
HEAT PUMP TRAINING PROGRAM

Course 7 – Installation Practice

One of ten vendor-neutral courses, with worked examples, P&IDs, a quiz and a glossary, written for Indian conditions.

Values marked "typical", "approximate" or "illustrative" are not test data; check them against manufacturers' manuals and current standards before use.

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7 Installation Practice

Level 3 · Field Practice

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Course 7 — Installation Practice

Powered by Sunniva. This Level 3 Field Practice course is for installers, plumbers and electricians who put heat pumps on site. It assumes you know the basic refrigeration cycle and hydronic terms from earlier courses. After it you will be able to: (1) survey a site and spot problems before the truck arrives; (2) lay out, size and fit the water side with the right valves, strainers and vessels; (3) braze, pressure-test, evacuate and charge a split system safely; (4) wire, earth and commission a unit and avoid the ten most common installation mistakes.

7.1 The site survey checklist

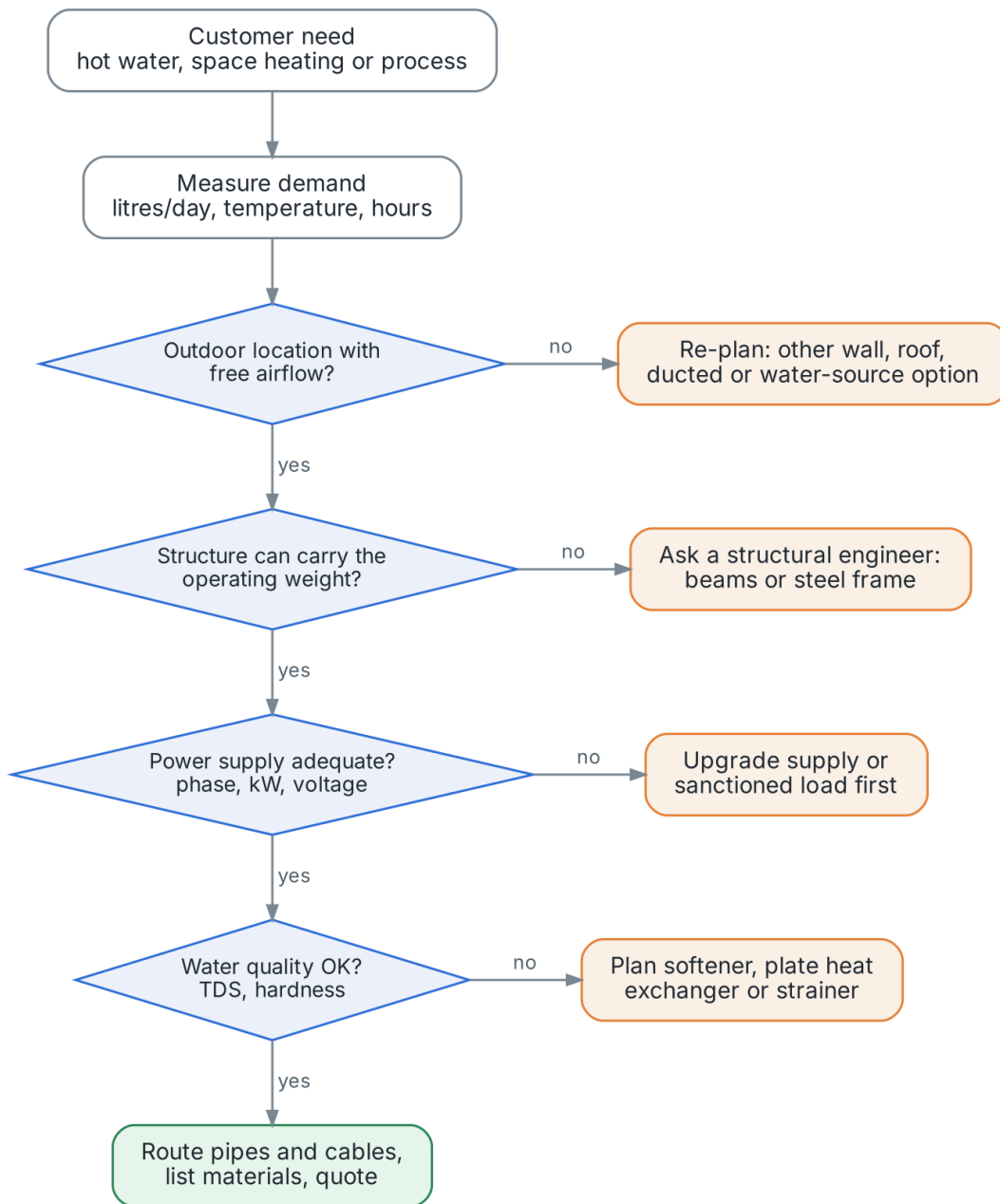
Key idea: Most installation problems are decided at the site survey, long before the first pipe is cut.

A site survey is a planned visit to check the location, services and access before quoting or installing. Think of it like a tailor taking measurements. Cut the cloth without measuring and no stitching can save the suit.

Carry a tape, a camera, a clamp meter, a TDS meter (total dissolved solids; it does not measure hardness) and a hardness test-strip kit and a compass app. Photograph everything. Your photos settle arguments later.



Site survey: the questions to answer before quoting



Site survey: the questions to answer before quoting

Site survey checklist

Demand and use

- ☐ Application confirmed (domestic hot water, space heating, pool, process)
- ☐ Daily hot water volume (litres/day) and peak hour draw
- ☐ Required supply temperature (°C) and existing heater type (geyser, LPG, diesel boiler)
- ☐ Operating hours and any night-tariff or solar-hour preference

Location

- ☐ Proposed unit position photographed from four sides

- ☐ Clearances measured against the manufacturer's manual (front, rear, sides, top)
- ☐ No recirculation risk (fan outlet not facing a wall within ~1.5–3 m, typical)
- ☐ Distance to bedrooms, neighbours and boundary noted (noise)
- ☐ Prevailing wind, dust, salt air (coast) and direct rain exposure noted
- ☐ Crane, lift or staircase access for the unit and its weight checked

Structure

- ☐ Floor or roof type (RCC slab, sheet, ground) recorded
- ☐ Operating weight of unit plus tank known; structural check asked for if on a roof
- ☐ Space for plinth or steel frame and condensate drain run

Water side

- ☐ Incoming water TDS (ppm) and hardness measured; source noted (municipal, borewell, tanker)
- ☐ Supply pressure (bar) measured at the nearest point
- ☐ Pipe route length, number of bends, rise and fall measured
- ☐ Existing tank volume, material and condition checked
- ☐ Drain point for safety valve, strainer flushing and condensate located

Electrical

- ☐ Supply type (single-phase 230 V / three-phase 415 V) and sanctioned load
- ☐ Voltage measured at the DB (phase-neutral and phase-phase, under load if possible)
- ☐ Distance from DB to unit for cable sizing
- ☐ Earth pit available and tested; neutral-earth voltage measured
- ☐ Space for a local isolator next to the unit

Safety and approvals

- ☐ Safe working-at-height plan for roofs (harness anchor, edge protection)
- ☐ Society or landlord permission for roof or façade work
- ☐ Hot work (brazing) permit needed? Fire extinguisher plan

Remember

- Measure, do not guess: TDS, voltage, distances and clearances.
- Photograph every survey point; attach photos to the job file.
- Check structure and power before promising a location.
- Plan drains (safety valve, condensate, flushing) at survey time.

Field tip: Measure the voltage at 7 pm as well as at noon. Evening peak sags in many Indian towns can trip compressors.

7.2 Location, airflow, clearances and noise

Key idea: An air-source heat pump is only as good as the air it can breathe, so give it free inlet air and let the outlet air escape.

An air-to-water heat pump pulls heat from outdoor air through its finned coil (evaporator). If the cold discharge air loops back to the inlet, the coil sees colder air. This is called recirculation. Output and COP (coefficient of performance, heat out ÷ electricity in) fall, and defrost becomes more frequent.

It is like a person breathing their own exhaled air in a closed lift. Each breath is worse than the last.

Typical clearances

Always use the manufacturer's manual. The figures below are typical starting points only.

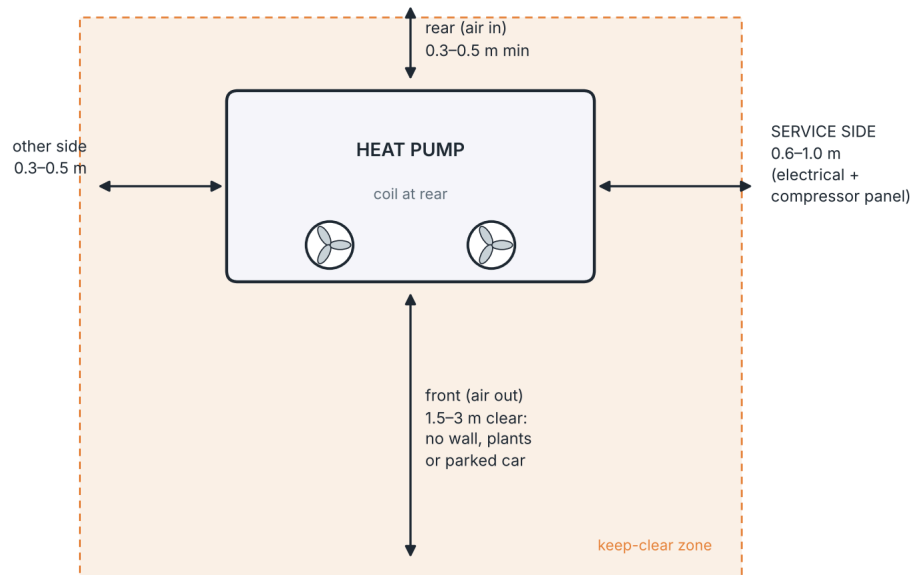
Side	Typical minimum clearance	Why
Air inlet (coil side, rear)	0.3–0.5 m	Coil must draw air evenly
Air outlet (fan side, front)	1.5–3 m clear	Stop discharge air bouncing back
Service side (electrical / compressor panel)	0.6–1.0 m	Technician must open panel and work
Other side	0.3–0.5 m	Airflow and pipe access
Top (vertical fan units)	2–3 m open sky; no roof slab just above	Hot / cold air must rise away
Between two units side by side	0.5–1.0 m typical	Avoid one unit breathing the other's air



Clearances around an outdoor unit (plan view, typical values)

Always use the manual's figures; these are typical

boundary wall / building



Vertical-discharge units: keep 2–3 m open above. Mark the zone with floor paint at handover.

Clearances around an outdoor unit (plan view)

Noise

Sound pressure level (dB(A), what the ear hears at a point) falls with distance. In open space it drops about 6 dB each time the distance doubles. Hard surfaces near the unit reflect sound back and add to the level.

Placement	Typical addition
Free-standing in open space	0 dB
Against one wall	about +3 dB
In a corner (two walls)	about +6 dB
In a corner under a slab (three surfaces)	about +9 dB

India's Noise Pollution (Regulation and Control) Rules set residential-area limits of 55 dB(A) by day and 45 dB(A) at night. Keep units away from bedroom windows, both yours and the neighbour's.

Worked example — noise at a neighbour's window

A unit's datasheet gives 60 dB(A) at 1 m. It is placed in a corner in a Pune housing society. The neighbour's bedroom window is 8 m away.

$$L_p(r) = L_p(1\text{ m}) - 20 \log_{10} \left(\frac{r}{1\text{ m}} \right) + \text{reflection}$$

1. Distance loss: $20 \times \log_{10}(8) = 20 \times 0.90 = 18\text{ dB}$.

2. Free-field level: $60 - 18 = 42 \text{ dB(A)}$.
3. Corner reflection: $+6 \text{ dB} \rightarrow 48 \text{ dB(A)}$.
4. Night limit is 45 dB(A) . This location fails at night.
5. Moving the unit out of the corner to a single wall: $42 + 3 = 45 \text{ dB(A)}$. Borderline. Better to add distance or run quiet-mode at night.

Remember

- Keep the outlet path clear; recirculation kills COP.
- Use the manual's clearances; the table above is typical only.
- Corners and slabs amplify noise; distance reduces it.
- Do not face the fan outlet towards a neighbour's window or a narrow gap between buildings.

Common mistake: Tucking the unit into a narrow duct shaft "to hide it". It recirculates its own cold air and freezes up.



7.3 Foundations, anti-vibration mounts and service access

Key idea: A solid, level base plus correct anti-vibration mounts stops noise, cracked pipes and early compressor failure.

The heat pump has a compressor and fans that vibrate. A rigid bolt to a thin slab turns the whole roof into a loudspeaker. Anti-vibration (AV) mounts are rubber pads or springs that stop vibration passing into the structure.

Foundations

- Ground mounting: a concrete plinth 100–150 mm above finished ground (typical). It keeps the unit above splash water and flooding.
- Roof mounting: place the unit on a steel frame or plinth that sits over beams or columns, not mid-span on a thin slab. Ask a structural engineer for heavy units.
- Level within the manual's tolerance (often a few mm per metre). An unlevel unit can hold water in its drain pan and strain pipe joints.
- In high-wind or cyclone areas (Odisha, coastal Andhra, Gujarat coast) bolt the unit or frame down.
- In snow areas (Leh, Kashmir, upper Himachal) raise the unit above expected snow depth so the coil and drain stay clear.

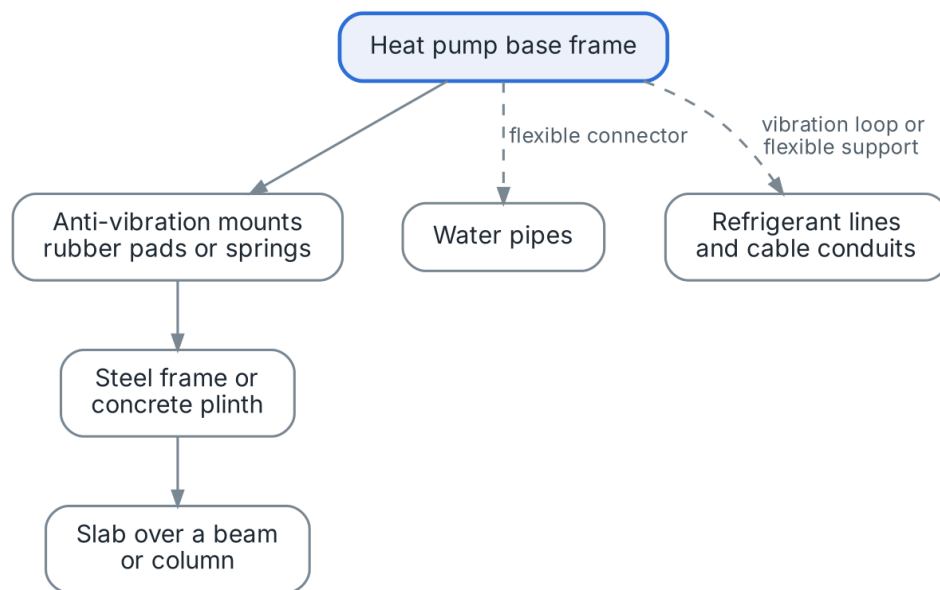
Anti-vibration mounts

Mount type	Typical static deflection	Use
Ribbed rubber / neoprene pad	2–5 mm	Small and medium units on ground or strong slab
Rubber-in-shear mount	5–10 mm	Medium units on roofs
Spring mount (with restraint)	15–25 mm	Large units on light structures, near bedrooms

Static deflection (δ) is how far the mount squashes under the unit's weight. More deflection means a lower natural frequency and better isolation.

Create • Conserve • Sustain

Vibration isolation chain: nothing rigid between the unit and the building



Vibration isolation chain

Worked example — will a rubber pad isolate the compressor?

A unit sits on rubber pads that deflect 3 mm. The compressor runs at 2,900 rpm (48 Hz).

$$f_n \approx \frac{15.8}{\sqrt{\delta_{\text{mm}}}} \text{ Hz} \quad T = \frac{1}{r^2 - 1}, \quad r = \frac{f}{f_n}$$

1. Natural frequency: $15.8 \div \sqrt{3} = 15.8 \div 1.73 = 9.1 \text{ Hz}$.
2. Frequency ratio: $r = 48 \div 9.1 = 5.3$.
3. Transmissibility: $T = 1 \div (5.3^2 - 1) = 1 \div 27.1 = 0.037$, so about 4% passes through.
4. Isolation $\approx 96\%$. Good.
5. Now an inverter compressor slowing to 20 Hz: $r = 20 \div 9.1 = 2.2$; $T = 1 \div (4.84 - 1) = 0.26$. Only 74% isolation. On a light roof near bedrooms, softer (spring) mounts help.

Isolation only works when r is above about 1.4 ($\sqrt{2}$). Near $r = 1$ the mount makes vibration worse (resonance).

Service access

Leave room to open every panel, remove the compressor and pull the fan. Keep isolation valves, strainers and the electrical isolator reachable without a ladder where possible. On roofs, provide a safe walkway and a fixed anchor for a harness.

Remember

- Plinth or frame on beams, not on a thin mid-span slab.
- Mounts must deflect enough; check isolation at low inverter speed too.
- Bolt down in windy areas; raise above snow in cold regions.
- Flexible connectors on all pipes leaving the unit.

Field tip: Use a spirit level on two axes before tightening mount bolts, then recheck after the unit is filled with water.



7.4 Water piping layout and sizing

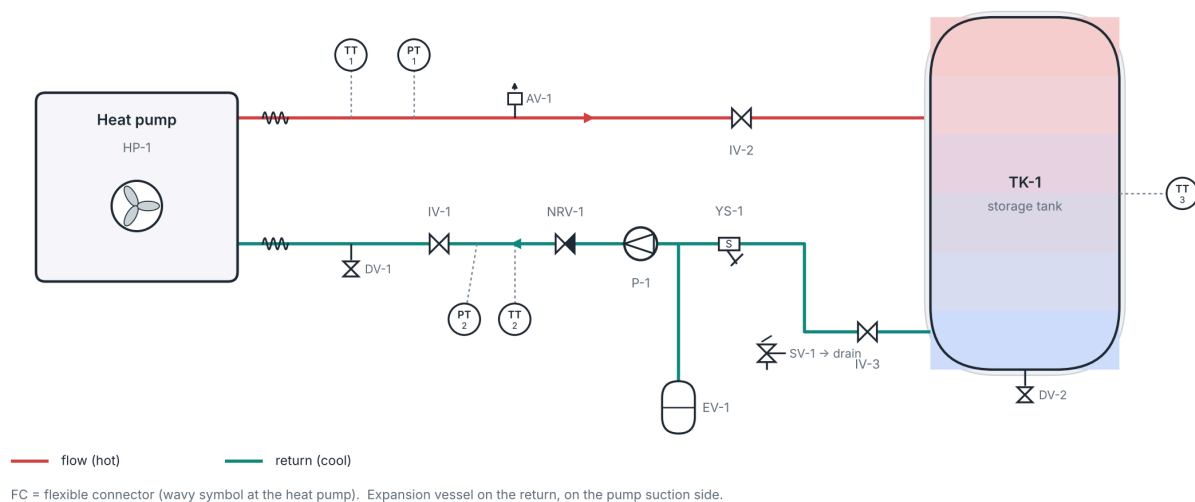
Key idea: The water side must carry the right flow at a sensible velocity, with every component in its correct place.

Flow rate is how much water passes per hour (m^3/h or LPH, litres per hour). Velocity is how fast it moves in the pipe (m/s). Too fast is noisy and erodes fittings. Too slow lets air and dirt settle, and the pipe costs more than needed.

A typical heat pump circuit runs at a temperature difference (ΔT) of about 5 K between flow and return. The heat carried depends on flow and ΔT .

Typical installation P&ID: heat pump to storage tank (closed loop)

Flow: heat pump → tank → strainer → pump → non-return valve → heat pump



Typical installation P&ID: heat pump to storage tank

Flow direction: heat pump → flow pipe → tank coil / tank → return pipe → strainer → pump → non-return valve → heat pump.

Tag	Item	Purpose
HP-1	Heat pump	Heat source
TK-1	Storage tank	Stores hot water, buffers load
IV-1/2/3	Isolation valve (ball valve)	Isolate unit or tank for service
FC-1/2	Flexible connector	Stop vibration reaching pipes; allow small movement
YS-1	Y-strainer	Catch dirt and scale before pump and heat exchanger
P-1	Circulation pump	Moves water around the loop
NRV-1	Non-return valve	Stops reverse flow when pump stops
EV-1	Expansion vessel	Absorbs water expansion as it heats
SV-1	Safety (relief) valve	Opens if pressure rises above set point
AV-1	Automatic air vent	Releases trapped air at high point
DV-1/2	Drain valve	Empty and flush the system
TT-1/2/3	Temperature transmitter / test point	Read flow, return and tank temperatures
PT-1/2	Pressure transmitter / gauge point	Read pressure; across strainer and unit shows blockage

Typical pipe sizing table

Water flow at typical velocities of 0.7–1.5 m/s, based on typical internal diameters of medium-grade steel pipe. Copper and PPR (polypropylene random copolymer) pipes have different internal diameters, so check the maker's chart. These are typical guides, not design values.

Nominal size	Typical ID (mm)	Flow at 0.7 m/s (m ³ /h)	Flow at 1.5 m/s (m ³ /h)	Approx. heat at ΔT 5 K, upper flow (kW)
DN15 (½")	16	0.5	1.1	6
DN20 (¾")	22	0.9	2.0	11
DN25 (1")	27	1.5	3.2	18
DN32 (1¼")	36	2.6	5.5	32
DN40 (1½")	42	3.5	7.5	43
DN50 (2")	53	5.6	12.0	70
DN65 (2½")	69	9.4	20.1	117
DN80 (3")	81	13.0	27.8	160
DN100 (4")	105	21.9	47.0	270

Small pipes near homes are best kept at the lower end of velocity for quiet running.

Worked example — size the pipe for a 30 kW heat pump at a Bengaluru hotel

The unit heats at 30 kW with ΔT = 5 K.

$$\dot{V} \text{ (m}^3\text{/h)} = \frac{Q \text{ (kW)}}{1.163 \times \Delta T \text{ (K)}} \quad v = \frac{\dot{V}}{3600 \times \frac{\pi}{4} d^2}$$

1. Flow: $30 \div (1.163 \times 5) = 30 \div 5.815 = 5.16 \text{ m}^3\text{/h (5,160 LPH)}$.

2. Try DN32 (ID 0.036 m): $\text{area} = 0.7854 \times 0.036^2 = 0.00102 \text{ m}^2$. $\text{Velocity} = 5.16 \div (3,600 \times 0.00102) = 1.41 \text{ m/s}$. Upper end, possible but noisier.
3. Try DN40 (ID 0.042 m): $\text{area} = 0.7854 \times 0.042^2 = 0.00139 \text{ m}^2$. $\text{Velocity} = 5.16 \div (3,600 \times 0.00139) = 1.03 \text{ m/s}$. Comfortable.
4. Choose DN40 for the main run. The unit's own connection may be smaller; reduce only at the unit.

(1.163 is the heat in Wh needed to warm 1 litre of water by 1 K.)

Remember

- $\text{Flow} = \text{kW} \div (1.163 \times \Delta T)$; then pick a pipe for about 0.7–1.5 m/s.
- Strainer and pump on the return, before the heat pump.
- Air vents at high points, drains at low points.
- Fit TT and PT points on flow and return for commissioning.

Common mistake: Matching the main pipe to the unit's small connection size. Over a long run that starves the unit of flow and trips it on high pressure.



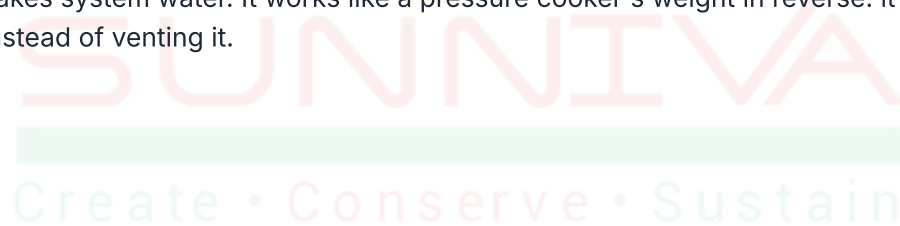
7.5 Valves, strainers, expansion vessels and air vents

Key idea: Each small fitting protects the heat pump from a specific enemy: dirt, air, pressure or backflow.

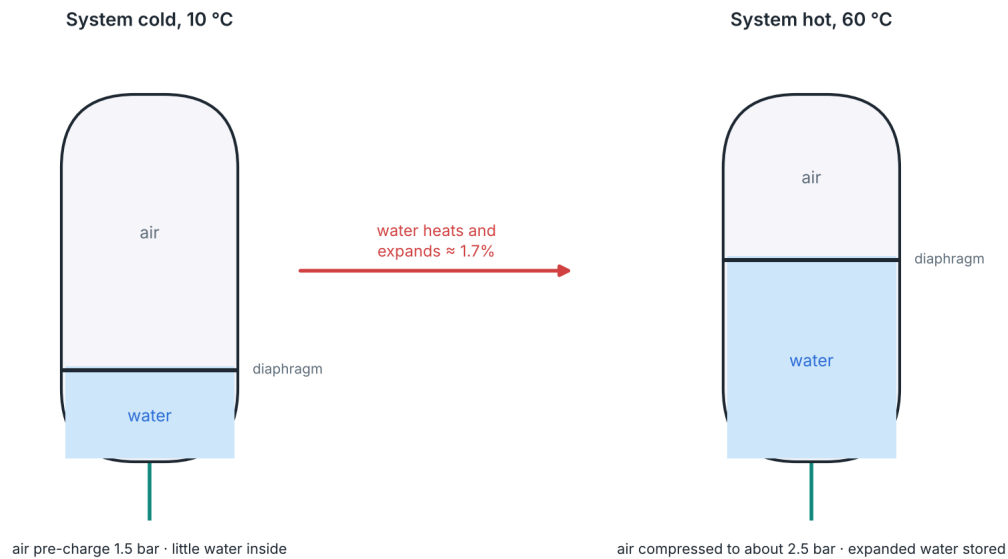
Component	Protects against	Where it goes	Typical spec
Ball valve (isolation)	Draining the whole system for service	Both sides of unit, pump, strainer	Full-bore, same size as pipe
Y-strainer	Dirt, scale, welding slag	Return, before pump and heat pump	Mesh typically 0.5–1 mm (follow manual)
Non-return valve (NRV)	Reverse flow, thermosiphon	After pump	Low-pressure-drop type
Expansion vessel	Pressure rise as water heats	Return side, near pump suction	Sized to system volume; pre-charged
Safety valve	Over-pressure	On the closed circuit, no valve between it and the heat source	Set below the weakest component's rating
Auto air vent	Air locks, noise, poor flow	Every high point	With isolating valve for replacement
Drain valve	Cannot empty or flush	Every low point	Hose-union type
Flexible connector	Vibration and pipe stress	At unit inlet and outlet	Rated for temperature and pressure

A Y-strainer is a Y-shaped fitting with a mesh basket that catches dirt. In Indian borewell and tanker water, scale and sand are common. A blocked strainer is the top cause of low-flow trips.

An expansion vessel is a steel tank with a rubber diaphragm. One side has air at a set pre-charge pressure; the other side takes system water. It works like a pressure cooker's weight in reverse: it gives the water room to grow instead of venting it.



Expansion vessel: how it absorbs expanding water



Expansion vessel cold vs hot

Worked example — size an expansion vessel

Closed heating loop in a Delhi school: system water 500 L, fill at 10 °C, maximum 60 °C. Pre-charge 1.5 bar(g). Safety valve 3 bar(g), so final working pressure is kept at 2.5 bar(g). Water expands about 1.7% from 10 to 60 °C (from density 999.7 to 983.2 kg/m³).

$$V_{EV} = \frac{e \times V_{sys}}{1 - \frac{p_i}{p_f}} \quad (p \text{ in bar absolute})$$

1. Expansion volume: $0.0168 \times 500 = 8.4$ L.
2. Absolute pressures: $p_i = 1.5 + 1 = 2.5$ bar(a); $p_f = 2.5 + 1 = 3.5$ bar(a).
3. Acceptance factor: $1 - 2.5 \div 3.5 = 0.286$.
4. Vessel: $8.4 \div 0.286 = 29.4$ L.
5. Choose the next size up: 35 L.

Check pre-charge with a tyre gauge before filling. Set it to about the static fill pressure at the vessel.

Remember

- Strainer before the pump and heat pump; clean it after the first week.
- Never put an isolation valve between the heat source and its safety valve.
- Size the expansion vessel from system volume; check pre-charge before filling.
- Air vents at every high point; bleed again after first run.

Field tip: Fit a pressure gauge on each side of the strainer. When the difference grows, it is time to clean the mesh.

7.6 Insulation of pipes and tanks

Key idea: Heat you pay to make should reach the tap, not warm the terrace.

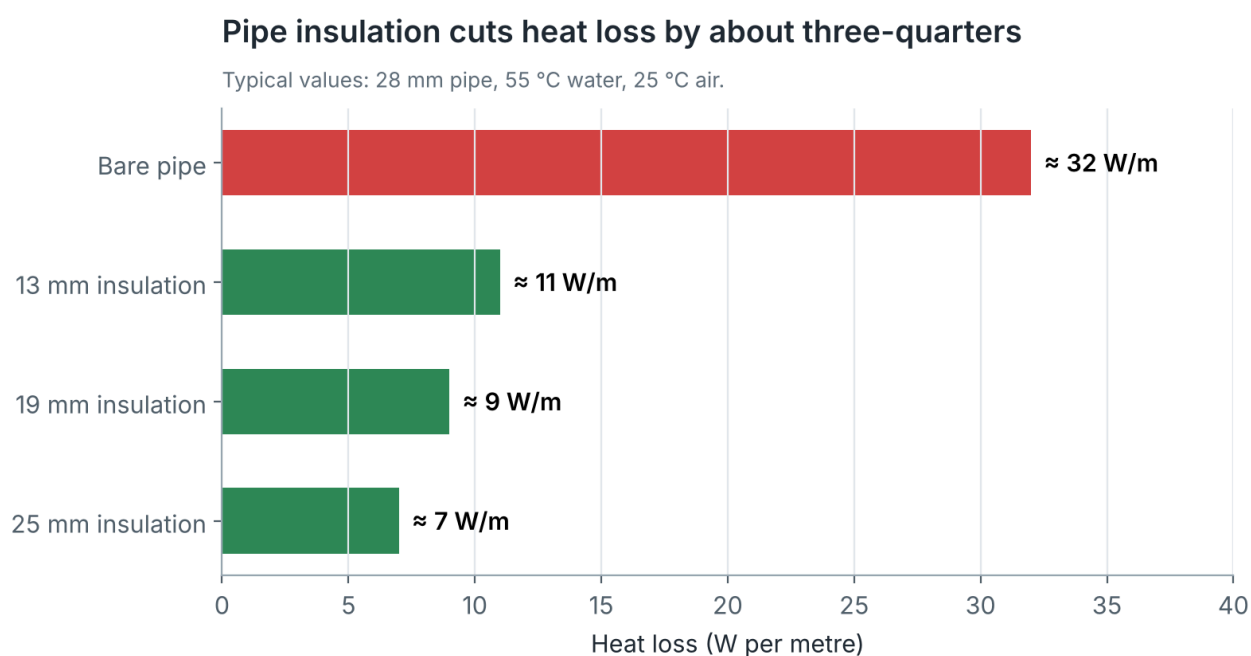
Insulation slows heat flow through pipe and tank walls. The common material is closed-cell elastomeric foam (nitrile rubber tube). Closed cells resist water uptake, which matters in Indian monsoons. Glass wool and PUF (polyurethane foam) are used on tanks.

It works like the wall of a vacuum flask: it keeps hot water hot by slowing the heat leaving it.

Pipe service	Typical insulation thickness	Notes
Hot water / heating, indoor	13–19 mm	Thicker for larger pipes
Hot water / heating, outdoor	19–25 mm	UV protection essential
Chilled water / cooling	19–32 mm	Must be vapour-sealed to stop sweating
Refrigerant lines (split units)	9–19 mm on both lines	Separate tubes for each line
Storage tanks	50–100 mm PUF or equivalent	Cover top and nozzles too

Outdoor protection

Sunlight breaks down most foam in one or two summers. Outdoors, cover it with aluminium cladding, UV-resistant paint or tape. Seal all joints with the maker's adhesive, not just plastic tape.



Heat loss: bare vs insulated pipe

Worked example — what does bare pipe cost?

A Jaipur hostel has 20 m of 28 mm hot water pipe on the terrace at 55 °C, with air at 25 °C. Typical losses are about 32 W/m bare and 9 W/m with 19 mm insulation. Circulation runs 12 h a day. Heat pump COP 3.5. Electricity ₹9/kWh (example rate).

$$E_{loss} = q \times L \times t \quad \text{Electricity} = \frac{E_{loss}}{COP}$$

1. Bare loss: $32 \times 20 \times 12 = 7,680 \text{ Wh} = 7.7 \text{ kWh/day}$ of heat.
2. Insulated loss: $9 \times 20 \times 12 = 2,160 \text{ Wh} = 2.2 \text{ kWh/day}$.
3. Heat saved: $7.7 - 2.2 = 5.5 \text{ kWh/day}$.
4. Electricity saved: $5.5 \div 3.5 = 1.57 \text{ kWh/day}$.
5. Money saved: $1.57 \times 9 = ₹14/\text{day}$, about ₹5,100 a year, from roughly 20 m of insulation.

Remember

- Insulate every hot pipe, valve body and tank nozzle.
- Outdoors, foam must have UV protection.
- Chilled pipes need a continuous vapour seal or they drip.
- Keep insulation dry; wet insulation works poorly.

Common mistake: Leaving valves, strainers and pump bodies bare. A bare DN40 valve can lose as much as a metre or more of bare pipe.



7.7 Refrigerant piping for split units: brazing, nitrogen purge, pressure test

Key idea: Clean, dry, leak-free copper joints made under nitrogen are the foundation of a reliable split system.

A split heat pump has the compressor or the water heat exchanger in separate units joined by refrigerant pipes. Those pipes must stay clean and dry inside. Moisture and oxide scale cause acid, blocked expansion valves and burnt compressors.

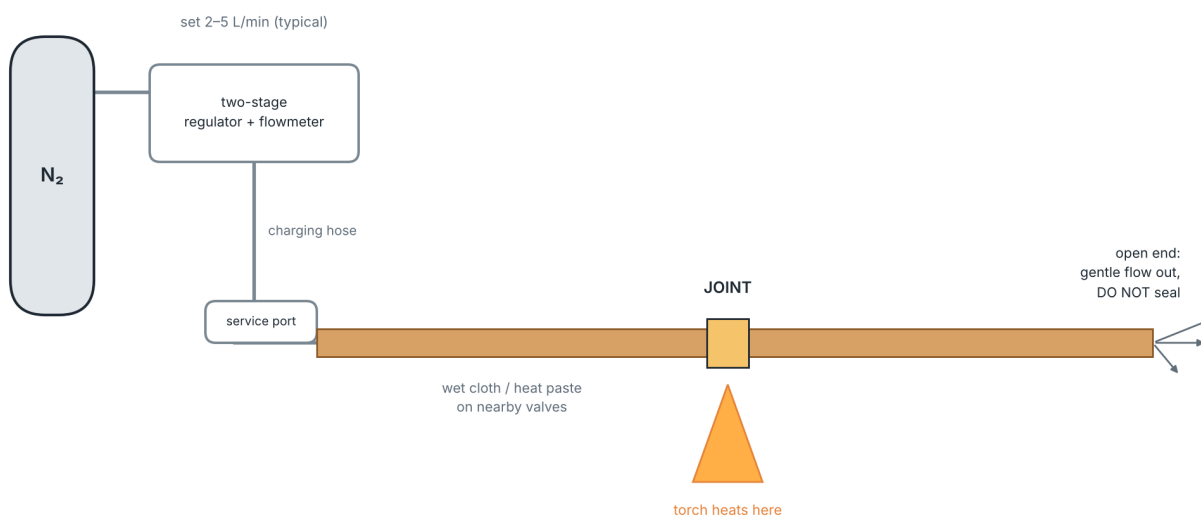
Brazing is joining copper at high temperature (above 450 °C) using a filler rod. Copper-to-copper joints commonly use copper-phosphorus rods; copper-to-brass or steel needs a silver rod with flux. Hot copper reacts with air and forms black oxide flakes inside the pipe. Flowing nitrogen through the pipe while brazing pushes the air out and stops this. Flowing nitrogen through the pipe while brazing pushes the air out and stops this.

Safety first

- Use only oxygen-free dry nitrogen (OFN). Never use oxygen or compressed air: oxygen with oil can explode.
- Always use a nitrogen regulator. A full cylinder can be above 150 bar.
- Keep a fire extinguisher and a wet cloth or heat shield at the joint. Protect valves and sensors from heat.
- Work in ventilated space. Nitrogen displaces oxygen in closed rooms.
- Recover any refrigerant first; never braise a pipe that holds refrigerant.

Brazing with a nitrogen purge

Low nitrogen flow keeps oxygen out, so no black oxide scale forms inside the pipe



Sequence: purge about 1 minute → keep low flow while brazing → keep flowing until the joint cools below about 200 °C → stop.

Brazing with a nitrogen purge

Sequence: purge for about a minute to displace air → keep low flow while brazing → keep flowing until the joint cools below about 200 °C (no colour) → stop.

Good practice

- Cut copper with a tube cutter, not a hacksaw. Ream the burr. Cap pipe ends until joined.
- Use refrigeration-grade copper (cleaned and capped). Plumbing copper is not dry inside.
- Bend with a bender; keep bend radius per the tool. Avoid kinks.
- Support pipes with clamps at typical intervals of 1–1.5 m. Insulate each line separately.
- For long vertical rises on suction lines, follow the manual on oil traps.

Pressure test

After brazing, test with dry nitrogen before evacuation.

1. Pressurise in stages (for example, 5 bar, then higher). Check for gross leaks at each stage.
2. Reach the test pressure in the manual. For R32 and R410A systems this is often around 38–42 bar on the high side (typical; always follow the manual and never exceed the unit's rated pressure).
3. Soap-test every joint and flare.
4. Hold. Typical practice is a few hours minimum and 24 h for larger systems. Record pressure and ambient temperature at start and end.
5. Pressure changes about 1% for every 3 °C change in temperature at these pressures. Correct for this before calling a leak.

Worked example — temperature-corrected hold test

A split system in Lucknow is pressurised to 40.0 bar(g) at 6 pm at 32 °C. Next morning at 24 °C it reads 39.0 bar(g). Is it leaking?

$$\frac{p_2}{p_1} = \frac{T_2}{T_1} \quad (\text{absolute values})$$

1. $p_1 = 40.0 + 1 = 41.0 \text{ bar(a)}$; $T_1 = 32 + 273 = 305 \text{ K}$; $T_2 = 24 + 273 = 297 \text{ K}$.
2. Expected $p_2 = 41.0 \times 297 \div 305 = 39.9 \text{ bar(a)} = 38.9 \text{ bar(g)}$.
3. Measured 39.0 bar(g). The drop is explained by cooling. No leak indicated.

Remember

- Braze only with nitrogen flowing; never with oxygen or air in the pipe.
- Always regulate nitrogen; never connect a cylinder directly.
- Pressure-test before vacuum; vacuum does not find small leaks well.
- Correct the hold-test result for temperature.

Common mistake: Brazing without nitrogen "because it is a short pipe". The black scale goes straight to the expansion valve and compressor.

7.8 Evacuation and charging

Key idea: Pull a deep, steady vacuum to remove air and moisture, then charge the exact refrigerant weight the system needs.

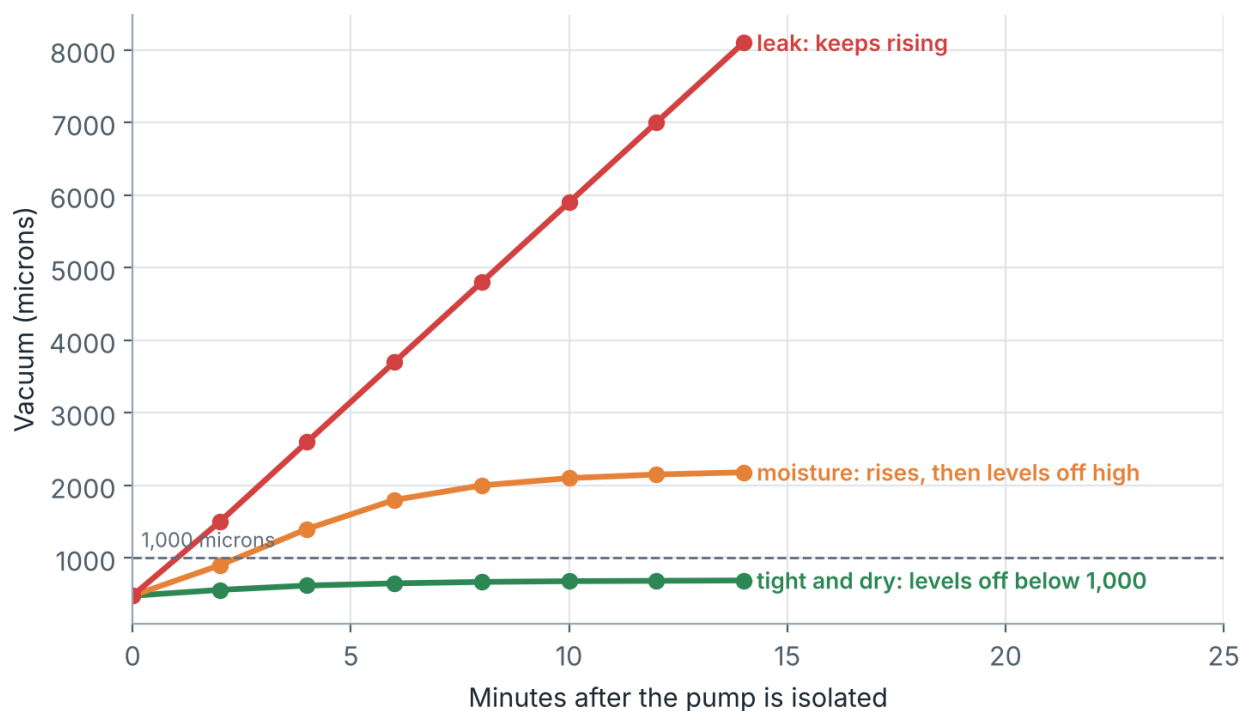
Evacuation means removing air and water vapour from the refrigerant circuit with a vacuum pump. Water boils at very low pressure, so a deep vacuum makes moisture boil off and get pumped away. A micron gauge measures vacuum in microns of mercury (1 micron $\approx$ 0.133 Pa). The manifold's compound gauge is not accurate enough for this.

Evacuation steps

1. Remove Schrader cores with a core tool and use short, large-bore hoses for speed.
2. Connect the micron gauge as far from the pump as possible, ideally at the system.
3. Run a two-stage vacuum pump with fresh oil.
4. Pull down to the target. A common field target is 500 microns or lower (typical; follow the manual).
5. Isolate the pump and do a decay test, typically 10–15 minutes.
6. If the gauge rises and levels off below about 1,000 microns, the system is dry and tight. If it keeps rising steadily, there is a leak. If it rises and stops high, moisture remains: evacuate further.

Reading a vacuum decay test

Pump isolated at 0 min. Typical curves. Target below 500 microns before the test.



Reading a vacuum decay test

Charging

- Charge by weight on a digital scale. Do not charge "by pressure" or "by feel of the suction line".

- Many split units are pre-charged for a set pipe length. Add extra charge per metre beyond it, as the manual states.
- Blends such as R410A and R407C must be charged as liquid. R32 is a single refrigerant, but liquid charging is still the normal practice.
- R32 and R290 are flammable (A2L and A3 safety classes). Use tools rated for them, remove ignition sources, and ventilate. R290 needs specific training.
- Record the charge on the unit label and in the commissioning sheet.

Refrigerant	Safety class	Charge as	Notes
R410A	A1 (non-flammable)	Liquid	High pressure blend
R32	A2L (mildly flammable)	Liquid (normal practice)	Single component
R407C	A1	Liquid	Large glide blend
R134a	A1	Liquid or vapour	Lower pressure
R290 (propane)	A3 (highly flammable)	Per manual only	Special training and tools

Worked example — additional charge

A split unit in Kolkata is pre-charged for 7.5 m of pipe. The actual pipe run is 15 m. The manual says add 20 g per metre (example value) for the liquid line size used.

$$m_{add} = (L_{actual} - L_{pre}) \times g/m$$

1. Extra length: $15 - 7.5 = 7.5$ m.
2. Extra charge: $7.5 \times 20 = 150$ g.
3. Weigh in 150 g as liquid, slowly, through the suction service port with the unit running (or as the manual says).

Remember

- Use a micron gauge; pressure test first, then vacuum.
- Target and decay test tell you dry, wet or leaking.
- Charge by weight; blends as liquid.
- Treat R32 and R290 as flammable: right tools, no sparks.

Field tip: Change vacuum pump oil after every wet system. Milky oil cannot pull a deep vacuum.

7.9 Electrical wiring and earthing

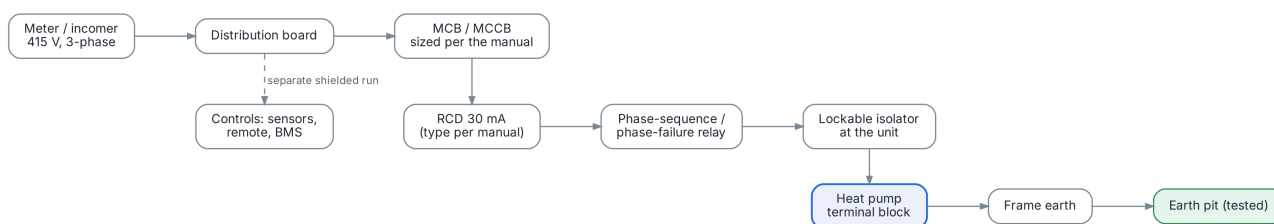
Key idea: Correct supply, protection and earthing keep the installer, the user and the compressor safe.

A heat pump draws high current, has a compressor motor and often an inverter drive. Undersized cables, missing earths and wrong protection cause trips, burnt terminals and electric shock. All electrical work must follow the Indian Electricity Rules / CEA regulations and the earthing code IS 3043, and be done by a licensed electrician.

Main items

- **Dedicated circuit** from the distribution board (DB) with its own breaker.
- **MCB** (miniature circuit breaker) rated for the unit. Motor loads often need C or D curve; follow the manual's MOCP (maximum over-current protection) value.
- **RCD / RCCB** (residual current device), typically 30 mA for personal protection. Inverter units may need a Type B or another type the manufacturer specifies.
- **Local isolator** within sight of the unit, lockable for service.
- **Phase sequence** check on three-phase units. Scroll compressors run backwards on the wrong sequence, get noisy and fail.
- **Earthing:** a low-resistance earth conductor to the unit frame and a tested earth pit. Bond metal pipework.
- **Control and sensor cables** run separately from power cables, or shielded, to avoid noise.
- **Glands and drip loops:** cables enter from below with a drip loop so rain does not run into the panel.

Three-phase supply to a heat pump: single-line view



Three-phase supply: single-line view

Check	Typical acceptable value	Tool
Supply voltage, single-phase	230 V $\pm$ 10%	Multimeter
Supply voltage, three-phase	415 V $\pm$ 10%, phase imbalance under ~2%	Multimeter
Neutral-earth voltage	Under ~2 V (typical good practice)	Multimeter
Earth resistance	As low as practical; follow local inspector (a few ohms or less is common)	Earth tester
Insulation resistance of compressor	Above 1 M Ω typical (check manual)	Insulation tester (megger)
Voltage drop along cable	Within ~3–5% typical	Calculation / measurement

Worked example — current and breaker for a three-phase unit

A unit in Ahmedabad draws 10 kW electrical input at full load on a 415 V supply, power factor 0.9.

$$I = \frac{P}{\sqrt{3} V \cos \varphi}$$

1. $I = 10,000 \div (1.732 \times 415 \times 0.9) = 10,000 \div 647 = 15.5$ A per phase.
2. Breaker: next standard size above full-load current, but not above the manual's MOCP. A 20 A C/D-curve MCB is a typical choice.
3. Cable: 4 mm² copper is a typical choice for 20 A on a short run. Check voltage drop on runs over about 30 m and upsize if needed.
4. Confirm with the nameplate maximum current, which can be higher than the rated current.

Remember

- Dedicated circuit, correct MCB, RCD and lockable isolator.
- Check phase sequence before first start on three-phase units.
- Test earth resistance and insulation resistance; record the values.
- Separate control cables from power cables.

Common mistake: Using the neutral as earth, or no earth at all. The frame can become live and the electronics fail.



7.10 Condensate drainage

Key idea: An air-source heat pump makes a lot of water from humid air and defrost, and it must drain away freely.

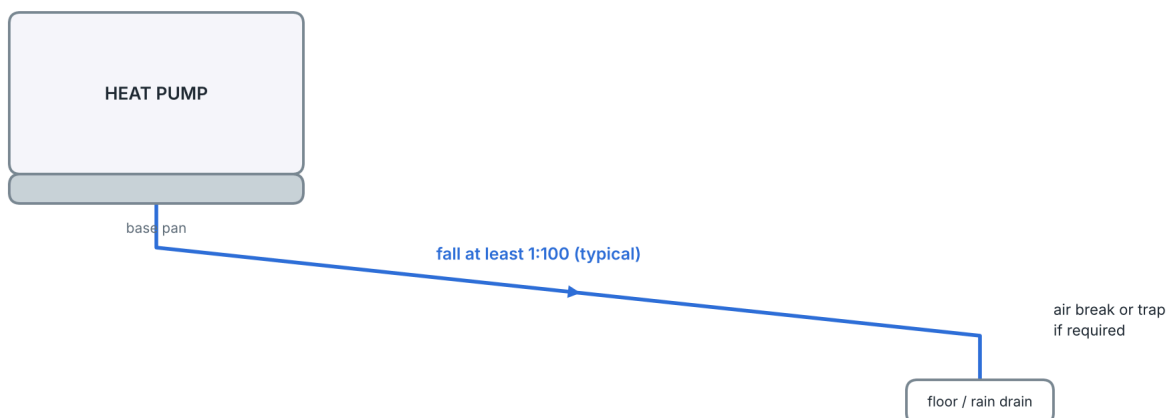
When outdoor air passes over the cold coil, its moisture condenses, just as a cold bottle from the fridge "sweats" on a humid day. In defrost, the ice on the coil melts and drains too. In coastal humid cities like Mumbai, Chennai and Kochi, the volume is large.

Good practice

- Drain from the unit base pan with the fitting supplied. Do not block base holes.
- Lay the drain pipe with a fall of at least 1:100 (1 cm per metre, typical) to a drain point, never to a walkway.
- Use a trap or air break where the manual requires it, and where draining into a sewer to stop smells.
- On roofs, route to the rainwater outlet. Water on the slab causes dampness and moss.
- In cold regions (Leh, Spiti, Kashmir, upper Himachal) drains can freeze. Keep them short and steep, and use a drain heater where the manual requires it. Ice blocking the base pan can damage the coil.
- Condensate is close to distilled water. It is soft but may carry dust and metals, so it is not drinking water. It can be reused for gardening.

Condensate drain: keep it falling all the way (side view)

Cold regions: a short, steep run with a drain heater; avoid long horizontal sections that freeze.



Condensate drain route

Worked example — how much water?

A large air-source unit in Chennai moves 10,000 m³/h of air. Air enters at a humidity ratio of 20 g/kg (moisture per kg of dry air) and leaves at 18.5 g/kg. Air density is about 1.15 kg/m³.

$$\dot{m}_{water} = \dot{V}_{air} \times \rho_{air} \times (W_{in} - W_{out})$$

1. Air mass: $10,000 \times 1.15 = 11,500 \text{ kg/h}$.
2. Moisture removed: $11,500 \times (0.020 - 0.0185) = 17 \text{ kg/h}$.
3. About 17 litres per hour, roughly 400 litres in a 24-hour day. This needs a proper drain, not a bucket.

Remember

- Plan the drain at survey time; it can be many litres per hour.
- Keep a steady fall to an approved drain; never onto walkways.
- In cold regions protect the drain from freezing.
- Keep base pan holes clear of debris and leaves.

Field tip: Pour a bucket of water into the base pan at commissioning and watch where it goes.



7.11 The ten most common installation mistakes

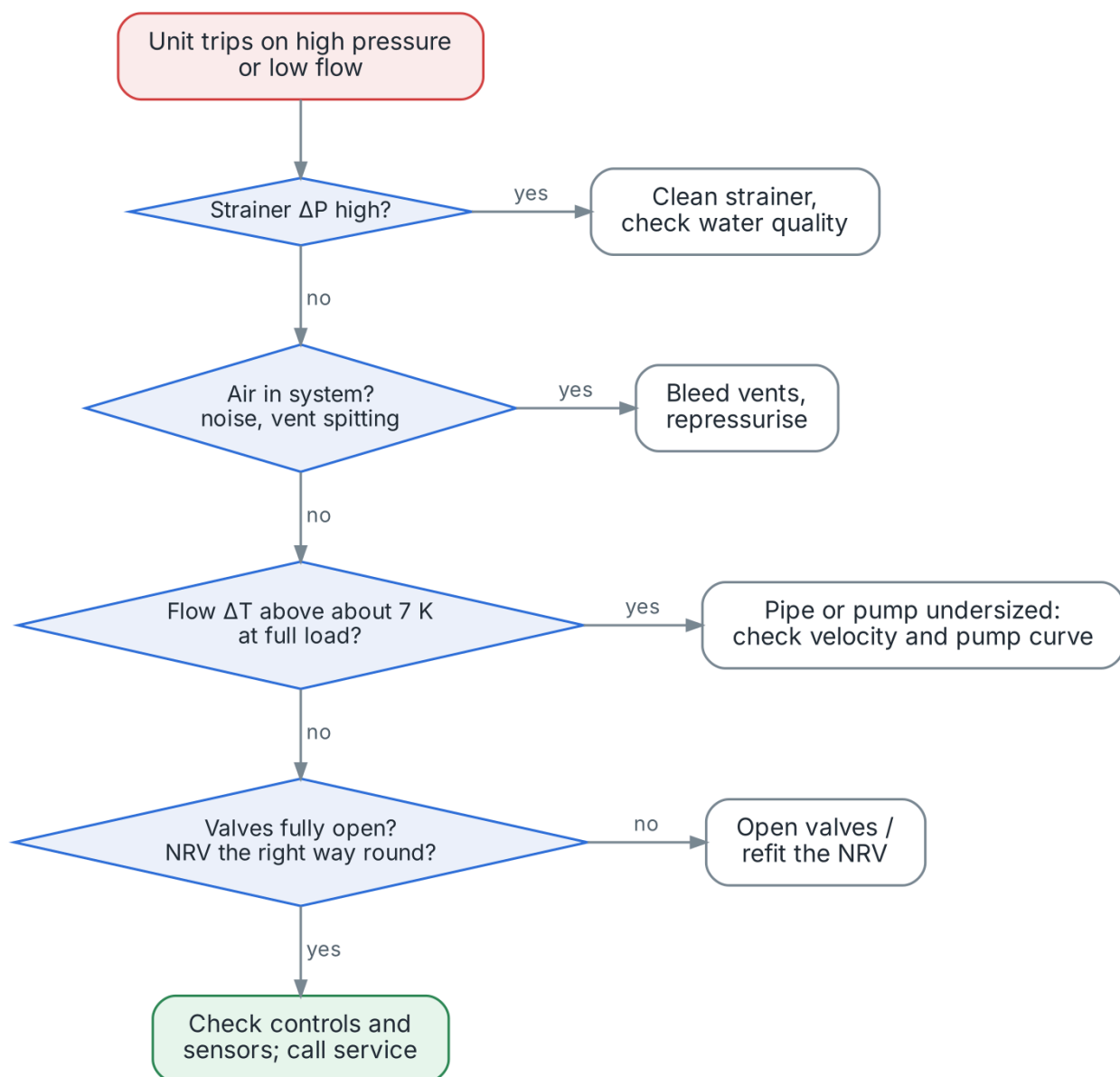
Key idea: Most early heat pump failures come from a short list of avoidable installation mistakes.

Learn this list and check it on every job. Each mistake has a clear symptom and an easy prevention.

#	Mistake	Symptom	Prevention
1	Unit boxed in, outlet facing a wall	Low output, frequent defrost, icing	Respect clearances; keep outlet path clear
2	Pipe too small for the flow	High-pressure or flow trips, noise	Size for 0.7–1.5 m/s; do not copy unit stub size
3	No strainer, or never cleaned	Low flow, blocked plate heat exchanger	Y-strainer on return; clean after first week
4	Air trapped in the circuit	Gurgling, pump noise, flow alarm	Air vents at high points; bleed after first run
5	Expansion vessel missing, wrong size or flat	Safety valve dripping, pressure swings	Size from system volume; check pre-charge
6	Brazing without nitrogen	Blocked expansion valve, compressor failure	Always flow OFN while brazing
7	Poor vacuum / no decay test	Moisture, acid, high discharge temperature	Micron gauge, 500 microns typical, decay test
8	Wrong charge (by guess)	Low COP, high or low pressure trips	Charge by weight per manual
9	Weak supply, no earth, wrong phase sequence	Trips, burnt terminals, reverse-running compressor	Proper cable, MCB, RCD, earth, phase check
10	No or poor insulation and no UV cover	Heat loss, sweating, foam crumbling	Insulate fully; clad outdoors

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Create • Conserve • Sustain

From a trip back to its installation cause



CREATE - CULTIVATE - SUSTAIN
From a trip back to its installation cause

Commissioning record (minimum)

Record these values at handover: supply voltage, running current, flow and return temperatures (TT-1, TT-2), system pressure (PT-1, PT-2), strainer pressure difference, refrigerant charge (split units), earth resistance and insulation resistance. Leave a copy with the customer.

Remember

- Clearances, pipe size, strainer and air vents fix most water-side trips.
- Nitrogen, vacuum and weighed charge fix most refrigerant-side failures.
- Earth, protection and phase sequence fix most electrical failures.
- Record commissioning values; they are your baseline for future service.

Field tip: Revisit after one week: clean the strainer, bleed the air and recheck pressure. It prevents most callbacks.



Quiz 7

1. During a site survey, which tool gives a quick indication of dissolved salts (TDS)?
 - A. Clamp meter B. TDS meter C. Micron gauge D. Megger
2. Discharge air recirculating back to the coil inlet will:
 - A. Raise COP B. Lower output and increase defrost C. Have no effect D. Reduce noise only
3. A unit gives 60 dB(A) at 1 m. Ignoring reflections, roughly what is the level at 4 m?
 - A. 54 dB(A) B. 48 dB(A) C. 45 dB(A) D. 30 dB(A)
4. Anti-vibration mounts isolate well only when the forcing frequency divided by the natural frequency is:
 - A. Exactly 1 B. Below 1 C. Above about 1.4 D. Zero
5. A 20 kW heat pump runs at ΔT 5 K. The water flow is about:
 - A. 1.2 m³/h B. 3.4 m³/h C. 6.9 m³/h D. 17 m³/h
6. Where should the Y-strainer go in a heat pump water circuit?
 - A. On the flow pipe after the tank B. On the return, before the pump and heat pump C. On the drain line D. Only on the cold water inlet of the house
7. Which gas must flow through copper pipe during brazing?
 - A. Oxygen B. Compressed air C. Oxygen-free dry nitrogen D. Refrigerant
8. After isolating the vacuum pump, the micron gauge keeps rising steadily without levelling. This means:
 - A. The system is dry B. There is a leak C. The gauge is new D. The charge is correct
9. Why must the phase sequence be checked on a three-phase scroll compressor unit?
 - A. To reduce the electricity bill B. A scroll can run backwards and fail on wrong sequence C. To set the thermostat D. It is only needed for single-phase units
10. Outdoor elastomeric foam insulation without UV protection will typically:
 - A. Last forever B. Crack and crumble within a few summers C. Improve with sunlight D. Turn into a vapour barrier

Answer key

1. **B** — A TDS meter reads total dissolved salts; use a hardness kit for hardness.
2. **B** — The coil sees colder air, so output and COP fall and defrost happens more often.
3. **B** — 4 m is two doublings of distance: $60 - 6 - 6 = 48$ dB(A).
4. **C** — Isolation needs a ratio above $\sqrt{2}$ (about 1.4); near 1 is resonance.
5. **B** — $20 \div (1.163 \times 5) = 3.4$ m³/h.
6. **B** — It protects the pump and the heat pump's heat exchanger from dirt.
7. **C** — OFN displaces air and prevents oxide scale; oxygen and air are dangerous or useless.
8. **B** — A steady, non-levelling rise points to a leak; a rise that levels high points to moisture.
9. **B** — Scroll compressors run backwards on reversed phases, are noisy and get damaged.
10. **B** — Sunlight degrades most foams; cladding or UV paint is needed outdoors.

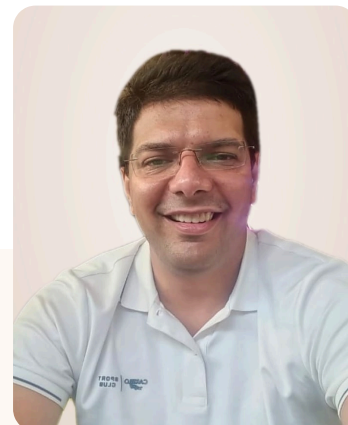
Glossary

Term	Meaning
Acceptance factor	Fraction of an expansion vessel's volume that can take water; $1 - p_i/p_f$ in absolute pressure
Air vent (automatic)	Valve at a high point that releases trapped air from the water circuit
Anti-vibration (AV) mount	Rubber or spring support that stops vibration passing to the structure
Brazing	Joining metals above 450 °C with a filler rod that melts below the base metal
COP	Coefficient of performance: heat delivered ÷ electricity used
dB(A)	A-weighted sound level, close to how the human ear hears loudness
Decay test	Watching vacuum after isolating the pump to check for leaks or moisture
Evacuation	Removing air and moisture from a refrigerant circuit with a vacuum pump
Expansion vessel	Diaphragm tank that absorbs water expansion in a closed circuit
Flexible connector	Braided or rubber pipe section that absorbs vibration and movement
Isolation valve	Valve (often a ball valve) used to shut off a section for service
MCB	Miniature circuit breaker: protects a circuit from overload and short circuit
Micron gauge	Instrument that measures deep vacuum in microns of mercury
Non-return valve (NRV)	Valve that allows flow in one direction only
OFN	Oxygen-free (dry) nitrogen used for purging and pressure testing
P&ID	Piping and instrumentation diagram: schematic of pipes, valves and instruments with tags
Phase sequence	Order of the three phases (R-Y-B); sets the rotation direction of three-phase motors
Pre-charge	Air or nitrogen pressure set in an expansion vessel before filling
PT	Pressure transmitter or pressure test point
RCD / RCCB	Residual current device: trips when current leaks to earth
Recirculation	Discharge air from the unit flowing back into its own inlet
Safety valve	Valve that opens automatically above a set pressure
Site survey	Visit to check location, structure, power, water and access before quoting
Static deflection	How far a mount compresses under the unit's weight
TDS	Total dissolved solids in water, in ppm
Transmissibility	Fraction of vibration force that passes through a mount
TT	Temperature transmitter or temperature test point
Velocity (pipe)	Speed of water in a pipe, in m/s; typically 0.7–1.5 m/s for heat pump circuits
Y-strainer	Y-shaped fitting with a mesh that catches dirt in the water flow

ABOUT THE AUTHOR

Kashyap Anandpara

Founder Director, Sunniva Encon LLP



It started as an instinct. In 2012 I wanted to do something in energy conservation. That was the whole of it. There was no plan to build machines, and no plan to build them in India. Both came later.

Kashyap founded Sunniva Encon in 2012 to work on energy conservation. The company now designs and builds heat pumps at its own factory in Asangaon, Maharashtra, with its office in Mumbai, and supplies hot water, space heating and process heat systems across India, including remote, high-altitude sites.

Over these years he has seen heat pumps chosen, sized, installed and serviced in every kind of Indian condition, and seen how often good machines are let down by poor selection, rushed installation or missing maintenance. Most of those problems come from knowledge that is not widely taught.

This program is his answer: an open, vendor-neutral course that shares that knowledge with students, technicians, installers, consultants and facility teams. It teaches the technology, not a brand. The lessons carry no product names or sales claims; Sunniva's part is only to make the material available.

- Founder Director, Sunniva Encon LLP, since 2012
- More than 5,000 heat pump installations across India
- Own heat pump factory in Asangaon, Maharashtra, built for 2,000 machines a year
- Nationwide service network reaching sites as remote as Leh

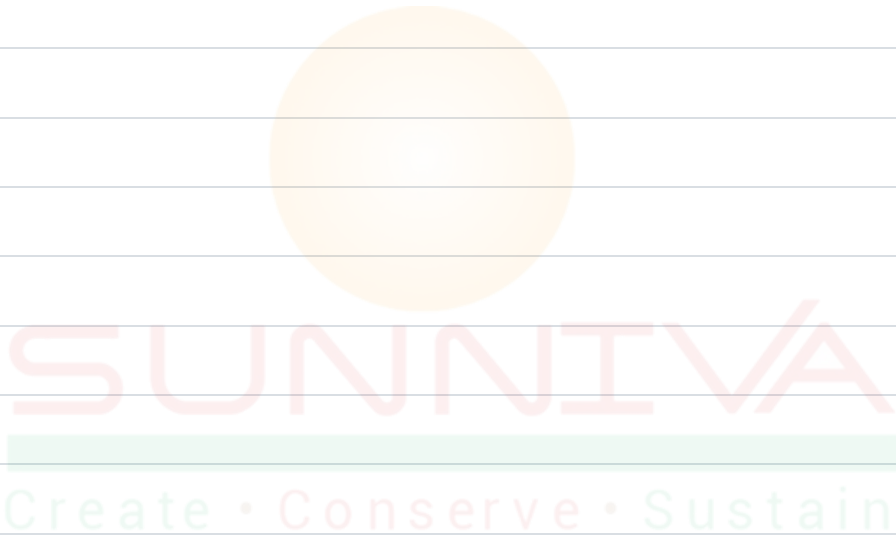
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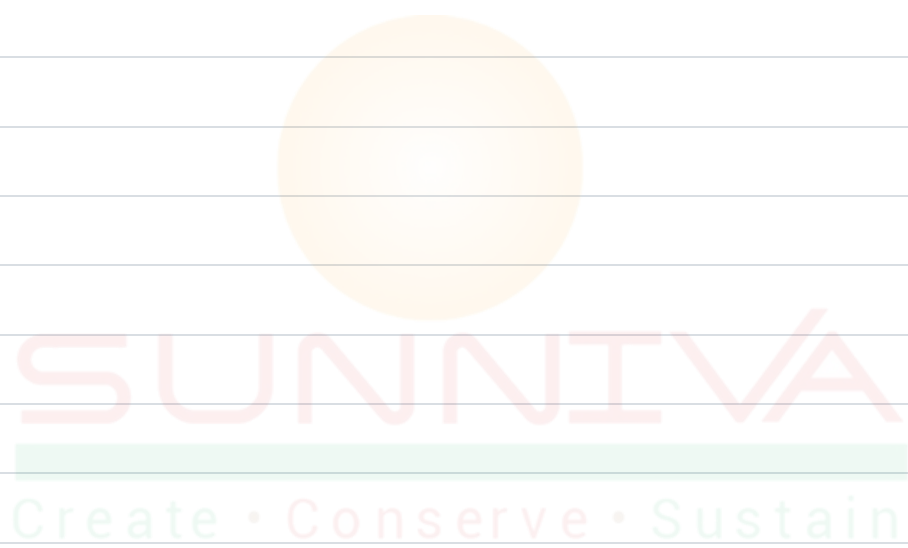
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THANK YOU.

Thank you for learning with us. Questions, corrections and suggestions for the next edition are welcome.

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