

INDUSTRIAL TRAINING INSTITUTE

CRAFTSMEN TRAINING SCHEME (CTS)

ANNUAL INSTRUCTIONAL PLAN BREAKUP (42 WEEKS)

SECOND YEAR - REFRIGERATION AND AIR CONDITIONING TECHNICIAN

Trade Name & Code	REFRIGERATION AND AIR CONDITIONING TECHNICIAN (RAC)
NSQF Level & Duration	NSQF Level-4 Two Years (Second Year - 42 Weeks)
Academic Session	
Instructor Name & Designation	
Group Instructor (GI) Name	
Principal / Superintendent Name	
Institute Name & Address	

(Curriculum as per DGT / CSTARI Guidelines for RAC Technician CTS Scheme - 2nd Year)

Week No.	Trade Practical (Professional Skills)	Trade Theory (Professional Knowledge)
Week 1	- Familiarization with commercial reciprocating, rotary, centrifugal and screw compressors. - Dismantling open-type and semi-hermetic commercial compressors and checking accessories. - Inspect cylinder block, crankshaft, pistons, connecting rods, wrist pins, and bearings.	- Commercial Compressors: Types (fixed & variable speed), construction, and applications. - Open-type vs Semi-hermetic compressors used in industrial cold storage and central plants. - Volumetric efficiency, cylinder clearance volume, and compressor capacity control mechanisms.
Week 2	- Service valve plate assemblies, lap reed and ring valves on lapping plate, and refit. - Measure and adjust compressor belt tension on open-type belt-driven units and replace belts. - Inspect and service compressor lubricating system: Reversible gear oil pump and strainer.	- Valve assemblies: Ring valves, reed valves, valve lift, valve breakage causes, and lapping methods. - Belt drives: V-belt sizing, alignment, tensioning gauges, and calculation of pitch diameters. - Compressor lubrication: Splash feed vs forced-feed gear/vane oil pumps, net oil pressure (NOP).
Week 3	- Cut cylinder head, crankcase, and bottom plate gaskets using gasket material and hollow punches. - Reassemble commercial compressor components to specified torque ratings. - Test reassembled compressor for overall volumetric pumping efficiency and vacuum pull-down.	- Gaskets: Materials, thickness selection, cutting methods, and prevention of oil leakage. - Tightening sequences: Cylinder head torque patterns and torque wrench applications. - Lubricating oil properties: Viscosity, floc point, dielectric strength, and synthetic polyolester oils.
Week 4	- Connect 3-phase AC motor in Star and Delta configurations; verify line/phase voltages and currents. - Identify terminals of Squirrel Cage Induction Motor (SCIM) and test insulation with Megger. - Wire and operate Direct-On-Line (DOL), Star-Delta, and Auto-Transformer motor starters. - Connect and start Slip-Ring Induction Motor (SRIM) using Rotor Resistance starter; demonstrate DOR change.	3-Phase AC fundamentals: Rotating magnetic field, synchronous speed, torque, and slip relations. - Squirrel Cage (SCIM) vs Slip-Ring Induction Motors (SRIM): Comparative analysis. 3-Phase Starters: Working principles of DOL, semi-automatic/automatic Star-Delta, and Auto-transformer. - Rotor resistance starter and common electrical motor faults (single phasing, phase reversal).
Week 5	- Service shell-and-tube, shell-and-coil, and tube-in-tube water-cooled condensers. - Remove end bells/heads, inspect tube fouling, and evaluate inlet/outlet water temperatures and pressures. - Pump down refrigerant into liquid receiver for system servicing.	- Water-Cooled Condensers: Types, construction, capacity, and water velocity in tubes. - Liquid receivers: Sizing, safety pressure relief valves, fusible plugs, and pump-down procedures. - Evaporative condensers: Operating principle, water spray nozzles, and heat transfer efficiency.
Week 6	- Perform mechanical cleaning and chemical de-scaling of water-cooled condensers using acid circulating pump. - Service natural draft, induced draft, and forced draft cooling towers. - Clean cooling tower basin, sump, distribution nozzles, drift eliminators, and PVC louvers.	- Condenser fouling: Scale formation, algae growth, corrosion inhibitors, and descaling chemicals. - Cooling Towers: Classification (natural, induced, forced draft), counterflow vs crossflow. - Performance parameters of cooling towers: Range, Approach, cooling tower efficiency, and blowdown.
Week 7	- Dismantle, inspect impeller, mechanical seals, and reassemble centrifugal water circulating pump. - Service and backwash circulating water treatment/water softening plant. - Measure total dissolved solids (TDS), pH, and water hardness using chemical testing kits.	- Water circulating pumps: Centrifugal pumps, impellers, stuffing boxes, mechanical seals, and head. - Water contamination: Scaling, biological fouling, slime formation, and corrosion in cooling loops. - Water treatment plants: Base-exchange softeners, resin regeneration with brine, and chemical dosing.
Week 8	- Inspect and install Thermostatic Expansion Valves (TXV) with internal and external equalizers. - Mount and insulate sensing bulb at correct orientation on suction line. - Adjust TXV superheat setting screw according to actual cooling heat load.	- Expansion Devices: Operating principles of Thermostatic Expansion Valves (TXV). - Superheat control: Static superheat, opening superheat, and external equalizer requirements. - Sensing bulb charges: Liquid charge, gas charge, and cross charge; bulb mounting orientations.

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Week 9	- Identify and test Automatic Expansion Valves (AXV), float valves (high-side and low-side), and orifice controls. - Install and calibrate Electronic Expansion Valves (EEV) and stepper motor controllers. - Select correct expansion valve orifice size and capillary tubes for specified refrigeration tonnages.	- Automatic Expansion Valves (AXV): Constant evaporator pressure operation and limitations. - Float valves: Low-side float vs High-side float mechanisms in flooded refrigeration systems. - Electronic Expansion Valves (EEV): Stepper motors, pulse control algorithms, and rapid response. - Sizing criteria of expansion valves based on pressure drop, refrigerant type, and capacity.
Week 10	- Inspect and service extended-surface forced-air direct expansion (DX) evaporator coils. - Service water-cooled and brine-cooled chillers; clean chiller tubes and check anti-freeze thermostats. - Flush oil logged in evaporator coils using dry nitrogen; service liquid-suction heat exchangers and accumulators.	- Evaporator types: DX evaporators, flooded chillers, shell-and-tube brine coolers. - Secondary refrigerants: Calcium chloride brine, sodium chloride brine, ethylene/propylene glycols. - Defrost methods: Off-cycle, electric heater, hot gas bypass defrost, and water spray defrost. - Function of suction accumulators, liquid-suction heat exchangers, and oil separators.
Week 11	- Identify mechanical and electrical parts of pressure-type and storage-type water coolers and bubble dispensers. - Service water tanks, clean copper cooling coils, and test cold/hot water thermostats. - Troubleshoot condenser fan motor failure, water leakages, and compressor short cycling.	- Water Coolers: Storage type vs Instantaneous pressure type water coolers and dispensers. - Refrigeration circuit and plumbing connections of hot & cold water dispensers. - Electrical controls: Thermostats, relay, overload protectors, and condenser fan circuits.
Week 12	- Conduct pressure leak testing, deep evacuation, and refrigerant gas charging in water coolers. - Test water temperature pull-down rate and verify thermostat cut-in and cut-out temperatures.	- System charging in water coolers: Refrigerant charge optimization and temperature regulation. - Corrosion protection in drinking water systems: Stainless steel 304 tanks and food-grade piping. - Routine sanitization and preventive maintenance schedules for drinking water dispensers.
Week 13	- Inspect and service commercial Visi Coolers and Bottle Coolers. - Flush refrigeration circuits with dry nitrogen, replace filter driers, and evacuate systems. - Retrofit commercial coolers with eco-friendly refrigerants (HFC-134a, R-290, R-600a). - Test sealed electrical components and flameproof switches used with flammable refrigerants.	- Visi Coolers and Bottle Coolers: Construction, forced-air cooling, glass door heaters. - Retrofitting procedures: Drop-in vs substitute refrigerants, oil compatibility, and capillary adjustments. - Safety standards for flammable hydrocarbon refrigerants (R-290/propane, R-600a/isobutane). - Sealed/spark-proof electrical components and leak detection protocols in commercial appliances.
Week 14	- Inspect horizontal chest-type and vertical upright deep freezers and commercial display cabinets. - Service skin condensers, wire-tube condensers, and fan-cooled condensing units. - Trace electrical wiring, replace defective thermostats, fan motors, and test pull-down to -18°C / -25°C.	- Deep Freezers & Display Cases: Construction, PUF insulation thickness, and temperature zones. - Cascade refrigeration systems: Low-temperature refrigeration, primary & secondary stages. - Ice Lined Refrigerators (ILR): Principle, vaccine storage standards, and thermal holdover time.
Week 15	- Service and troubleshoot Automatic Ice Cube machines and softy ice cream machines. - Inspect water distribution trays, harvest solenoid valves, harvest water pumps, and hot gas defrost valves. - Test reverse cycle hot-gas harvest cycle, bin thermostat controls, and measure ice harvest cycles.	- Ice Cube Machines: Operating sequence (freezing cycle vs harvest cycle), reverse-cycle defrosting. - Water circuit: Sump pumps, float switches, and spray grids for clear cube production. - Softy Ice Cream Machines: Beater mechanisms, freezing cylinders, overrun control, and sanitization.
Week 16	- Identify components of commercial Ice Candy plants: Brine tank, mould frames, and mechanical agitator. - Prepare brine solution (Calcium Chloride / Sodium Chloride) to achieve required eutectic freezing point. - Check agitator propeller rotation, brine temperature distribution, and refrigerant expansion valve setting.	- Ice Candy Plant: Operating principle, refrigeration cycle, and brine tank construction. - Brine chemistry: Eutectic point, specific gravity, hydrometer measurements, and corrosion inhibitors. - Agitator mechanisms: Propeller design, fluid velocity, and uniform heat transfer in tanks.

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Week 17	- Inspect commercial Ice Plant equipment: Ice cans, brine tank, crane hoist, thawing tank, and can dumper. - Service ammonia / fluorocarbon compressors, evaporative condensers, and surge drums. - Evacuate, test leaks, and operate ice plant; study ice flake machines.	- Commercial Ice Plant: Components, ice can filling, freezing time calculations, and harvesting. - Ammonia (NH₃ / R-717) as an industrial refrigerant: Advantages, toxicity hazards, and safety codes. - Flake Ice & Slush Ice Machines: Drum evaporators, rotating scrapers, and industrial applications.
Week 18	- Identify parts, controls, and accessories of Walk-in Coolers, Reach-in Cabinets, and Cold Storage rooms. - Inspect unit coolers (evaporator coils), defrost heaters, fan delay thermostats, and solenoid valves. - Practice two-stage rotary pump evacuation, pressure testing, and charging in cold storage units.	- Walk-in Coolers & Reach-in Cabinets: Cold room construction, modular PUF panels, and air curtains. - Cold Storage Plants: Preservation of perishables, respiratory heat, and storage humidity. - Freezing methods: Blast freezers, freezing tunnels, plate freezers, and milk chilling plants. - Log sheet maintenance, vibration eliminators, and cold room preventive maintenance schedules.
Week 19	- Study psychrometric chart and determine Dry Bulb Temp (DBT), Wet Bulb Temp (WBT), Relative Humidity (RH). - Measure DBT and WBT using sling psychrometer and digital psychrometers. - Measure air velocities and volumetric airflow (CFM) across coils and grilles using vane anemometers.	- Introduction to HVAC: Comfort air conditioning parameters (temperature, humidity, air motion, purity). - Psychrometry: Fundamental terms, DBT, WBT, Dew Point Temperature (DPT), RH, and Enthalpy. - Psychrometric processes: Sensible heating/cooling, humidification, dehumidification, and cooling with dehumidification. - Measurement instruments: Sling psychrometer, digital thermo-hygrometer, and anemometers.
Week 20	- Service forward-curved and backward-inclined centrifugal blowers, propeller fans, and drive motors. - Measure static pressure, velocity pressure, and total pressure in air ducts using inclined manometers and pitot tubes. - Align blower pulleys, adjust V-belt tension, and lubricate pillow block bearings.	- Blowers and Fans: Centrifugal blowers vs axial flow fans; fan laws and operating characteristics. - Air pressure fundamentals: Static pressure (SP), velocity pressure (VP), and total pressure (TP). - Pressure measuring devices: U-tube manometers, inclined manometers, and Pitot tubes.
Week 21	- Construct galvanized sheet metal ducts as per layout drawings (elbows, transitions, reducers). - Apply thermal insulation (fiberglass / nitrile rubber foam) on duct exteriors with vapor barriers. - Apply acoustic insulation (fiberglass boards with perforated metal facing) inside duct interiors.	- Air Ducts: Types, materials (GI, aluminum, pre-insulated ducts), and duct design methods (equal friction, static regain). - Thermal duct insulation: Materials, K-values, vapor barrier application, and condensation prevention. - Acoustic insulation: Sound attenuation, decibel reduction, and noise criteria (NC) in HVAC systems.
Week 22	- Disassemble, inspect, wash, and service different types of HVAC air filters. - Test and install panel filters, washable metallic filters, bag/pocket filters, and HEPA filters. - Check differential air pressure across filter banks using Magnehelic gauges.	- Air Filtration: Importance of Indoor Air Quality (IAQ) and airborne particulate contamination. - Classification of air filters: Coarse filters, pre-filters, micro-vee filters, and HEPA / ULPA filters. - MERV ratings, filter maintenance schedules, and effects of choked filters on system performance.
Week 23	- Inspect and service Package Air Conditioner (Air-Cooled Condenser type). - Trace electrical control wiring: Contactor coils, crankcase heaters, HP/LP cutouts, and thermal relays. - Perform leak testing, deep evacuation, refrigerant charging, and start-up performance testing.	- Package Air Conditioners (Air-Cooled): Unitary design, scroll/reciprocating compressors, and duct connections. - Electrical control circuits: Interlocking between blower motor, condenser fan, and compressor. - Safety controls: High Pressure (HP) cutout, Low Pressure (LP) cutout, and anti-recycle timers.
Week 24	- Inspect and service Split Package AC systems with remote air-cooled condensing units. - Check Air Handling Unit (AHU), belt-driven blower assembly, mixing box, and dampers. - Troubleshoot package AC problems: High discharge pressure, low suction pressure, and motor overload.	- Split Package AC systems: Separation of indoor AHU and outdoor condensing unit, piping limits. - Air Handling Units (AHU): Construction, cooling coil rows, drain pan slope, and access doors. - Package AC troubleshooting protocols and routine preventive maintenance checklists.

Week No.	Trade Practical (Professional Skills)	Trade Theory (Professional Knowledge)
Week 25	- Identify various components of Direct Expansion (DX) Central Air Conditioning plant. - Trace electrical power and control wiring schematics of central DX plant. - Service Air Handling Unit (AHU), clean cooling coils, and test motorized fire dampers and volume control dampers.	- Central Air Conditioning Systems: Overview of Direct Expansion (DX) plants vs Chilled Water systems. - AHU components: Chilled water/DX coils, blower wheels, face-and-bypass dampers, and mixing plenums. - Fire dampers: Fusible links, motorized actuators, smoke detector interlocks, and life safety codes.
Week 26	- Inspect airflow volume, air velocity, damper positions, and temperature drops across AHU. - Practice pump-down procedure on central DX plant into high-pressure liquid receiver. - Test and calibrate dual pressure switches (HP/LP cutouts) and oil pressure differential switches (OPDS).	- Air distribution systems: Supply air grilles, return air diffusers, registers, and volume dampers. - Pump-down systems: Automatic pump-down using liquid solenoid valves vs manual service pump-down. - Pressure and safety controls: Differential oil pressure switches (OPDS) and time-delay mechanisms.
Week 27	- Identify parts of Variable Refrigerant Flow / Variable Refrigerant Volume (VRF/VRV) systems. - Inspect inverter-driven scroll compressors, accumulator, oil separator, and sub-cooler circuits in Outdoor Unit (ODU). - Inspect various Indoor Units (IDU): Ceiling cassette, ductable, and wall-mounted VRF units.	- VRF/VRV Systems: Working principle, heat pump vs heat recovery VRF systems, and energy efficiency. - System architecture: Master ODU, slave ODU, branch selector (BS) boxes, and multiple IDUs. - Inverter technology, electronic expansion control, and oil management in long refrigerant piping runs.
Week 28	- Inspect VRF/VRV Y-joints (refnet joints), headers, and brazing under nitrogen purging. - Check central controller, 2-wire communication bus wiring between IDUs and ODU. - Diagnose system faults using error code charts, service software tools, and controller displays.	- Refnet joints: Selection, symmetrical distribution, horizontal mounting rules, and piping restrictions. - Communication wiring: Shielded twisted pair cables, polarity sensitivity, and addressing protocols. - Self-diagnosis: Error codes for high pressure, low pressure, inverter faults, and communication errors.
Week 29	- Identify components of Indirect Chilled Water Central AC plant (water-cooled chillers). - Inspect shell-and-tube flooded evaporators, centrifugal/screw chillers, and refrigerant controls. - Check electrical panel, power contactors, electronic microprocessor controllers, and safety interlocks.	- Indirect / Chiller Systems: Working principles of water-cooled and air-cooled chiller plants. - Flooded chillers: Shell-and-tube design, refrigerant pool boiling, mist eliminators, and level controls. - Reciprocating, screw, and centrifugal chillers: Comparison of capacities, COP, and part-load efficiency.
Week 30	- Inspect chilled water piping loops, primary/secondary circulating pumps, and balancing valves. - Apply closed-cell elastomeric nitrile rubber insulation on chilled water lines with vapor barrier. - Service Fan Coil Units (FCU), clean drain trays, wash air filters, and test 2-way/3-way modulating valves.	- Chilled water distribution: Primary-secondary pumping systems, expansion tanks, and air vents. - Chilled water pipe insulation: Insulation thickness, thermal bridging, and vapor seal integrity. - Fan Coil Units (FCU): 2-pipe vs 4-pipe systems, thermostat interfacing, and modulating water valves.
Week 31	- Check vibration isolators (spring mounts, inertia bases) and flexible canvas duct connections. - Inspect electromechanical, pneumatic, and direct digital electronic (DDC) controls in central plants. - Test air washers, steam grid humidifiers, and pan humidifiers used in central station systems.	- Vibration and noise control: Inertia bases, neoprene pads, spring isolators, and sound attenuators. - HVAC Control Systems: Electromechanical thermostats, pneumatic actuators, and Direct Digital Controllers (DDC). - Humidification and Dehumidification: Air washers, steam injection, pan humidifiers, and humidity sensors.
Week 32	- Practice comprehensive troubleshooting on central AC plants (both DX and indirect chiller systems). - Perform heat load calculations for commercial buildings: Calculating transmission, solar, and internal loads. - Use HVAC software tools for cooling load calculation and equipment sizing.	- Comprehensive troubleshooting: High condensing temperature, low evaporator pressure, surging, freeze-ups. - Heat Load Estimation: Space heat gains (conduction, radiation, lighting, occupants, equipment, infiltration). - Sensible Heat Ratio (SHR), Grand Sensible Heat Ratio (GSHR), and Ton of Refrigeration selection.

Week No.	Trade Practical (Professional Skills)	Trade Theory (Professional Knowledge)
Week 33	- Identify mechanical and electrical components of automotive Car Air Conditioning systems. - Inspect wobble plate / swash plate compressors, parallel flow condensers, serpentine evaporators, and receiver-driers. - Test electromagnetic clutch operation, pulley bearing condition, and drive belt tension.	- Car Air Conditioning: Working principle, engine-driven compressor, and refrigerant circuit. - Variable displacement wobble/swash plate compressors: Internal control valves and displacement variation. - Parallel flow condensers and block-type expansion valves (H-valves) used in automotive HVAC.
Week 34	- Install automotive gauge manifold, check suction and discharge pressures during idling and running at 1500 RPM. - Conduct nitrogen leak testing / fluorescent UV dye leak detection on automotive AC systems. - Evacuate and charge refrigerant (HFC-134a / HFO-1234yf) by weight using automotive recovery and recycling stations.	- Automotive service fittings: Quick-connect R-134a couplers, high/low service ports, and safety caps. - Leak detection methods: UV dye injection, electronic halogen sniffers, and nitrogen pressure tests. - Environmentally friendly automotive refrigerants: HFO-1234yf properties, A2L safety, and oil compatibility (PAG oil).
Week 35	- Troubleshoot car AC electrical systems: Blower motor resistor pack, AC request switch, thermistor, and relays. - Overview of electric and hybrid vehicle (EV/HEV) air conditioning systems using high-voltage electric scroll compressors. - Inspect Mobile AC systems: Construction, roof-mounted units, and engine drive systems in Passenger Buses.	- Automotive electrical circuits: Blower speed control, radiator/condenser fan interlocks, dual/triple pressure switches. - Hybrid and Electric Vehicle (EV) AC: Hermetic scroll compressors with brushless DC (BLDC) motors, POE oil safety. - Bus Air Conditioning: Roof-mounted packages, sub-engine drives, large reciprocating compressors, and ducting.
Week 36	- Study Railway Train Air Conditioning: Under-slung equipment, Roof Mounted AC Packages (RMPU), and power cars. - Inspect RMPU microprocessor control panel, fresh air dampers, emergency exhaust, and reverse-cycle heating. - Introduction to Aircraft Air Conditioning: Air cycle refrigeration (air craft bootstrap system) and cabin pressurization.	- Train Air Conditioning: RMPU packages, hermetic scroll compressors, 415V 3-phase supply, and inverter controls. - Aircraft Air Conditioning: Air cycle refrigeration system (Bell-Coleman / reverse Brayton cycle). - Air cycle machines (ACM): Heat exchangers, cooling turbines, pack valves, and cabin air distribution.
Week 37	- Inspect Precision Air Conditioning (PAC) units used in Data Centers and Clean Rooms. - Check constant temperature and relative humidity controls, electronic steam humidifiers, and EC backward-curved plug fans. - Study positive pressure air systems in operation theaters and negative pressure isolation rooms in hospitals.	- Precision Air Conditioning (PAC): Comfort vs Precision cooling, high sensible heat ratio (SHR > 0.9). - Clean Room standards: ISO clean room classifications, laminar airflow, and airborne particle counts. - Hospital HVAC: Positive pressure in surgical suites, negative pressure in infectious disease wards, and HEPA filtration.
Week 38	- Study Smart Air Conditioners: Wi-Fi controllers, IoT-enabled mobile app management, and AI thermal vision. - Implement comprehensive Preventive Maintenance schedules for commercial plants, chillers, and AHUs. - Record daily operational parameters in Plant Log Book and prepare final AITT portfolio documentation.	- Modern Smart HVAC: Smart thermostats, Wi-Fi modules, IoT cloud monitoring, and predictive maintenance algorithms. - Preventive Maintenance Management: Daily, weekly, monthly, quarterly, and annual maintenance checklists. - Plant Log Sheets: Recording compressor suction/discharge pressures, oil levels, chilled water temps, and electrical amps.
Week 39-42	On the Job Training (OJT) / Group Project	On the Job Training (OJT) / Group Project

APPROVAL & SIGNATURES

Sign of Instructor	Sign of Group Instructor (GI)	Sign of Superintendent / Principal
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