

INDUSTRIAL TRAINING INSTITUTE (ITI)

CRAFTSMEN TRAINING SCHEME (CTS)

ANNUAL INSTRUCTIONAL PLAN BREAKUP (42 WEEKS) FIRST YEAR

Trade Name & Code	REFRIGERATION AND AIR CONDITIONING TECHNICIAN
NSQF Level & Duration	NSQF Level-4 Two Years (First 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 - 1st Year)

Week No.	Trade Practical (Professional Skills)	Trade Theory (Professional Knowledge)
WEEK 01	- Identify workshop machineries, tools and safety equipment in RAC shop. - Practice safety precautions, first aid methods, and artificial respiration. - Demonstrate firefighting methods and operation of ABC dry powder fire extinguishers. - Practice working at height using personal protective equipment (PPE) and safety ladders.	- Introduction to Refrigeration & Air Conditioning trade, scope and career progression. - General workshop safety rules and industrial hazards identification. - First aid measures for cuts, chemical burns, electrical shock, and suffocations. - Classification of fires and operation of different types of fire extinguishers. - Ladder safety, working at heights, safety belts, and technician grooming.
WEEK 02	- Identify fitting hand tools, measuring instruments, and bench equipment. - Care and maintenance of fitting tools and instruments. - Perform measuring, marking, punching, hacksawing, and flat filing on mild steel plates. - Check flatness and squareness using try square and steel rule.	- Fitting hand tools: Types, construction, specifications, and uses. - Measuring and marking tools: Steel rule, scribe, punches, calipers, and surface plates. - Hacksaw frames and blades: Types, selection of pitch for different metals. - Files: Classification by cut, grade, shape, length, and filing methods.
WEEK 03	- Perform sheet metal cutting using straight snip and bent snip as per layout. - Practice bending, folding, hemming, and seaming on galvanized iron (G.I.) sheets. - Join sheet metal pieces using rivet set, snap, and soft soldering.	- Sheet metal tools: Types of snips, stakes, hammers, and mallets. - Types of sheet metal joints: Lap seam, grooved seam, and knocked-up joints. - Rivets and riveting methods: Types of rivets, rivet sets, and snap tools. - Soft soldering in sheet metal work: Composition of solder and selection of flux.
WEEK 04	- Identify, use and maintain basic electrical tools and instruments. - Measure voltage, current, resistance, power, frequency, and energy in single-phase circuits. - Measure earth resistance and check insulation continuity of single-phase motors using Megger.	- Fundamentals of electricity: AC and DC supply, voltage, current, resistance, power, and power factor. - Electrical conductors, insulators, series circuits, parallel circuits, open and short circuits. - Measuring instruments: Voltmeter, ammeter, wattmeter, multimeter, and clamp-on tong tester. - Earthing in electrical systems: Importance, earth resistance, and megger insulation testing.
WEEK 05	- Identify basic electronic components, tools and test instruments. - Determine resistor values using 4-band and 5-band color codes. - Practice soldering and de-soldering electronic components on PCB. - Identify and test diodes, Zener diodes, transistors, SCR, UJT, ICs, and sensors.	- Introduction to electronics and semiconductor theory (P-type and N-type semiconductors). - P-N junction diode characteristics, biasing, and Zener diode as a voltage regulator. - Bipolar Junction Transistors (BJT): NPN and PNP configurations and terminal identification. - Overview of Silicon Controlled Rectifier (SCR), Uni-junction Transistor (UJT), and thermal sensors.

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WEEK 06	- Construct and test half-wave, full-wave center-tapped, and bridge rectifier circuits. - Setting up Air-LPG, Oxy-LPG, and Oxy-Acetylene gas welding/brazing plants. - Adjust neutral, carburizing, and oxidizing flames with two-stage gas regulators. - Practice gas welding and brazing on thin sheet metal plates with backfire arresters.	- Rectification principles: Rectifier circuits, filter capacitors, and DC power supplies. - Oxy-fuel gas welding and brazing fundamentals: Base metals, filler rods, and fluxes. - Differences between soldering and brazing: Melting points, joint strength, and applications. - Safety in gas cylinders: Regulators, torches, hoses, and functions of flashback arresters.
WEEK 07	- Practice brazing copper-to-copper, copper-to-mild steel, and copper-to-brass joints. - Identify general and special hand tools, instruments, and machinery used in RAC works. - Identify components of vapour compression system: Compressor, condenser, expansion device, evaporator. - Inspect vapour absorption refrigeration system (VARs) components.	- Brazing techniques in refrigeration piping: Silver brazing alloys and flux application. - History and basic principles of refrigeration and air conditioning systems. - Thermodynamic laws, work, power, energy, force, heat, temperature, and pressure scales. - Types of refrigeration systems: Vapour Compression (VCR) vs Vapour Absorption (VAR) systems.
WEEK 08	- Unroll, measure, cut and ream soft copper tubes using miniature and standard pipe cutters. - Practice bending copper tubing using external bending springs and lever-type tube benders. - Practice swaging on copper tubing using punch-type and screw-type swaging tools.	- Copper tubing: Specifications, soft annealed vs hard drawn copper tubes, OD sizing. - Tube cutting and reaming precautions to prevent internal burrs and restrictions. - Tube bending techniques: Minimum bend radius and prevention of flattening or kinking. - Swaging operation: Expansion ratios and preparing tubes for slip-fit brazed joints.
WEEK 09	- Make standard 45° single flare joints and double flare joints on copper tubing. - Test flare joints with standard flare brass nuts and union fittings. - Practice pinch-off and piercing operations on copper process tubes.	- Flaring tools: Construction, flaring bar, yoke, cone angle, and depth of pipe in block. - Flare fittings: SAE flare nuts, unions, tees, elbows, and torque specifications. - Pinch-off tools and piercing valves: Purpose during system servicing and sealing.
WEEK 10	- Practice using Lokring tool and mechanical lokring fittings for solder-free pipe joints. - Practice silver brazing of copper-to-copper and copper-to-aluminum joints using Air-LPG and Oxy-Acetylene flames. - Pressure test brazed piping loops with dry nitrogen.	- Lokring connection technology: Mechanical tube joining without heat, lokprep sealant. - Copper-to-aluminum brazing techniques: Specialized filler rods and flux requirements. - Sensible heat, latent heat, superheating, sub-cooling, and saturation temperatures. - Vapour Compression Cycle: Low-side vs High-side pressure, Ton of Refrigeration (TR), and COP.

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WEEK 11	- Identify mechanical and electrical components of single-door Direct Cool Refrigerator. - Check, test and replace cabinet components: Door gasket, door switch, and cabinet lamp. - Trace electrical circuit diagram of single-door direct cool refrigerator.	- Direct Cool Refrigerator: Construction, layout, storage capacity, and working principle. - Mechanical components: Hermetic compressor, wire-mesh condenser, capillary, roll-bond evaporator. - Electrical accessories: Thermostat switch, door switch, interior lamp, and wiring schematic. - Cabinet heat insulation: Glass wool, Polyurethane Foam (PUF), and thermal sealing.
WEEK 12	- Test compressor motor terminals (Common, Start, Run) using multimeter and test lamp. - Test starting relay (current type), Overload Protector (OLP), and thermostat switch. - Start hermetic compressor directly without relay (manual jumping) and with relay.	- Hermetic compressor motor: Main/running winding, auxiliary/starting winding resistances. - Current-type starting relay: Construction, plunger mechanism, pickup/dropout current. - Bimetallic Overload Protector (OLP): Operating principle, trip rating, and reset mechanism. - Thermostat switch: Sensing bulb, bellows, differential temperature adjustment.
WEEK 13	- Perform internal cleaning and flushing of condenser and roll-bond evaporator with dry nitrogen. - Replace choked capillary tube and filter drier according to manufacturer specifications. - Braze process tube with service Schrader pin valve.	- System contamination: Moisture, sludge, burnt oil, non-condensable gases, and acids. - Nitrogen flushing: Pressure regulation, procedure, and safety precautions. - Capillary tube: Bore diameter, length calculation, and throttling/metering action. - Filter drier: Molecular sieve desiccant (XH-7, XH-9), mesh filters, and replacement rules.
WEEK 14	- Connect gauge manifold, conduct pressure leak test using dry nitrogen and soap bubble solution. - Evacuate refrigeration system using two-stage rotary vacuum pump and micron vacuum gauge. - Charge refrigerant (HFC-134a / R-600a) by weight using digital scale; verify running pressures and cooling.	- Gauge manifold assembly: Compound gauge, high-pressure gauge, service hoses, and valves. - Evacuation: Importance of deep vacuum (down to 500-20 microns), moisture boiling under vacuum. - Gas charging methods: Vapor charging vs liquid charging, charging by weight with digital scales. - Operating pressures: Suction pressure, discharge pressure, frost line, and ampere consumption.
WEEK 15	- Identify constructional parts of Frost-Free (2-door / 3-door) refrigerator. - Inspect forced draft air cooling system, evaporator fan motor, and air distribution ducts. - Test defrost timer, defrost heater (glass/sheath type), bimetal defrost thermostat, and thermal fuse.	- Frost-Free Refrigerator: Principle of forced-draft cooling, air ducts, and multi-flow vents. - Automatic defrost system: Defrost timer cycle (cooling mode vs defrost mode). - Defrost components: Tubular heater, bimetal thermostat, thermal safety fuse, and drain heater. - Freezer and fresh food compartment temperature control dampers and air louvers.

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WEEK 16	- Trace electrical schematic and wiring harness of Frost-Free refrigerator. - Test airflow dampers (mechanical and electronic stepper motor types) and door cooling systems. - Troubleshoot common frost-free faults (frost accumulation, evaporator icing, drain choking).	- Wiring circuit analysis of frost-free refrigerators: Timer sequence and defrost termination. - Air circulation issues: Fan motor defects, jammed air dampers, and door seal leakage. - Calculation of refrigerator internal storage volume and star rating energy efficiency.
WEEK 17	- Identify components of Multi-Door / Side-by-Side Frost-Free Inverter Refrigerator. - Test inverter PCB, DC inverter compressor, BLDC evaporator fan motor, and NTC thermistors. - Leak testing, evacuation, and gas charging (HC R-600a) in inverter frost-free refrigerators.	- Inverter technology in domestic refrigerators: Variable-speed DC inverter compressors. - Electronic inverter board (Power PCB and Main PCB): Inverter drive signals (U, V, W). - Sensor circuits: NTC temperature thermistors, defrost sensors, and ambient sensors. - Safety precautions while handling flammable hydrocarbon (HC R-600a / isobutane) refrigerants.
WEEK 18	- Identify different types of refrigeration compressors (reciprocating, rotary, scroll). - De-oil hermetic compressor, cut compressor shell/dome with pipe cutter/hacksaw. - Separate internal mechanical pump assembly from compressor dome and inspect parts.	- Compressor classification: Hermetic, semi-hermetic, and open-type compressors. - Reciprocating compressor: Piston, connecting rod, crankshaft, valve plate, and suction/discharge reed valves. - Rotary compressor: Roller, eccentric shaft, sliding vane/blade, spring, and cylinder. - Scroll compressor: Fixed scroll, orbiting scroll, working chambers, and axial compliance.
WEEK 19	- Inspect cylinder bore, piston rings, wrist pin, connecting rod bearings, and valve plates for wear. - Clean components, lap valve reeds on lapping plate, and reassemble mechanical pump unit. - Reweld compressor dome, perform nitrogen pressure test, and test volumetric pumping efficiency.	- Valve assembly: Reed valves, valve lift, valve flutter, clearance volume, and volumetric efficiency. - Internal spring suspension and discharge shock loops: Vibration damping and noise suppression. - Compressor dome welding procedures, leak testing, and vacuum holding capability.
WEEK 20	- Check compressor lubricating oil level and test oil quality/acidity. - Flush contaminated oil and recharge fresh mineral oil / Polyolester (POE) / Alkylbenzene (AB) oil. - Measure locked rotor amps (LRA) and running amps of reassembled compressor.	- Refrigeration lubricants: Mineral oils, Synthetic oils (POE, PAG, AB), and their properties. - Viscosity, flash point, pour point, floc point, and dielectric breakdown strength. - Oil miscibility with different refrigerants (CFCs, HCFCs, HFCs, and HCs). - Lubrication methods: Splash lubrication and forced-feed lubrication systems.
WEEK 21	- Identify terminal sequence (C, S, R) of single-phase compressor motor using digital multimeter. - Measure winding resistance and check continuity, open circuit, short circuit, and body ground fault. - Measure starting inrush current and running current using digital panel meters.	- Single-phase induction motors: Theory of split-phase, rotating magnetic field generation. - Starting winding vs Running winding: Resistance, inductance, wire gauge, and turn count. - Common motor faults: Open winding, shorted turns, ground-to-shell, and insulation breakdown.

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WEEK 22	- Start and run split-phase induction motors: RSIR, CSIR, CSR, and PSC motor configurations. - Connect centrifugal switch, start capacitor, and run capacitor in CSIR and CSR circuits. - Wire and operate Direct-On-Line (DOL) starter with start/stop push buttons and overload relay.	- Resistance Start Induction Run (RSIR) and Capacitor Start Induction Run (CSIR) motors. - Permanent Split Capacitor (PSC) and Capacitor Start Capacitor Run (CSR) motors: Comparison. - Starting capacitors vs Running capacitors: Ratings, construction, and discharge resistors. - DOL starter: Contactor coils, auxiliary contacts, and bimetallic thermal overload relays.
WEEK 23	- Test and service different starting relays: Current relay, Potential (voltage) relay, and PTC relay. - Select suitable hermetic compressor, starting relay, capacitor, and OLP for different cooling appliances. - Connect compressor test bench and test running parameters under simulated load.	- Potential (Voltage-sensing) relay: Construction, pickup voltage, drop-out voltage, and CSR circuits. - Solid-state PTC relays: Ceramic resistance pill, temperature coefficient, and reset time. - Selection criteria of hermetic compressors for refrigerators, deep freezers, and air conditioners. - Safety cutouts: High pressure (HP) cutouts, Low pressure (LP) cutouts, and internal thermal protectors.
WEEK 24	- Inspect and service different condensers: Natural convection wire-on-tube, forced air-cooled, and micro-channel. - De-scale and clean air-cooled condenser fins using fin comb, degreasing chemical, and water jet. - Inspect liquid receiver, service valves, and practice pump-down procedure.	- Condensers: Function, types, heat of compression, and total heat of rejection (THR). - Natural convection condensers vs Forced-air condensers: Fin spacing, airflow, and heat transfer. - Micro-channel condensers: Aluminum multi-port tubes, louvered fins, and refrigerant charge reduction. - Liquid receiver: Construction, purpose, dip tube, and pump-down operations.
WEEK 25	- Identify filter driers and capillary tubes used in domestic and commercial refrigeration appliances. - Replace filter drier and capillary tube during system repairs; braze connections cleanly. - Cut and flare capillary tube ends without restriction using capillary tube cutter and gauge.	- Filter driers: Solid core vs loose bead molecular sieves, acid removal, and bidirectional driers. - Desiccant materials: Synthetic zeolites (XH-7, XH-9, XH-11) and moisture adsorption capacities. - Refrigerant throttling: Capillary tube sizing, pressure drop curves, and critical charge systems.
WEEK 26	- Inspect and service evaporators: Plate-and-tube, bare pipe, roll-bond, and finned-tube forced air coils. - Flush accumulated lubricating oil from evaporator tubes using dry nitrogen. - Inspect suction accumulator and liquid-suction heat exchanger.	- Evaporators: Heat absorption mechanism, boiling refrigerants, flooded vs direct expansion (DX). - Superheating in evaporators: Definition, calculation, and importance in preventing liquid floodback. - Suction line accumulator: Construction, U-tube orifice, oil return hole, and liquid slugging protection. - Liquid-suction heat exchanger: Sub-cooling enhancement and suction vapor superheating.

Week No.	Trade Practical (Professional Skills)	Trade Theory (Professional Knowledge)
WEEK 27	- Identify refrigerant cylinders by colour codes: HFC-134a, R-410A, R-32, R-404A, R-290, R-600a, R-123. - Measure pressure-temperature relationship using PT chart and manifold gauges. - Safely handle refrigerant cylinders, inspect tare weight, hydrostatic test dates, and pressure relief valves.	- Classification of refrigerants: Halocarbons, Hydrocarbons (HCs), Hydrofluoroolefins (HFOs), Inorganics. - Refrigerant numbering system (ASHRAE nomenclature) and chemical molecular formulas. - Environmental impacts: Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). - Montreal Protocol, Kigali Amendment, and phase-out timelines for ODS and high-GWP refrigerants.
WEEK 28	- Recover refrigerant from a working or faulty AC/refrigerator into recovery cylinders using recovery station. - Transfer refrigerant from bulk storage cylinder to small service cylinders using ice bath / differential pressure. - Test recovered refrigerant for contamination and practice recycling procedures.	- Refrigerant recovery methods: Vapor recovery, liquid recovery, and push-pull recovery methods. - Recovery equipment: Oil-less recovery compressors, filter driers, and recovery cylinders. - Safe filling limits of recovery cylinders (80% maximum liquid volume rule at 21°C). - Ozone Depleting Substances (Regulation and Control) Rules, 2000 and environmental compliance.
WEEK 29	- Identify flammability and toxicity classifications of refrigerants (ASHRAE safety group A1, A2L, A3, B2L). - Safe handling procedures for mildly flammable (A2L - R-32, HFO-1234yf) and highly flammable (A3 - R-290, R-600a) gases. - Test zeotropic refrigerant blends (R-404A, R-407C, R-410A) and observe temperature glide.	- Refrigerant safety groups: Toxicity (A and B) and Flammability (1, 2L, 2, and 3). - Lower Flammability Limit (LFL) and Upper Flammability Limit (UFL) of A2L and A3 refrigerants. - Azeotropic vs Zeotropic refrigerant blends: Temperature glide, fractionation, and liquid-state charging. - Electronic leak detectors (corona discharge, heated diode, infrared) and ultrasonic detectors.
WEEK 30	- Identify thermal insulation materials: Glass wool, Polyurethane Foam (PUF), expanded polystyrene (thermocool), and nitrile rubber. - Pack thermal insulation in refrigerator cabinets and suction lines to eliminate sweating and heat leakage. - Seal insulation joints with vapor barrier adhesive tape.	- Thermal insulation: Function, heat transfer mechanisms (conduction, convection, radiation). - Thermodynamic properties of insulators: Thermal conductivity (K-value), density, and moisture absorption. - Vapor barrier: Necessity of airtight vapor sealing to prevent moisture condensation and frost rot.
WEEK 31	- Identify mechanical and electrical components of Window Air Conditioner. - Inspect selector switch, thermostat switch, fan motor (multi-speed PSC), starting/running capacitors, and PCB. - Trace electrical circuit diagram and wiring harness of window AC.	- Window Air Conditioner: Operating principle, room air circulation, ventilation, and exhaust. - Refrigeration cycle of window AC: Hermetic/rotary compressor, finned tube condenser and evaporator. - Electrical controls: Master selector switch, thermostat, double-shaft blower motor, and capacitors.

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WEEK 32	• Conduct pressure leak testing on window AC piping using dry nitrogen. • Evacuate system with two-stage rotary vacuum pump and charge specified refrigerant (R-32 / R-410A / R-22). • Measure running suction pressure, discharge pressure, air temperature drop across evaporator, and amperage.	1. Pressure and vacuum testing standards for window air conditioners. 2. Charging procedure for window units: Weighing scale method and suction pressure monitoring. 3. Air conditioning airflow parameters: Supply air temperature, return air temperature, and Delta-T.
WEEK 33	• Installation practice of window air conditioner: Making wall opening, fixing wooden/steel frame, securing unit. • Perform troubleshooting on window AC: Unit not cooling, compressor tripping on OLP, blower noisy, ice formation. • Service air filters, wash cooling coils, and straighten bent fins with fin comb.	1. Window AC installation guidelines: Location selection, sill height, slope for condensate drainage. 2. Common faults and diagnosis: High head pressure, low suction pressure, frosted coil, and fan failures. 3. Preventive maintenance schedule: Filter cleaning, coil washing, and annual overhaul.
WEEK 34	• Identify various types of Split Air Conditioners: Wall-mounted, floor-standing, ceiling cassette, and ducted units. • Identify components of indoor unit (IDU) and outdoor unit (ODU). • Mount wall installation plate, drill wall passage hole with core drill machine, and mount indoor unit.	1. Split Air Conditioner: Advantages over window AC, aesthetic design, low indoor noise level. 2. Indoor Unit (IDU) components: Cross-flow fan (tangential blower), cooling coil, air filters, PCB, swing louvers. 3. Outdoor Unit (ODU) components: Compressor, propeller fan, condenser coil, service valves, and electrical terminal block.
WEEK 35	• Mount outdoor unit on cantilever wall brackets with anti-vibration rubber pads. • Connect interconnecting copper refrigerant pipes (suction and liquid lines), flare nuts, and insulation sleeves. • Connect indoor-outdoor electrical interconnecting cable and condensate drain pipe.	1. Site selection criteria for IDU and ODU: Clearances, airflow, direct sunlight, and structural strength. 2. Piping limitations: Maximum piping length, vertical elevation difference, and oil return traps. 3. Condensate drain piping: Proper slope, prevention of air locks, and gravity drainage.
WEEK 36	• Leak test interconnecting split AC piping using dry nitrogen; perform vacuuming of lines and IDU. • Open 2-way and 3-way service valves to release factory refrigerant charge; check running parameters. • Install floor/ceiling mounted cassette split AC and ducted split AC indoor units.	1. 2-way and 3-way service back-seating valves: Construction, hex key operation, and gauge port. 2. Purging vs Vacuuming: Why vacuuming is mandatory in R-410A and R-32 systems. 3. Cassette split AC: Construction, 4-way airflow, built-in drain lift pump, and false ceiling mounting. 4. Ducted split AC: Low-profile ducted units, canvas connection, and static pressure distribution.

Week No.	Trade Practical (Professional Skills)	Trade Theory (Professional Knowledge)
WEEK 37	• Service and troubleshoot Multi-Split AC systems with single ODU and multiple IDUs. • Identify components of Inverter Split AC: Variable-speed DC twin-rotary compressor, electronic expansion valve (EEV). • Test power PCB, noise filter PCB, reactor coil, and DC fan motors in Inverter AC.	1. Multi-Split AC: System layout, refrigerant distribution headers, and independent room controls. 2. Inverter AC Technology: AC-DC-AC conversion, Pulse Width Modulation (PWM), IPM intelligent power modules. 3. Electronic Expansion Valve (EEV): Stepper motor mechanism, pulse count control, and precise superheat control. 4. Reactor (choke coil), smoothing electrolytic capacitors, and heat-sink thermal management.
WEEK 38	• Troubleshoot Inverter Split AC: Diagnose error codes via remote controller and PCB flashing LEDs. • Test NTC thermistors (room temp, coil temp, discharge temp sensors) using multimeter resistance-temperature check. • Study Energy Efficiency Star Labeling and Indian Seasonal Energy Efficiency Ratio (ISEER).	1. Self-diagnosis and error code interpretation for leading inverter AC brands. 2. Sensor troubleshooting: Room temperature sensor, evaporator coil sensor, compressor discharge sensor. 3. Bureau of Energy Efficiency (BEE) standards: Star rating metrics, ISEER calculation formula. 4. Annual energy consumption estimation and eco-friendly servicing best practices.
WEEK 39	On the Job Training (OJT) / Group Project	On the Job Training (OJT) / Group Project
WEEK 40	On the Job Training (OJT) / Group Project	On the Job Training (OJT) / Group Project
WEEK 41	On the Job Training (OJT) / Group Project	On the Job Training (OJT) / Group Project
WEEK 42	On the Job Training (OJT) / Group Project	On the Job Training (OJT) / Group Project
INSTRUCTIONAL PLAN APPROVAL & SIGNATURES		
Sign of Instructor	Sign of Group Instructor (GI)	Sign of Superintendent / Principal