable pulling: use lubricant compatible with cable sheath material; maximum pulling tension per manufacturer; pull rope attached to conductor bundle via pulling eye — never to core insulation ends.

D. Mechanical protection: all cables below 2.4 m in plant rooms must be in conduit or metallic trunking; no bare cable runs at accessible height.

E. Segregation: minimum 300 mm between power cables (230 V and above) and signal/control/BACnet cables; metallic barrier or separate conduit where 300 mm not achievable.

F. Earth continuity: maintain PE throughout; connect PE at every junction box; test continuity before energising.

G. Fire stopping: seal all cable penetrations through fire-rated walls and floors with intumescent putty or collars maintaining the rated fire period; record every penetration.

H. Terminations: identify each core with ferrule before terminating; tighten terminals to manufacturer's specified torque; no insulation under terminal clamp; no exposed bare conductor outside terminal.

3.3 TESTING AND COMMISSIONING

A. Insulation resistance test: each cable core to earth and between cores; minimum 1 MΩ at 500 V DC for 0.6/1 kV cables; minimum 100 MΩ at 500 V DC for control cables; record results per cable tag.

B. Continuity test: PE and neutral conductors; maximum 1 Ω end-to-end for circuits < 100 m.

C. Polarity test: confirm L, N, PE correct at all outlets and equipment terminals.

D. Loop impedance test: measure earth fault loop impedance at all power outlets and motor terminals; verify overcurrent device disconnects within required time per CEI 64-8.

E. Submit signed electrical inspection and test report (Rapporto di Verifica per D.M. 37/2008) before energising; signed by a qualified electrician licensed per D.M. 37/2008.

3.4 IDENTIFICATION AT HANDOVER

A. Provide complete as-built cable schedule: cable tags, types, CPR Euroclasses, routes, lengths, and test results.

B. Mark cable routes on as-built drawings; update BIM model where applicable.

C. File all DoPs (Declarations of Performance) in the project O&M manual.

END OF SECTION 260518

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SECTION 260526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 260518 - Low-Voltage Electrical Power Conductors and Cables
2. Section 260534 - Raceways and Boxes for Electrical Systems
3. Section 262913 - Motor-Control Centers / electrical panels
4. Section 238143 - Air-Source Heat Pumps
5. Section 237300 - Air Handling Units
6. Section 232113 - Hydronic Piping

1.2 SUMMARY

A. Scope: Furnish all labour, materials, and equipment for a complete grounding (earthing) and bonding system for the new HVAC electrical installation, coordinated with the existing building earthing system, including:

1. Protective conductors (PE) for all new circuits and equipment
2. Main and supplementary equipotential bonding
3. Earthing of the LV distribution boards / panels, enclosures, and Surge Protective Devices (SPD)
4. Bonding of the heat pumps, AHU, pumps, metallic piping, ducts and cable raceways/EMT
5. Connection to the existing main earthing terminal (collettore di terra) / earth electrode
6. Continuity / earth-resistance testing and D.P.R. 462/2001 documentation

B. Electrical safety: all work shall be planned and executed under a documented electrical safety program consistent with **NFPA 70E** (shock and arc-flash risk assessment, boundaries, PPE) and **CEI 11-27** (PES/PAV/PEI qualified personnel).

1.3 DEFINITIONS

A. PE (protective conductor): conductor for protection against electric shock, connecting exposed-conductive-parts to the main earthing terminal; colour green/yellow.

B. Main earthing terminal / collettore di terra: central node connecting earth electrodes, the main protective conductor, and main bonding conductors.

C. Equipotential bonding: electrical connection placing exposed and extraneous-conductive-parts at substantially the same potential (main bonding at services entry; supplementary bonding locally).

D. Earth electrode (dispersore): conductive part in electrical contact with the soil providing the connection to earth.

E. SPD (Surge Protective Device): device limiting transient overvoltages; requires a short, low-impedance earthing connection (Type 1 at the origin against lightning/LPS, per CEI EN 62305).

F. Arc-flash / shock risk assessment (NFPA 70E): evaluation of shock and arc-flash hazards to establish approach boundaries, incident energy and required PPE before energized work.

1.4 PERFORMANCE REQUIREMENTS

A. System type: coordinate with the existing earthing arrangement (TN-S / TT as installed); maintain separation of PE and N for TN-S; verify with the COR.

B. Earth-fault protection: earthing and PE sizing shall ensure operation of protective devices within the disconnection times of CEI 64-8 for the relevant system.

C. PE conductor sizing: per CEI 64-8 table 54.2/54.3 (e.g., S_PE = S_phase for S <= 16 mm2; 16 mm2 for 16<S<=35; S/2 above 35 mm2), or by calculation (adiabatic).

D. Earth resistance: coordinate R_A with the RCD/protection so that R_A x I_dn <= 50 V (TT); confirm by measurement.

E. SPD earthing: Type 1 SPD at the main / origin board connected to earth with the shortest practical conductor (<= 0.5 m preferred), minimum cross-section per CEI EN 62305 (e.g. 16 mm2 Cu for Type 1).

F. Equipotential bonding: all metallic equipment, panel enclosures, piping, ducts and raceways bonded to PE; supplementary bonding in the plant room.

1.5 APPLICABLE STANDARDS

Key Applicable Standards	
CEI 64-8 (part 5-54)	Earthing arrangements, protective conductors and protective bonding conductors (<= 1000 V)
CEI 64-12	Guide to the earthing system in buildings for telecommunications and electrical safety
IEC/HD 60364-5-54	Low-voltage installations - earthing arrangements and protective conductors
CEI EN 62305-1..4	Lightning protection (LPS) - equipotential bonding and earthing of SPDs
CEI EN 62561 (series)	Lightning protection system components - earthing/bonding components
D.P.R. 462/2001	Mandatory registration (denuncia) and periodic verification of earthing installations
D.M. 37/2008	Installation of building systems and Declaration of Conformity (DiCo)
NFPA 70E	Standard for Electrical Safety in the Workplace - arc-flash/shock risk assessment, PPE, safe work practices (Owner/US requirement)
CEI 11-27	Operation of and work on electrical installations - personnel qualification (PES/PAV/PEI)
CEI EN 60204-1	Safety of machinery - electrical equipment of machines (equipotential bonding of equipment)
CEI UNEL 00722	Identification of cables by colour - protective conductor green/yellow
CEI 64-8	Electrical systems – user installations (≤ 1000 V)
UNI EN 60364	Electrical systems in buildings (series)
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.6 SUBMITTALS

A. Earthing/bonding layout and schematic: main earthing terminal, electrodes, PE routing, bonding points; SPD earthing detail.

B. Conductor schedule: PE / bonding conductor sizes and types per the design (sizes provided by the Designer).

C. Product data: earthing conductors, clamps, bars, connectors, labels, test points.

D. Electrical safety program (NFPA 70E / CEI 11-27): shock and arc-flash risk assessment, approach boundaries, PPE schedule, lockout/tagout procedure, and personnel qualifications (PES/PAV/PEI).

E. Test reports: continuity of protective and bonding conductors; earth-electrode resistance; earth-fault loop impedance; RCD operation.

F. D.P.R. 462/2001: documentation for registration (denuncia) of the earthing installation and the Declaration of Conformity (DiCo, D.M. 37/2008).

1.7 QUALITY ASSURANCE

A. Installer: firm qualified under D.M. 37/2008 (lett. a); work on/near live parts only by PES/PAV/PEI-qualified personnel (CEI 11-27).

B. All energized-work decisions shall follow the NFPA 70E hierarchy: de-energize wherever practicable; energized work only under an energized-work permit with the assessed PPE.

PART 2 – PRODUCTS

2.1 CONDUCTORS

A. Protective and bonding conductors: copper, insulated green/yellow (CEI UNEL 00722) or bare where permitted; sized per Article 1.4.

B. Main bonding conductors: copper, minimum 6 mm2 (supplementary) and per CEI 64-8 for main bonding (typically >= 6 mm2, up to 25 mm2 Cu).

C. SPD earthing conductor: copper, minimum 16 mm2 for Type 1, as short and straight as practicable.

2.2 CONNECTORS, BARS AND ACCESSORIES

A. Earth bars / collettore: copper or tinned-copper earth bar with disconnecting links and labelled terminals.

B. Connectors: corrosion-resistant mechanical clamps, exothermic welds, or compression lugs rated for the conductor and environment; bi-metallic where dissimilar metals meet.

C. Pipe/duct bonding clamps: rated earthing clamps for the pipe/duct diameter; on a cleaned metallic surface.

D. Test points: accessible disconnecting links/test clamps for resistance measurement.

E. Labels: durable warning/identification labels: 'Nodo equipotenziale - non rimuovere' / 'Main earthing terminal'.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Locate and verify the existing main earthing terminal and earth electrode; measure existing earth resistance before connection.

B. Perform the NFPA 70E / CEI 11-27 risk assessment before any work near energized parts; establish boundaries and PPE; apply lockout/tagout.

3.2 INSTALLATION

A. Install PE conductors with every circuit; do not use the neutral as a protective conductor (maintain TN-S separation).

B. Bond all panel/board enclosures, equipment frames (e.g., heat pumps, AHUs, pumps, motors), metallic piping, ducts, and cable raceways/EMT to the PE/earthing system.

C. Connect the Type 1 SPD to earth with the shortest, straightest conductor; avoid sharp bends.

D. Provide supplementary equipotential bonding in the plant room linking extraneous-conductive-parts.

E. Make connections accessible, mechanically sound and corrosion-protected; use bi-metallic connectors between dissimilar metals; label test points and the earthing terminal.

F. Maintain electrical continuity across flanges/joints where relied upon for bonding (bonding straps where required).

3.3 FIELD QUALITY CONTROL (TESTING)

A. Continuity: test continuity/resistance of all protective and bonding conductors.

B. Earth-electrode resistance: measure and record; verify coordination R_A x I_dn <= 50 V (TT systems).

C. Loop impedance / RCD: measure earth-fault loop impedance and verify RCD trip times per CEI 64-8.

D. Documentation: submit signed test reports; complete D.P.R. 462/2001 registration and the D.M. 37/2008 Declaration of Conformity.

3.4 SAFETY AND ACCEPTANCE

A. Confirm all exposed-conductive-parts are bonded and protective measures are effective before energization.

B. Provide as-installed earthing/bonding drawings and the electrical safety documentation to the COR.

END OF SECTION 260526

SECTION 260534
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

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PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 260518 – Low-Voltage Electrical Power Conductors and Cables
2. Section 262913 – Motor-Control Centers
3. Section 230900 – Instrumentation and Controls for HVAC
4. Section 232123 – Hydronic Pumps

1.2 SUMMARY

A. Scope: Furnish and install all conduit systems, metallic cable trays, metallic trunking, and junction/outlet boxes for HVAC electrical and control wiring.

B. Permitted raceway types (metallic only):

1. EMT (Electrical Metallic Tubing) — standard for all indoor HVAC runs
2. IMC (Intermediate Metal Conduit) — for exposed, outdoor, and heavy-duty zones
3. RMC (Rigid Metal Conduit) — for direct burial and highest mechanical protection
4. LFMC (Liquidtight Flexible Metal Conduit) — final connections to vibrating equipment only
5. Perforated metallic cable trays and cable ladders — for main power and control runs
6. Metallic trunking (cable duct) — for surface-mounted runs in plant rooms and finished areas
7. Junction boxes, pull boxes, and outlet boxes — pressed steel or die-cast aluminium

*NOTE: Plastic (PVC/HDPE) conduit and nonmetallic flexible conduit (LFNC) are NOT permitted anywhere in this project. Primary basis: **CEI 64-8** for general installation methods and **EN 13501-1** for reaction-to-fire performance in air-handling spaces. NFPA 70 Art. 300.22 (plenum cabling) and NFPA 90A (HVAC materials) are referenced as concurrent best practice but are not cogent in Italy.*

1.3 DEFINITIONS

A. EMT (Electrical Metallic Tubing): thin-wall galvanised steel conduit per NFPA 70 Art. 358 and EN 61386-21 Class 3; connected with compression or set-screw fittings (no threads); standard wiring method for all indoor commercial HVAC electrical runs.

B. IMC (Intermediate Metal Conduit): medium-wall galvanised steel conduit per NFPA 70 Art. 342; threaded fittings; used for exposed outdoor runs, mechanical protection zones, and locations requiring greater crush resistance than EMT.

C. RMC (Rigid Metal Conduit): heavy-wall galvanised steel conduit per NFPA 70 Art. 344; threaded; for direct burial, concrete encasement, and highest mechanical protection requirements.

D. LFMC (Liquidtight Flexible Metal Conduit): helically wound galvanised steel strip with liquidtight PVC outer jacket per NFPA 70 Art. 350; used exclusively for the final 300–600 mm connection to vibrating HVAC equipment (motors, compressors, AHUs); provides vibration absorption while maintaining metallic ground continuity and liquidtight IP67 rating.

E. PE (Protective Earth Conductor) / EGC (Equipment Grounding Conductor): dedicated green/yellow protective conductor ensuring fault current returns to source. On this project, per **CEI 64-8 Section 543**, a separate green/yellow PE conductor shall be installed in every circuit alongside the live conductors; the metallic conduit alone is NOT relied upon as the protective earth conductor. The metallic raceway itself shall additionally be bonded to earth at terminations and at suitable intervals for mechanical fault path and EMC purposes, but does not replace the dedicated PE conductor required by CEI 64-8.

F. Plenum space: air-handling space above suspended ceilings or below raised floors used as return-air path; per NFPA 70 Art. 300.22 and NFPA 90A, only metallic conduit or plenum-rated cable permitted.

G. Cable tray: open metallic support system (perforated tray or ladder) for grouped cable runs; provides mechanical support but not a closed conduit; cables not individually protected from mechanical damage — use in accessible locations only.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
CEI 64-8	Electrical systems – user installations ≤ 1000 V (Italian transposition of HD 60364); primary cogent standard
EN 61386-1	Conduit systems for cable management – general requirements
EN 61386-21	Conduit systems – rigid metallic conduits (rigid steel conduit equivalent to IMC/RMC)
EN 61386-22	Conduit systems – pliable metallic conduits
EN 61386-23	Conduit systems – flexible metallic conduits (equivalent to LFMC)
EN 50085-1	Cable trunking and cable ducting systems – general requirements
EN 50085-2-1	Cable trunking systems intended for mounting on walls and ceilings
EN 61537	Cable management – cable tray systems and cable ladder systems
CEI EN 60529	Degrees of protection (IP) – boxes and enclosures
EN 60423	Conduit systems – outside diameters and threads
EN 13501-1	Fire classification – reaction to fire for cable management systems
NTC 2018 §7.2.3	Norme Tecniche per le Costruzioni – seismic bracing of non-structural elements
Circ. 21/01/2019 n.7	NTC 2018 application instructions
NFPA 70 (NEC)	National Electrical Code – US standard, referenced here only for terminology (EMT/IMC/RMC/LFMC) and plenum-space best practice; **not cogent in Italy** — grounding/earthing follows CEI 64-8
NFPA 90A	Standard for the Installation of Air-Conditioning and Ventilating Systems – US standard; referenced for plenum-space material guidance only
CEI 64-8	Electrical systems – user installations (≤ 1000 V)
UNI EN 60364	Electrical systems in buildings (series)
CEI EN 60529	Degrees of protection (IP rating)
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act

1.5 SUBMITTALS

A. Product data: manufacturer's data sheets for each raceway type; material, wall thickness, IP rating, fire class, and load capacity.

B. Raceway layout drawings: conduit and tray routing on structural drawings; hanger spacing; penetration schedules; EMT/IMC/RMC designation by zone.

C. Seismic bracing plan: lateral and longitudinal bracing per NTC 2018 §7.2.3 (non-structural elements) and Circolare 21/01/2019 n.7.

D. Plenum compliance statement: written confirmation that all wiring methods in air-handling spaces comply with NFPA 70 Art. 300.22 and NFPA 90A.

1.6 QUALITY ASSURANCE

A. All metallic raceway systems: CE marked per applicable EN standard; listed per UL 797 (EMT), UL 1242 (IMC), or UL 6 (RMC) where NFPA 70 compliance is required.

B. Metallic raceways bonded to earth throughout; continuity tested per CEI 64-8 and NFPA 70 Art. 250.

C. **Plastic conduit and LFNC are not permitted** — verify at inspection; non-compliant installations to be removed and replaced at Contractor's cost.

D. **D.M. 37/2008 and CEI 64-8 are the primary cogent standards** for installation methods. EN 61386 series and EN 50085 series apply to product conformity. NFPA 70 / NFPA 90A are referenced as best-practice for terminology and plenum-space guidance; where NFPA imposes a more stringent requirement than the European standards on a topic explicitly cited in this Section, the more stringent shall apply.

1.7 WARRANTY

A. All raceway systems: **1 year** from Substantial Completion.

PART 2 – PRODUCTS

2.1 EMT — ELECTRICAL METALLIC TUBING (STANDARD INDOOR CONDUIT)

A. **Standard:** NFPA 70 Art. 358; EN 61386-21 Class 3; UL 797 listed.

B. **Material:** cold-drawn carbon steel; electrolytic zinc-coated (galvanised) inside and outside.

C. **Diameter range:** 16, 20, 25, 32, 40, 50, 63 mm nominal (metric); or ½", ¾", 1", 1¼", 1½", 2" trade size (inch-series) as shown on drawings.

D. **Fittings:** steel compression couplings and connectors (raintight type outdoors); set-screw type for concealed dry locations only; steel locknuts; steel insulated bushings at all conduit terminations in enclosures.

E. **Use:** all indoor HVAC electrical and control cable runs — in plant rooms, ceiling voids, wall chases, and above suspended ceilings (plenum spaces).

F. **Earth bonding of raceway:** ensure all compression / set-screw fittings are fully tightened so that the metallic raceway itself remains electrically continuous and bonded to the earthing system at terminations. This bonding is **in addition to** the dedicated green/yellow PE conductor required inside the raceway per CEI 64-8; it does not replace it.

NOTE: EMT is the default conduit type for all indoor runs. Use IMC or RMC only where EMT does not provide sufficient mechanical protection (e.g., areas exposed to physical damage, below 2.4 m in plant rooms, outdoor, or direct burial).

2.2 IMC AND RMC — INTERMEDIATE AND RIGID METAL CONDUIT

A. **IMC standard:** NFPA 70 Art. 342; UL 1242; EN 61386-21 Class 4; threaded fittings.

B. **RMC standard:** NFPA 70 Art. 344; UL 6; EN 61386-21 Class 4 (heavy); threaded fittings.

C. **Material:** hot-dip galvanised steel; stainless AISI 316 or PVC-coated galvanised for coastal / chemical environments.

D. **Fittings:** malleable iron or steel; galvanised; threaded couplings; weatherproof threaded hubs at enclosures; drain fittings at low points on outdoor runs.

E. **Use of IMC:** areas exposed to physical damage (below 2.4 m in plant rooms), outdoor runs, conduit on building exterior.

F. **Use of RMC:** direct burial (minimum 450 mm cover per NFPA 70 Table 300.5); concrete-encased runs; areas with highest mechanical impact risk.

G. **Earth bonding of raceway:** threaded joints provide reliable mechanical and electrical continuity; bond raceway to earthing system at terminations. As for EMT (Article 2.1), the metallic raceway bonding is supplemental to — and does not replace — the dedicated green/yellow PE conductor required inside the raceway per CEI 64-8.

2.3 LFMC — LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. **Standard:** NFPA 70 Art. 350; UL 360; EN 61386-23.

B. Construction: helically-wound galvanised steel strip with outer liquidtight PVC jacket; metallic core provides mechanical bonding continuity for the raceway.

C. Application: final **300–600 mm** connections to all vibrating HVAC equipment — motors, compressors, AHUs, fan-coil units, heat pumps; connections to panel-mounted equipment requiring flexibility for maintenance removal.

D. IP rating: IP67 when assembled with LFMC liquidtight fittings (threaded steel with sealing gland).

E. Maximum length: 1800 mm per NFPA 70 Art. 350.30 (or shorter per voltage drop calculation); not to be used as a substitute for properly routed rigid conduit.

F. Minimum bend radius: 7× nominal conduit diameter.

G. Grounding: a dedicated green/yellow PE conductor shall be run inside LFMC per CEI 64-8 Section 543; the LFMC casing shall additionally be bonded to earth at both termination glands to ensure mechanical continuity of the raceway.

NOTE: Liquidtight Flexible NONmetallic Conduit (LFNC / FNMC, NFPA 70 Art. 356) is NOT permitted on this project. All flexible conduit connections to HVAC equipment shall be LFMC only.

2.4 METALLIC CABLE TRAYS AND LADDERS

A. Perforated cable tray: hot-dip galvanised steel; 1.5 mm thickness for trays ≤ 300 mm wide; 2.0 mm for wider; perforation ≥ 30% of base area for cable ventilation.

B. Cable ladder: for heavy power feeders; galvanised steel; rung spacing 300 mm maximum; side rails minimum 50 mm deep.

C. Width: as shown on drawings; minimum 150 mm; size for design cable fill + 30% spare capacity.

D. Supports: wall brackets or trapeze hangers; maximum 1500 mm centres on straight runs; 600 mm either side of bends and tees.

E. Covers: mandatory in plenum spaces (NFPA 90A); in all areas exposed to dripping water or mechanical damage.

F. Seismic bracing: lateral and longitudinal bracing per NTC 2018 §7.2.3 and Circolare n.7/2019 at maximum 6 m intervals.

G. Segregation: separate trays for power cables (230 V and above) and signal/control/BACnet cables; minimum 300 mm separation or metallic divider; never share a tray with different voltage classes without a fixed metallic divider.

H. Earthing: bond across every joint with proprietary earth bonding links; test continuity of complete tray run before cable installation.

2.5 METALLIC TRUNKING (CABLE DUCT / WIREWAY)

A. Standard: EN 50085-1; NFPA 70 Art. 376 (Metal Wireways).

B. Material: galvanised steel or powder-coated steel; snap-lid or hinged-lid cover; IP40 standard; IP54 with sealed covers for plant rooms.

C. Use: surface-mounted runs in plant rooms, finished office areas, and anywhere plastic trunking would otherwise be specified.

D. Fill: maximum 20% of cross-sectional area for conductors (NFPA 70 Art. 376.22); 75% for a single conductor.

E. Partitioned trunking: two-compartment metallic trunking where power and signal cables must share the same duct; metallic divider fixed throughout full length.

F. EMC-screened trunking: fully sealed metallic trunking (no perforations) for BACnet/IP, control, and sensor cable runs adjacent to VFD power cables.

NOTE: PVC (plastic) trunking is NOT permitted. All cable ducting shall be metallic, consistent with the all-metallic raceway policy of this project.

2.6 JUNCTION BOXES AND OUTLET BOXES

A. Standard junction boxes: pressed steel; IP54 in plant rooms and above ceiling voids; IP44 in dry finished areas; knock-outs all four sides and base; earthing lug inside.

B. Weatherproof boxes (outdoor): die-cast aluminium or GRP (glass-reinforced polyester); IP65; stainless steel screws; neoprene gasket.

C. HVAC-specific pull boxes: where cable changes direction or pull length exceeds 30 m; minimum 300 mm × 300 mm × 100 mm deep; hinged lid; accessible at all times — no permanent concealment behind fixed structure.

D. Terminal boxes at equipment: IP54 minimum; DIN rail terminal blocks; earth bar; wiring diagram laminated inside lid.

E. Marking: label all junction and pull boxes with permanent markers showing circuit numbers and distribution board reference.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Confirm structural elements are complete before installing conduit supports; identify all penetrations through rated walls and floors and obtain structural engineer approval before coring.

B. Confirm that all specified conduit types in the submitted raceway drawings are metallic; reject any non-metallic conduit specified in error.

3.2 INSTALLATION — EMT / IMC / RMC CONDUIT

A. Install conduit to neat, parallel, and plumb lines; parallel to building grid; no diagonal runs unless unavoidable and approved.

B. Support spacing: EMT maximum 1500 mm and within 900 mm of each box, fitting, or cabinet per NFPA 70 Art. 358.30; IMC/RMC maximum 3 m and within 900 mm of terminations.

C. Bends: use factory or hydraulic-bender-formed bends; minimum bending radius 6× conduit diameter; no kinking, flattening, or heat-formed bends.

D. Expansion joints: install conduit expansion couplings where conduit crosses structural expansion joints.

E. Metallic raceway earth bonding: bond every metallic raceway run to the building earthing system at terminations; ensure all compression / threaded fittings are wrench-tight to maintain mechanical-continuity bonding of the raceway; test raceway continuity (≤ 0.5 Ω end-to-end) before cable installation. This bonding is in addition to the dedicated green/yellow PE conductor required inside the raceway per CEI 64-8.

F. Concrete-embedded conduit: IMC or RMC only; secure to rebar at 600 mm centres; protect open ends with foam plugs; minimum cover 40 mm concrete.

G. Plenum spaces: all conduit runs in ceiling voids used as air-handling return plenum shall be EMT minimum; verify classification with mechanical engineer before installation.

H. Fire stopping: seal all conduit penetrations through fire-rated walls and floors with intumescent putty or collars maintaining the rated fire period; document all penetrations with photo record.

3.3 INSTALLATION — LFMC FLEXIBLE CONDUIT

A. Install LFMC only at equipment termination points — not as a routing method over distances.

B. Cut LFMC square with a hacksaw; remove burrs; install liquidtight fittings hand-tight plus ¾ turn with wrench.

C. Support LFMC within 300 mm of each fitting; no unsupported spans greater than 900 mm.

D. Verify that LFMC maintains sufficient slack to absorb equipment vibration without tensioning the conduit; provide a single loop or offset where necessary.

NOTE: Inspect all flexible connections after 6 months of operation; replace any conduit showing outer jacket cracking or inner core corrosion. Record in maintenance log.

3.4 INSTALLATION — CABLE TRAY AND METALLIC TRUNKING

A. Install cable tray continuous and level; butt-joint with matching couplers and earth bonding straps across every joint.

B. Provide purpose-made radius fittings at all direction changes; no site-cut sharp-edge bends in tray base.

C. Do not support other services from cable tray or trunking.

D. Secure cables on open tray with cable ties at 300 mm centres on horizontal runs; 200 mm on vertical runs.

E. Test earth continuity of complete tray/trunking run before cable installation; document results.

3.5 INSTALLATION — BOXES

A. Mount junction boxes flush with finished wall in finished spaces; surface-mounted in plant rooms.

B. Install weatherproof gaskets on all outdoor box lids; seal conduit entries with appropriate LFMC fittings or compound.

C. Leave minimum 150 mm spare cable coiled inside each junction box; tag each cable with marker sleeve at entry point.

D. Plug all unused knock-outs with IP-rated plugs matching box IP rating; no open knock-outs permitted.

3.6 TESTING AND INSPECTION

A. Conduit continuity: test metallic conduit earth continuity on each run; maximum 0.5 Ω end-to-end; record results per circuit.

B. Visual inspection: verify 100% metallic raceways — no plastic conduit or LFNC installed anywhere; non-conformances to be corrected before cable pull.

C. Raceway integrity: verify all box covers secured; all penetrations sealed; IP rating maintained; LFMC fittings wrench-tightened.

D. Plenum compliance check: before ceiling closure, confirm all wiring in air-handling ceiling void is in metallic conduit or plenum cable; sign off on NFPA 90A compliance checklist.

E. Submit signed raceway inspection report; include in electrical commissioning report per Section 260518.

END OF SECTION 260534

SECTION 262913
MOTOR-CONTROL CENTERS

Technical Specification — Coordinated with Italian / EU Standards
FAC ENGINEERING ROME | May 23, 2026 | Rev. 0

SENSITIVE BUT UNCLASSIFIED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract apply to this Section.

B. Related Sections:

1. Section 260518 – Low-Voltage Electrical Power Conductors and Cables
2. Section 260534 – Raceways and Boxes for Electrical Systems
3. Section 232123 – Hydronic Pumps
4. Section 237300 – Air Handling Units
5. Section 238143 – Air-Source Heat Pumps
6. Section 230900 – Instrumentation and Controls for HVAC
7. Section 260526 – Grounding and Bonding for Electrical Systems

1.2 SUMMARY

A. Scope: Furnish and install motor control centers (MCC), power distribution boards, and related variable frequency drives (VFD) for all HVAC mechanical equipment.

B. Included assemblies:

1. Motor control centers for pumps and fans (multi-compartment, plug-in unit type)
2. Individual motor starters (DOL and star-delta) in dedicated enclosures
3. Variable frequency drives (VFD/inverter) for controlled motors
4. Distribution boards for HVAC power distribution
5. Interface panels for BMS control signals

1.3 DEFINITIONS

A. MCC (Motor Control Center): multi-compartment assembly housing motor starters, VFDs, and protection devices in a common enclosure; structured wiring bus; withdrawable or plug-in compartments.

B. DOL (Direct-On-Line) starter: simplest motor starter; applies full voltage directly; suitable for motors ≤ 5.5 kW or where starting current is not restricted.

C. Star-Delta starter: reduces starting current by starting motor in star connection and switching to delta after run-up; suitable for motors 5.5–22 kW; torque dip at switchover.

D. VFD (Variable Frequency Drive / Inverter): adjusts motor speed by varying supply frequency and voltage; minimum current at start; best energy efficiency at part load.

E. SFP (Specific Fan Power): W/(m³/s); minimised by VFD operation of supply and return fans.

F. THDi (Total Harmonic Current Distortion): distortion of supply current due to VFD switching; limited by input filter/reactor.

1.4 APPLICABLE STANDARDS

Key Applicable Standards	
IEC 61439-1	Low-voltage switchgear and controlgear assemblies – general rules
IEC 61439-2	Low-voltage switchgear and controlgear assemblies – power switchgear and controlgear assemblies
IEC 61439-3	Low-voltage switchgear and controlgear assemblies – distribution boards
EN 60947-4-1	Low-voltage switchgear – AC motor starters (direct-on-line and star-delta)
EN 60947-2	Low-voltage switchgear – circuit-breakers
EN 60947-3	Low-voltage switchgear – switches, disconnectors, switch-disconnectors

EN 61800-5-1	Adjustable speed electrical power drive systems – safety requirements
EN 61800-3	Adjustable speed electrical power drive systems – EMC requirements
EN 55011	Industrial, scientific and medical equipment – radio disturbance
EN 60529	Degrees of protection (IP rating)
EN 60034-30-1	Motor efficiency classes IE1–IE5
CEI 64-8	Electrical systems – user installations
CEI EN 60898-1	Circuit-breakers for household and similar installations
CEI EN 61643-11	Surge protective devices connected to LV power systems – requirements and tests
CEI EN 62305-1..4	Protection against lightning – SPD selection and coordination
CEI EN 62423	Type F and Type B residual current circuit-breakers (inverter / VFD loads)
CEI EN 61008/61009	Residual current operated circuit-breakers (RCCB / RCBO)
Dir. 2014/68/UE	Pressure Equipment Directive (for compressed air systems, if applicable)
Dir. 2006/42/CE	Machinery Directive – power drive systems
CEI 64-8	Electrical systems – user installations (≤ 1000 V)
UNI EN 60364	Electrical systems in buildings (series)
CEI EN 60529	Degrees of protection (IP rating)
IEC 61158 / 61784	Modbus RTU/TCP fieldbus
ASHRAE 135	BACnet communication protocol
EIA-485	RS-485 electrical interface standard
D.M. 37/2008	Building systems – installer qualifications and requirements
D.Lgs. 192/2005 e s.m.i.	Energy performance of buildings
D.Lgs. 81/2008	Consolidated Workplace Safety Act
D.P.R. 380/2001	Consolidated Building Code

1.5 SUBMITTALS

A. MCC drawings: front elevation showing compartment layout, door sizes, busbar positions, and cable entry zones; single-line diagram of complete MCC.

B. Compartment schedule: list of all starters, VFDs, and MCBs; motor tag, kW, FLA, protection rating, starting method, and BMS interface.

C. VFD data sheets: efficiency vs. speed curve, harmonic spectrum (THDi), input filter specification, Modbus/BACnet register map.

D. Factory type test reports: IEC 61439-1 verification reports for the MCC assembly type.

E. CE declarations: IEC 61439-2, Machinery Directive for VFDs, EMC Directive.

F. Protection device schedule: all MCCBs/MCBs (frame, In, trip settings, Icu/Ics) and RCDs (type, Idn, selectivity), with explicit identification of **Type B** RCDs on inverter/VFD circuits.

G. SPD data: type (1 / 1+2 / 2 / 3), Iimp/In/Up ratings, backup protection, and coordination per CEI EN 61643-11 / CEI EN 62305.

H. Heat dissipation data: total heat output from MCC and individual VFDs; required for ventilation/air conditioning sizing of MCC room.

I. O&M manual: wiring diagrams as-built; maintenance schedule for contactors, VFD filters, and cooling fans.

1.6 QUALITY ASSURANCE

A. MCC assembly type-tested per IEC 61439-1/-2; test reports shall cover: temperature rise, short-circuit withstand, dielectric properties, IP classification, and mechanical operation.

B. VFDs: CE marked per EMC Directive 2014/30/UE; EN 61800-3 category C2 minimum for installations near residential buildings.

C. THDi: all VFDs > 7.5 kW to include DC bus choke or input line reactor; THDi ≤ 10% at PCC with all drives operating.

D. Motors: IE3 efficiency class minimum; IE4 for pump motors > 7.5 kW per **Reg. (UE) 2019/1781** (current motor ecodesign regulation, supersedes Reg. (CE) 640/2009 from July 2021).

E. Assembly by certified panel builder; IEC 61439-1 declarations submitted.

1.7 WARRANTY

A. MCC assembly: **1 year** from Substantial Completion.

B. VFDs: **1 year** including power electronics and control boards.

C. On-site support: response within 8 hours for drive failure during warranty period.

PART 2 – PRODUCTS

2.1 MCC ENCLOSURE

A. Type: floor-standing, multi-compartment, modular; minimum 2000 mm high × 600 mm deep; width in 200 mm increments.

B. Construction: 2.0 mm minimum steel sheet; powder-coated RAL 7035; internal galvanised steel frame; individual compartment steel partitions.

C. IP rating: IP41 for indoor dry MCC rooms; IP54 for damp or outdoor locations.

D. Busbars: copper 98% conductivity; silver-plated joints; sized for 125% of maximum simultaneous load; full-length horizontal busbar; rising main busbar for multi-section assemblies.

E. Compartments: withdrawable or plug-in type; each compartment independently shuttered; motor status indicator (green = run, red = fault) on door.

F. Cable entry: bottom entry preferred (gland plates); top entry where required; cable management channels within enclosure.

G. Ventilation: natural convection or forced ventilation with filtered inlet and exhaust; thermostat-controlled fan in VFD sections.

H. Door interlocks: mechanical interlock preventing door opening when compartment is live; defeatable with tool for authorized personnel only.

2.2 MOTOR STARTERS – DIRECT-ON-LINE (DOL)

A. Application: motors ≤ 5.5 kW where starting current is not restricted; small circulator pumps, small fans.

B. Components per starter:

1. Isolating switch-disconnector: rotary, lockable, full-load breaking capacity
2. Motor circuit breaker (MCB/MPCB) with adjustable thermal and magnetic trip; rated FLA +20%
3. Main contactor: AC3 rating ≥ motor kVA; minimum 100,000 operations mechanical endurance
4. Thermal overload relay: class 10A; bimetal type; manual or auto-reset selectable; trip on single-phase loss
5. 24 VAC control circuit: Start/Stop pushbuttons on door; AUTO/MANUAL selector; run indicator lamp; fault indicator lamp
6. BMS interface: 24 VDC digital input for remote start/stop; volt-free contact output for run status; volt-free contact for fault

2.3 MOTOR STARTERS – STAR-DELTA

A. Application: motors 5.5–22 kW where direct-on-line starting is restricted by supply authority or where motor torque permits star-delta transition.

B. Components: as DOL plus main, star, and delta contactors; solid-state timer (adjustable 2–30 s); current surge suppressor across delta contactor.

C. Wiring: six-wire motor connection required (separate star and delta windings accessible at terminal box).

NOTE: Star-delta starters cause torque dip at changeover. For pumps with low starting torque they are suitable. For fans with high load inertia, consider VFD instead.

2.4 VARIABLE FREQUENCY DRIVES (VFD / INVERTER)

A. Application: all pumps > 1.1 kW; all AHU supply and return fans; heat pump outdoor fans where controllable; other equipment as noted.

B. Power range: 0.37–630 kW from single manufacturer for project.

C. Input: 400 V ±10%, 3-phase, 50 Hz; wide voltage range tolerance.

D. Output: 0–50 Hz (or higher for special applications); V/f or vector control; built-in PID controller for constant pressure/flow mode.

E. Protection: electronic motor protection (overcurrent, overtemperature, phase loss, undervoltage); no separate overload relay required when VFD provides full motor protection.

F. EMC: built-in Class C2 EMC filter (EN 61800-3); DC bus choke for THDi < 10% for drives > 7.5 kW.

G. Braking: DC injection braking as standard; dynamic braking resistor for high-inertia loads (fans > 15 kW) where required.

H. Minimum speed: programmable; set to 20 Hz minimum for fans to prevent motor overheating at low speed.

I. BMS/Control interface:

1. Analogue input: 0–10 V or 4–20 mA speed reference from BMS
2. Digital inputs: remote enable/disable, forward/reverse, fault reset
3. Analogue outputs: 0–10 V speed feedback, 4–20 mA motor current
4. Digital outputs: running, fault, at-speed
5. Communication: **BACnet/IP or BACnet MS/TP** as standard (ASHRAE 135 / EN ISO 16484-5); Modbus RTU as legacy alternative

J. Enclosure: IP21 for MCC-mounted; IP54 for wall-mounted in plant room.

K. Integral bypass: for critical circuits (e.g., pressurisation fans), provide manual bypass contactor to allow DOL operation when VFD fails.

L. Copy keypad: portable parameter copy/restore keypad for commissioning and replacement.

2.5 DISTRIBUTION BOARDS

A. Type: flush or surface-mounted, metal or thermoplastic enclosure; IP40 indoor; IP54 in plant rooms.

B. Main switch: rotary isolating switch; lockable OFF; full-load breaking capacity.

C. MCBs (final circuits): Type B (general) or Type C (motor circuits) per CEI EN 60898-1; breaking capacity ≥ prospective short-circuit current at installation point.

D. MCCBs (main incomers and frames > 125 A): molded-case circuit-breakers per EN 60947-2 with adjustable thermal-magnetic or electronic trip units; rated breaking capacity Icu/Ics stated and ≥ the prospective fault level at the board (e.g., **36 kA** where required); 4-pole with neutral protection where required; main breaker arranged as a lockable disconnector.

E. RCD protection – general: Type A residual current device (30 mA) for socket and lighting circuits per CEI 64-8.

F. RCD protection – inverter / VFD circuits (mandatory): all circuits supplying frequency converters / inverter-driven equipment (e.g., inverter-driven heat pumps/chillers, pumps and fans) shall be protected by **Type B** RCDs / RCBOs per CEI EN 62423 / CEI 64-8, to ensure correct tripping in the presence of smooth DC residual currents that blind Type A/AC devices; provide time-delayed / selective (S-type) RCDs where upstream–downstream selectivity is required.

G. Busbar: 63–160 A copper per phase + neutral + earth; 100% rated neutral for 3-phase circuits with harmonic load.

H. Spare capacity: minimum 25% spare MCB ways; physical space for 50% expansion.

2.6 METERING AND MONITORING

A. Each MCC section shall include:

1. Ammeter with phase selector switch (or 3 separate ammeters) on main incomer
2. Voltmeter with phase/line selector on main incomer
3. Energy meter (kWh) with pulsed output for BMS; class 1.0 accuracy
4. Power factor meter or correction capacitor bank (if required by supply authority)

B. Individual VFD sections: VFD display shows motor speed, current, power; readable through enclosure door.

C. Energy meters / multimeters with **RS485 (Modbus)** communication to the BMS where indicated (e.g., one per major load).

2.7 SURGE PROTECTIVE DEVICES (SPD)

A. Standard: SPDs per CEI EN 61643-11, selected and coordinated per CEI EN 62305 (lightning protection) and CEI 64-8.

B. Main / origin board: where the installation is exposed to lightning or connected to an external lightning-protection system (LPS), provide a **Type 1 (or combined Type 1+2)** SPD, 4-pole, with impulse current limp rated for the site lightning-protection level (LPL).

C. Sub-distribution / sensitive equipment: Type 2 SPD where required; Type 3 at terminal equipment where indicated; maintain SPD coordination between stages.

D. Backup protection: protect each SPD with the manufacturer-specified backup overcurrent device (e.g., dedicated 4P fuses) where the upstream protection exceeds the SPD's maximum rating.

E. Connection and earthing: total length of the SPD connecting leads to the earthing terminal ≤ 0.5 m; earthing/bonding per Section 260526.

F. Indication: local end-of-life / status indicator; volt-free remote-signalling contact to the BMS where indicated.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify MCC room dimensions, floor-to-ceiling height, and access door width accommodate MCC transport and installation.

B. Confirm structural floor loading capacity ≥ MCC weight per m².

C. Verify ventilation/cooling of MCC room is adequate for total MCC heat dissipation.

3.2 INSTALLATION

A. Foundation: install on floor channel sills or grout-filled channels; level to ±1 mm/m; anchor to floor with M12 bolts.

B. Busbar jointing: use manufacturer's jointing kits; tighten to specified torque; apply contact grease to all busbar joints.

C. Cable entry: dedicate gland plate sections per section; label all gland plates with circuit numbers before cable installation.

D. Earthing: connect main earth bar to building earth; minimum 50 mm² copper earth cable; each section bonded to main earth bar.

E. Anti-condensation heaters: install where MCC is exposed to temperature cycling (outdoor or near-outdoor); connect to separate supply maintained when MCC is de-energised.

3.3 VFD COMMISSIONING

A. Set motor nameplate parameters: rated voltage, FLA, frequency, power factor.

B. Set acceleration and deceleration ramps; adjust to avoid process shock; record final settings.

C. Enable motor protection parameters: overload class, phase loss protection.

D. Configure BMS interface: set BACnet Device Instance, network address, and object list per Section 230900; verify BMS reads speed, current, and fault status via BACnet/IP or BACnet MS/TP.

E. Set minimum and maximum frequency; test across full speed range; measure motor current at design duty point.

F. Document all parameter settings in commissioning report; provide parameter back-up copy.

3.4 TESTING AND ACCEPTANCE

A. **Insulation resistance:** test all feeder cables before connection; main busbar test at 1000 V DC; document results.

B. **Functional testing:** simulate each BMS start/stop command; verify contactor operation, DOL start sequence, star-delta changeover, and VFD speed response.

C. **Protection testing:** test overload relay trip for each motor (by introducing overcurrent); test VFD protection functions.

D. **RCD testing:** test trip current and time for all RCDs, including verification of **Type B** devices on inverter / VFD circuits.

E. **SPD verification:** confirm SPD type/rating per board, status indication, backup protection, and short (≤ 0.5 m) earthing-lead connection.

F. **Harmonic measurement:** measure THDi at MCC incoming busbar with all drives operating at 75% load; record; confirm ≤ 10%.

G. Submit signed test and commissioning report before energising permanently.

3.5 IDENTIFICATION

A. Label each compartment and door with motor tag, kW, and description; labels engraved or printed on metal/plastic; not adhesive tape.

B. Post single-line diagram inside main MCC door; laminated A3 format.

C. Label all cables, terminal strips, and busbar sections per cable schedule.

END OF SECTION 262913