CONSTRUCTION STANDARD

FOR

INSTALLATION, TESTING, ADJUSTING

AND

COMMISSIONING OF HVAC&R SYSTEMS

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0. INTRODUCTION

This Standard covers to applied requirements for installation and its affiliated works pertaining to HVAC&R equipment and system, providing practical guidance for professionals involved in such activities.

The object is to ensure that the completed installation is thoroughly checked, set to work, adjusted and regulated so that at the time of handover to the Company, the HVAC&R system is operating in accordance with the design specification and shall continue to do so throughout its working life.

1. SCOPE

This Standard covers subject on general construction requirements, installation provisions, noise and vibration control, TAB procedures, commissioning guidelines with start-up procedures and pre-commissioning check list.

It represents technical informations and provisions from installation right upto pre-commissioning, and start-up procedures of HVAC&R equipment and systems.

It shall also cover the requirements of good engineering practice and craftsmanship installation in order to obtain a given set of design conditions and system performance within a reasonable set of limitations.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Contractor.

ANSI/ASHRAE 111-1988 "Testing, Adjusting and Balancing Practices for Measurement of Building HVAC&R System"

ASHRAE 1-1989 "Guideline for Commissioning of HVAC System"

AIA (THE AMERICAN INSTITUTE OF ARCHITECTS)

BSRIA-1989 (THE BUILDING SERVICES RESEARCH AND INFORMATION ASSOCIATION (UK))

3. DEFINITIONS AND TERMINOLOGY

3.1 Adjusting

To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, adjust a damper).

3.2 Balance

To proportion flows within the distribution system (submains, branches and terminals) according to specified design quantities.

3.3 Capacity Testing

Demonstrating the capability of the installation to achieve and maintain the specified performance criteria.

3.4 Commissioning

Commissioning of an installation is a process for achieving, verifying, and documenting the performance of buildings to meet the operational needs of the building within the capabilities of the design and to meet the design documentation and the owner’s functional criteria, including preparation of operator personnel.

3.5 Commissioning Management

The planning, organization, coordination, and control of commissioning.

3.6 Commissioning Manager

The firm or individual appointed to manage the commissioning process,which represents planning, organization, coordination and control of commissioning.

3.7 Commissioning Specialist

The firm or individual appointed to carry out specified duties in connection with commissioning engineering services.

3.8 Design Criteria

Those measurements and quantities selected as the basis for the design of a system.

3.9 Environmental Testing

Measurement and recording of internal environment conditions.

3.10 Flushing

The washing out of an installation with water to a specified procedure to remove construction detritus.

3.11 Fine Tuning

The adjustment of the system where usage and system proving have shown such a need. This may also include the reassessment of design values and control set points to achieve the required performance.

3.12 Precommissioning

Specified systematic checking of a completed installation to establish its suitability for commissioning, that is the state of the system when it is installed in accordance with the specification, clean and ready for setting to work.

3.13 Pressure and Leakage Testing

The measurement and recording of pressure retention and gas and fluid losses and gains in the plant, equipment, distribution ways, and terminals.

3.14 Report Forms

Test data sheets arranged for collecting test data in logical order for submission and review. The data sheets should also form the permanent record to be used as the basis for any future testing, adjusting, and balancing.

3.15 Systems for Commissioning

Systems designed, installed, and prepared to specified requirements in such a manner as to enable commissioning to be carried out.

3.16 Testing

The measurement and recording of specified quantifiable characteristics of an installation or parts thereof. (This includes off-site testing.)

3.17 Vibration Isolation

Use of resilient material between a structure and a machine.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise is specified.

5. GENERAL CONSTRUCTION REQUIREMENTS

5.1 General

5.1.1 The general construction requirements mentioned herein shall be part of the contract documents between the HVAC Contractor and the Company.

5.1.2 These effective descriptions shall simplify coordinating the responsibilities between design and installation engineers.

5.2 Construction

5.2.1 The foundation shall be constructed according to dimension, shape and weight of the equipment in accordance with IPS-E-CE-120 and relevant civil drawings.

5.2.2 The poured concrete shall be reinforced type duly embedded with horizontal or vertical steel rods per manufacturer's instructions.

5.2.3 Where foundation design is not specified, the foundation dimensions, size of foundation bolts, method of setting, aligning and anchoring of equipment shall be executed per manufacturer's recommendations.

Notes:

1) For cement requirement on concrete, reference is made to IPS-C-CE-200 standard.

2) Retempering of concrete with addition of water or remixing of partially hardened concrete are not recommended.

3) The proper location of a machine directly influences the economic aspects, the flexibility, the sound level and continuous operation of any system.

5.3 Equipment Support

For equipment support such as fabrication of suspended platforms and saddles for machinery, tanks etc. following procedures are recommended.

a) Supporting structures shall be designed and constructed to safely withstand stresses to which they may be subjected and distribute the load evenly over the building areas.

b) Supports of tanks shall be located such that it will not cause undue strain on sheets and/or interference with pipe connections to tank outlets or tube pullings during service. In the event of using saddles for tank support, its material shall be of cast iron or welded-steel of curvature to fit the tank. (Prior to fabrication the contractor shall provide detailed drawing for approval).

c) The mounted equipment shall be mounted on legged stands constructed of structural steel members or steel pipe and fitting, duly braced and fastened with flange plate bolted to floors.

d) The ceiling suspended or wall mounting equipment shall be provided with suspended platform, or strap hangers, bracket or shelf whichever is suitable for the application. All steel structure shall be braced to purloin or building structure as the case may be.

5.4 Pipe Sleeves, Escutcheons

5.4.1 General

Sleeves shall be provided for all piping, ducting, wiring etc., crossing through walls or any other hurdle.

5.4.2 Sleeve material

5.4.2.1 Depending on its location sleeves shall be constructed with lock seam joints of following minimum sizes:

- Pipe sleeves smaller than 150 mm (6") shall be galvanized steel ASTM A53, Grade A.
- Pipe sleeves 6" and larger shall be galvanized sheet metal of 2 mm (10 gage) thickness round tube closed with welded longitudinal joint.

5.4.2.2 In the event sleeves are to be located in concrete beams or concrete fire proofing, the materials shall be of galvanized steel or wrought iron pipe. For outside walls, footings, water proofed floors or where sleeve is required to be extended above finished floor or through space between pipe and the sleeve shall be filled with proper mastic or caulking material. For sleeves in walls below grade, extra heavy cast iron soil pipe or steel shall be used.

5.4.2.3 For free movement of pipes, where expansion and contractions are anticipated, sleeve sizes shall be of sufficient diameter, two size larger than the pipe size.

5.4.2.4 The length of sleeves shall depend on various locations. Lengths shall be considered to comply with following areas:

a) Terminate sleeves flush with walls, partitions or ceiling.
b) In areas where pipes are concealed as in chases, terminate sleeve flush with floors.
c) In finished areas where pipes are exposed, extend sleeves 4 cm (1½") above finished floor.

5.4.3 Sleeve installation

5.4.3.1 For setting sleeves in required location, ample time for approval shall be obtained to permit pouring of concrete or other construction trade per time schedule.

5.4.3.2 Sleeves shall be securely fastened with mechanical sleeve seal to prevent displacement when concrete is being poured or when other construction work is in progress.

5.4.3.3 Space between sleeves and pipes in underground walls shall be filled with proper mastic or caulking material on both sides of the walls; for floors where water is to be kept out, the fillings shall be through graphite packing and appropriate compound.

5.4.3.4 For sleeves passing through membrane water proofing, a 16 oz soft sheet copper or 3 Kg lead flashing extended to 20 cm in all directions shall be provided.

5.4.3.5 Where sleeves are specified for pipes or stacks passing through roof, galvanized cast iron sleeve with caulking recess and flashing clamp device shall be used as approved; anchor sleeve in roof construction shall be caulked between sleeve recess and stack, flashed to clamp device, water tight with durable joints.

5.4.4 Escutcheons

5.4.4.1 The inside diameter size shall fit around insulation or around uninsulated pipes, its outside diameter shall cover sleeves. Where sleeves extend above floor, escutcheons shall clear sleeve extension.

5.4.4.2 The escutcheons or plates shall be secured to pipe or sleeve but never to insulation.

5.4.4.3 Escutcheon material

5.4.4.3.1 On walls, partitions, ceilings and floors, where sleeves are flushed or extend only ½" above finished floor, use sheet steel solid plates suitable for pipe size ½" to 4", or sheet steel split plates suitable for ½" to 6" pipe dia, or sheet steel hinged plates suitable for pipe sizes 3/8" to 4" diameter.

5.4.4.3.2 Plates shall be black with prime coat of rust-inhibiting paint or nickel plated, as specified.

5.4.4.3.3 In locations where water or condensation will accumulate, sleeves shall be flushed or extended ½" above finished floor, chrome-plated cast brass plates shall preferably be used.

5.5 Paintings

5.5.1 General

Painting shall include furnishing labor, materials, equipment, ladders, scaffolding, protecting covers, metal, rag containers, other items required to prepare, paint and finish of work specified. It shall be applied by skilled personnel, following manufacturer's recommended directions.

5.5.2 Requirements

5.5.2.1 Paints used for prime coats shall be suitable for subsequently applied finish coats.

5.5.2.2 Before painting, all surfaces shall remain cold and all equipment, piping and workmanship have obtained the TAB services approval.

5.5.2.3 Undercoats shall be allowed to dry completely before applying succeeding coats. Nameplates of equipment shall be free of any paint.

5.5.3 Surface preparation

5.5.3.1 Surfaces shall be clean and free of any dirt before the prime coat is applied. Clean with solvent to remove dirt, oil, grease; where solder flux has been used, clean with benzene and with wire-brush to remove mill scale or rust.

5.5.3.2 When sand blasting is required on pipes, painting on such surfaces shall be applied per paint manufacturer's recommendation. Also damaged spot, shop marks, rivets,bolts shall be touched up before prime coat is applied.

5.5.4 Extent of painting

5.5.4.1 In humid and corrosive areas for ferrous metal piping, ducts, equipment, special items which require insulation prior to insulating, one coat of asphaltum paint for cold surfaces and heat-resistant paint for hot surfaces shall be applied. These shall not apply to surfaces which are galvanized.

5.5.4.2 For ferous metal pipe exposed to weather, such as plumbing stack extensions, heating vent pipes etc., one prime layer and two finish coats shall be applied.

Note:

The contract specification shall clearly describe the extent of painting to be executed by the contractor, specifically on exposed work in mechanical rooms, the boiler room, equipment, ducts, pipes etc.

5.5.5 Paint manufacture

5.5.5.1 Prime and finish paints used for HVAC works shall be standard brands, ready mixed, as manufactured by leading paint manufacturers suitable for the specific type of service for which paint is utilized.

5.5.5.2 All paints shall be delivered in their original containers with unbroken seals, bearing the manufacturer's label specifying trade name, brand and quality.

5.5.5.3 For any deviations, IPS standards E-TP-100, E-TP-101 and E-TP-102 shall comply to this Standard.

5.6 Identification Procedure (or Practice)

5.6.1 General

5.6.1.1 Means of a standard practice in identifying the installed equipment, material and system shall be arranged on appropriate locations of mechanical equipment room and on valves, pipes, ducts etc.

5.6.1.2 Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechnical spaces with prior coordination, suitable identification shall be provided after completion of covering and painting. Also prior to installation of acoustical ceilings and similar removable concealment a suitable identification shall be installed.

5.6.2 Piping system identification

5.6.2.1 Unless otherwise mentioned the basic color scheme shall comply with ANSI-A13.1 Standards.

5.6.2.2 Arrows shall be provided indicating direction of flow integrally with piping system service lettering.

5.6.2.3 The lettering shall comply with piping system nomenclature as specified, scheduled or shown, and abbreviated only as necessary for each application length.

5.6.2.4 For each exterior underground piping, during back-filling/top soiling a continuous underground-type plastic line marker shall be installed. The line marker shall be located directly over buried line at 150 mm to 200 mm below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 400 mm, a single line marker shall be installed.

5.6.3 Valve identification

5.6.3.1 Each valve unit shall be identified according to its nature of service, in letters of approved size, shape and wording.

5.6.3.2 All valves, control dampers, temperature and pressure tubing for controls shall be identified by means of polished or lacquered brass or aluminum tags, 1½" diameter, with letters stamped or embossed (6 mm high) on a black or glowing background, securely fastened with brass "S" hooks or chains or through 4 mm hole for fastener.

5.6.3.3 For each page of valve schedule, a glazed display frame of plastic or SSB-grade sheet glass shall be provided with screws for removable mounting on masonry walls. The frames shall be of finished hardwood or extruded aluminum.

5.6.3.4 The marker shall be preferably be to an approximate size of 64 mm × 100 mm.

5.6.4 Duct identification

5.6.4.1 The air supply, return, exhaust, intake and relief ductwork shall be identified with duct markers or provided with stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color).

5.6.4.2 The duct markers shall preferably be of standard laminated plastic conforming to the following color code:

a) Green: Supply air
b) Yellow: Return air
c) Blue: Exhaust, outside and recirculated air
d) For hazardous exhausts color codes and designs, shall comply to ANSI A13.1,unless otherwise mentioned.

5.6.4.3 The nomenclatures are represented by the following:

a) Direction of air flow
b) Duct service (supply, return, exhaust, etc.)
c) Duct origin (from)
d) Duct destination (to)
e) Design air volume.

5.6.5 Mechanical equipment identification

5.6.5.1 Near or on each major item of mechanical equipment and each operational device shall be preferably provided with engraved plastic laminate or plastic equipment marker. The following general categories of equipment and operational devices shall be identified:

a) Main control and operating valves, including safety devices and hazardous units such as gas outlets.
b) Meters, gages, thermometers, etc.
c) Fuel burning units including boilers, furnaces, heaters, stills and absorption units.
d) Pumps, compressors, chillers, condensers and similar motor-driven units.
e) Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar units.
f) Fans, blowers, primary balancing dampers and mixing boxes.
g) Packaged HVAC central station or zone-type units.
h) Tanks and pressure vessels.
i) Strainers, filters, humidifiers, water treatment systems and similar equipment.

5.6.5.2 The equipment markers shall preferably be to an approximate size of 115 mm × 152 mm (4.5" × 6") and in standard laminated plastic conforming preferably to the following color code:

a) Green: Cooling equipment and component.
b) Yellow: Heating equipment and component.
c) Yellow-Green: Combination cooling and heating equipment and component.
d) Brown: Energy reclamation equipment and components.
e) Blue: Equipment and components that do not meet any of the above criteria.
f) The markers for hazardous equipment shall comply to ANSI A13.1, unless otherwise mentioned.

5.7 Coordination Responsibilities

5.7.1 After careful inspection of materials delivered, the contractor shall be held responsible for its proper storage and upkeep.

5.7.2 The contractor shall coordinate his work with adjacent work and cooperate fully with the work of other building trade contractors, so as to facilitate the general progress of the project.

5.7.3 The contractor shall make necessary arrangements with the general contractor for the use of hoist, elevator or other site machinery without hindrance to other trades. The contractor shall provide detailed shop drawing for approval.

5.8 System Flushing & Cleaning

5.8.1 After satisfactory completion of the installation, system filling and flushing shall be given due consideration. Interior cleanliness of all pipework, waterways and water equipment play an important part during pressure testing.

5.8.2 To flush dirt from the system, the pipework circuits shall be divided by adjustment of isolating valves into self-draining sections.

5.8.3 Items sensitive to dirt such as small bore coils, tubes, valves, pumps etc. shall remain isolated during the flushing process.

5.8.4 The general principle of flushing shall be from high to low points, using maximum possible flow rates which are continued until the out flow runs clear.

6. INSTALLATION PROVISIONS FOR HVAC&R AFFILIATED MECHANICAL WORKS

6.1 Mechanical Installations

6.1.1 General

In order to sequence, coordinate and integrate the various elements of mechanical systems, materials and equipment, the following requirements shall comply:

a) The mechanical systems, equipment and material installation shall be coordinated with other building components.

b) All dimensions shall be verified by field measurements.

c) To allow for mechanical installations, provide arrangements for chases, slots, and openings in other building components during progress of construction.

d) The installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components shall be coordinated as they are constructed.

e) For efficient flow of work, installation of mechanical material shall be integrated, coordinated and sequenced accordingly. Particular attention shall be given to large equipment requiring positioning prior to closing in the building.

f) Where mounting heights are not detailed or dimensioned, materials, systems and equipment shall be so installed to provide the maximum headroom possible.

g) Connection of mechanical systems with exterior underground and overhead utilities and services shall be coordinated complying with requirements of governing regulations.

h) The installed systems, materials and equipment shall conform with approved submittal data, including coordination drawings to greatest extent possible. Arrangements shall conform to the contract documents, recognizing that portions of the work are shown in diagrammatic form also.

i) The mechanical equipment shall be so installed to facilitate servicing, maintenance and repair or replacement of equipment components. As much as practical the equipment shall be connected for ease of disconnecting with minimum of interference for other installations. Grease fittings shall be extended to an accessible location.

j) Access panels or doors shall be provided where units are concealed behind finished surface.

k) The systems, materials and equipment shall be installed giving right-of-way priority to systems required to be installed at a specified slope.

6.1.2 Following factors shall warrant special attention:

a) All execution work shall be conducted by skilled personnel.
b) Consumable items such as electrodes, grease, graphite etc., shall be of quality make.
c) Supervision shall be expedited by experienced engineers.

6.2 Overall Equipment Installation

While installing the HVAC&R equipment the following manufacturer's step by step procedures as outlined in their published instruction manual shall be followed.

- "Boilers and Burners"
- "Packaged Air Conditioners"
- "Humidification & Dehumidification System"
- "Field Erected Air Conditioning System"
- "Packaged Refrigerators & Freezers"
- "Field-Erected Refrigeration System"
- "Fans, Filters and Air Distribution System"
- "HVAC Pipes Valves & Fittings"
- "General HVAC Affiliated Equipment"
- "HVAC Insulating Materials"
- "Room Air Conditioners"

6.3 Piping Installation

6.3.1 Installation guidelines

6.3.1.1 Pipings shall form right angles on parallel lines with building walls and installed straight plumb and as direct as possible.

6.3.1.2 Pipes shall remain close to walls, slabs, beams partitions, ceilings and other permanent elements of the building. Offset shall take place only when necessary to follow walls.

6.3.1.3 Group of pipes shall be located parallel to each other, spaced suitably to permit insulation works and allow access for servicing of valves. Risers between floors shall be free of couplings.

6.3.1.4 All supply and return main branches plus runs to riser shall be provided with pertinent shut-off valves.

6.3.1.5 All low points in the system main, risers and branch lines shall be provided with ¾" drain ball valves with short ¾" threaded nipple and cap; and high points provided with air vents.

6.3.1.6 Gradients in the piping shall be such that when system is filled, air in mains and risers are carried and discharged upwards at indicating venting points. Proper gradients shall ensure easy circulation and prevent noise and water hammer.

6.3.1.7 All drain lines over electrical equipment shall be extended with minimum ¾" pipes upto floor, preferably near the closest floor point.

6.3.2 Protection of open pipe ends

During delivery of pipes and/or work suspension, pipe ends shall be protected from foreign particles duly plugged or provided with end caps.

6.3.3 Concealed pipes

6.3.3.1 Whenever piping runs up branches passing through floor into partition, offset above the floor as closed to the equipment, as possible; expose only as much as necessary for final connection.

6.3.3.2 In furred spaces pipes shall be placed close to structural members to permit minimum furring.

6.3.4 Pipes over electrical equipment

6.3.4.1 When pipe joints or valves in water lines occur within 60 cms in horizontal direction from electrical panels, a suitable sized drip pan shall be furnished to provide protection over all electrical devices and units.

6.3.4.2 The drip pans shall be of galvanized, edges turned up 6 cms all sides and reinforced with steel angles, as approved.

6.3.4.3 Pipings shall be properly supported or suspended on stands, clamps, hangers etc., designed to permit free expansion and contraction while minimizing vibration.

6.3.5 Unions in pipelines

6.3.5.1 Screwed (or flanged) unions shall not be concealed in walls partitions or ceilings. These shall be provided for the following areas:

a) In long runs of piping with screwed joints to permit convenient disassembly for alterations and repairs.
b) In by-pass lines around equipment.
c) In connections to tanks, heaters, pumps, etc. where disconnection is required for repairs, replacements etc.

6.3.5.2 For sizes 50 mm (2") and smaller, unions shall be installed adjacent to each valve, and at the final connection to each piece of equipment.

6.3.5.3 Dielectric unions shall be installed to connect piping materials of dissimilar metals in dry piping system (gas, compressed air, vacuum).

6.3.6 Valves in pipelines

6.3.6.1 Valves shall be located for easy access and operations and when concealed, suitable access doors shall be provided.

6.3.6.2 All inlet and outlet of equipment shall be provided with pertinent shut-off valves and conveniently located to allow for unit removal for repairs without interfering with system circuits.

6.3.7 Refrigerant pipings

6.3.7.1 General

6.3.7.1.1 In view of the fact that halocarbon gasses are heavy refrigerants, usually operating at relatively low pressures, and that the refrigerating effect per pound is low and hence comparatively large volumes are circulated, the matter of pipe line sizes becomes of considerable importance.

6.3.7.1.2 Since halocarbon gasses are solvents,and not all materials can be safely used with them, care should be taken in using approved pipe joint compounds and gasket materials.

6.3.7.1.3 Pipes intended for use with halocarbon and ammonia gasses shall be kept dry, the ends shall be plugged at all times until the pipe is placed in the line.

6.3.7.2 General pipelines

6.3.7.2.1 The inside of steel pipe or steel tubing used on halocarbon gas systems shall be free of scale and dirt. (Use of pipe with mill-oil coating are not recommended.)

6.3.7.2.2 All steel pipe lines shall be welded to prevent leaks at the joints. Welded pipe connections shall be carefully made and proper care exercised so that scale and welding particles may be removed from the lines before putting the plant into operation.

6.3.7.2.3 All welding seams shall be made near a flange connection so that the line can be opened and cleaned, after the welding has been completed.

6.3.7.2.4 The following joining materials shall comply:

a) Welding material shall comply with Section II, Part C, ASME "Boiler and Pressure Vessel Code" appropriate for the wall thickness and chemical analysis of the pipe being welded.

b) Brazing material shall comply with Section II, Part C ASME "Boiler and Pressure Vessel Code" for brazing filler metal materials appropriate for the materials being joined.

6.3.7.2.5 On threaded connections weld joints shall be kept at least 40 cm away, because the welded heat on the pipe is apt to ruin the threaded connection.

6.3.7.2.6 The thread in the threaded joints shall be cut full length of standard taper and size to ensure that it does not shoulder at the end of the threads. The threads shall be cleaned with benzene, rubbed bright and dry and all rust removed by steel wool.

6.3.7.3 Soldered joints

6.3.7.3.1 The surface of the copper tubing, and specially the inside of the fittings being joined, shall be absolutely clean and free from oxidation, dirt, moisture or grease.

6.3.7.3.2 Steel wool or equal shall be used for cleaning the fittings and pipes, and only after thorough cleaning, the necessary joints should be made up.

6.3.7.3.3 Solders shall be applied in such a manner until the entire surface around the joint is at an even temperature, slightly above the melting point of the solder.

6.3.7.3.4 High temperature produced during welding or soldering will tend to break down any halocarbon gas (refrigerant) that is present releasing dangerous fumes. In such cases it is essential that the lines are cooled before admitting any refrigerant to it. Also any gases that may have been generated during this process shall be effectively removed.

Note:

When applying solder on soldered joints, use of acid core solders are not recommended as the fluxes in them tend to be corrosive.

6.3.7.4 Flared joints

6.3.7.4.1 The flaring tool shall not be used dry or without proper oiling, as it will thin out the tubing to a point where there may be danger of breakage.

6.3.7.4.2 Where the tubing is hard and tends to thinout and crack, the end shall be annealed before making the flare.

6.3.7.4.3 A non-freezing or vented nuts shall be used on all frosted flare connections.

6.3.7.4.4 All copper tubings of flared joints required for connecting high side with low side refrigeration circuit shall preferably be of type K.

6.3.8 Pipe supports

6.3.8.1 Suitable supports shall be provided to secure pipes, conduits in place, prevent pipe vibration, maintain required grading by proper adjustment, making provisions for expansion and contraction and establishing neat appearance.

6.3.8.2 Supports shall be designed such that it provides strength and rigidity to suit loading, service, and in a manner which will not unduly stress the building construction.

6.3.8.3 Wherever applicable, supports and hangers shall be fastened to building steel framing.

6.3.8.4 Wherever applicable, inserts shall be used for suspending hangers from reinforced concrete slab.

6.3.8.5 Hangers shall be capable of vertical adjustment after piping is erected. Care shall be taken not to pierce hanger rods through ducts. (Use of perforated band iron, wire or chain as hangers are not recommended.)

6.3.8.6 Horizontal piping support schedule shall be based on job classification, but following schedule are recommended on HVAC&R pipes:

PIPE SIZE mm (inch)	ROD DIAMETER	MAX. SPACING (APPROXIMATE)
25.4 mm (UPTO 1")	—	2.0M
25.4 TO 32 mm (1" to 1¼")	9.5 mm (3/8")	2.5M
38 TO 50 mm (1½" to 2")	9.5 mm (3/8")	3.0M
64 TO 76 mm (2½" to 3")	12.7 mm (½")	3.0M
100 TO 127 mm (4" to 5")	16 mm (5/8")	3.7M
150 mm———— (6")	19 mm (¾")	3.7M
200 mm———— (8")	22 mm (7/8")	4.3M
254 TO 305 mm (10" to 12")	22 mm (7/8")	5.0M
355 TO 400 mm (14" to 16")	25.4 mm (1")	5.0M

6.3.8.7 Shop fabricated pipe supports, hangers and inserts shall be of standard steel shape bar stock; channels, angles, strap plates, rods etc., shall preferably be with welded construction.

6.3.8.8 For overhead supports clevis type hanger shall be used. Where pipe to be supported exceeds maximum loading recommended for clevis type hanger, depending on loading, steel pipe clamps or heavy steel pipe clamps may be used.

6.3.8.9 For floor supports, cast iron pipe rests, suitable for pipe sizes 2" to 8" shall be used where no provision for expansion and contraction may be required. The pipe rests shall be with pipe nipple of length to suit conditions and floor flange fastened to floor as specified.

6.3.8.10 Where provisions of expansion and contraction may be required, pipe roll stands of suitable design shall be provided on concrete piers, wherein the stands shall be fastened to floor flange, as specified.

6.3.8.11 For wall support where no provision for expansion and contraction are required, steel J-hook suitable for pipe sizes upto 3" can be used.

6.3.8.12 For hanger suspension and pipe roll stand maximum safe loading as directed by relevant manufacturers shall be adhered to.

6.3.8.13 For vertical pipeline supports following guidelines are recommended.

a) Steel extension pipe clamps from sizes 1½" to 8" shall be used for intermediate floors. Clamps shall be securely bolted on building structure. When directed clamp shall be welded to building steel providing supplementary structural member for clamp rest.

b) Where pipe sleeves extend above floor, pipe clamps shall be placed at ceiling below.

6.3.8.14 Where beam clamps are specified for hanger and support, malleable iron beam clamp shall be used for 9.5 mm (3/8") hanger rods on pipe sizes upto 2"; forged steel beam clamp shall be used for hanger rod sizes upto 1½" for pipe sizes above 2".

6.3.8.15 Following guidelines are recommended for concrete inserts specified for pipe, duct or conduit support:

a) Inserts shall be placed in concrete form per approved location in ample time to permit pouring of scheduled concrete. Necessary re-inforcing rods for pipe sizes over 3" and for ducts shall be provided.

b) In areas where concrete slab forms finished ceiling, the insert shall be flushed with concrete slab surface for neat appearance.

6.3.8.16 On covering protection for pipes, the hangers and supports shall not pierce or damage the insulation. In such cases sheet metal shields shall be provided for protection of insulation.

6.3.8.17 For free expansion and contraction, approved anchors consisting of steel clamps welded to pipe, fastened to building construction or imbedded in seperate concrete pier shall be provided.

6.3.8.18 For copper tubing support, following guidelines are recommended:

a) For horizontal lines of copper tubing specially designed brass hangers shall be provided. Where pipe runs over roof a suitable support base shall be provided.

b) For uncovered vertical lines, heavy duty copper straps shall be used.

6.3.9 Access doors for pipes and ancillaries

Access doors for installation of pipes and its expertise shall not be less than size 60 cm × 60 cm, for all concealed valves, traps, strainers, expansion joints, coils and other mechanical parts which require accessibility for operation, inspection and maintenance.

6.3.10 Pipe insulation

6.3.10.1 Insulation activities shall mean to include surface preparation, insulating materials including vapor barrier applications with canvas jacket finish, cement finish, other finishes; weather protection, frost proofing etc., as specified.

6.3.10.2 Insulation covering material which is to be painted shall be in satisfactory condition to receive paint.

6.3.10.3 Insulation shall be continuous through walls, floors, partitions unless otherwise mentioned.

6.3.10.4 Approved insulation for copper tubing shall be specially pre-moulded outside diameter of tubing.

6.3.10.5 Wherever specified, insulation shall be terminated at sections where insulation is to be omitted neatly with sectional or plastic insulation and 19 mm (¾") wide metal bands with turned edges.

Note:

Depending on various services, the insulating material shall be as specified and methods of its application shall be executed per approved manufacturer's recommended instructions.

6.3.11 Drain lines

6.3.11.1 Adequate facilities shall be provided for drainage of pumps, boilers, piping, other equipment and apparatus as required.

6.3.11.2 Drain pipes shall be extended to the closest floor drains or to open drain trench.

6.3.11.3 Wherever possible necessary drainage connections shall be made and extended to existing building drains.

6.4 Air Distribution Ductwork

6.4.1 General

6.4.1.1 For sheet metal, the method of air duct fabrication with galvanized and aluminum sheets shall be per SMACNA regulations.

6.4.1.2 The installation method of fibreglass duct board and flexible ducts shall be conducted per AMCA recommendations.

6.4.1.3 Ducting shall adhere to ceiling height and coordination shall be established to maintain required headroom.

6.4.1.4 All elbows and tees for duct width 400 mm (16") and larger shall be integrated with turning vanes and/or splitters.

6.4.1.5 The air chambers shall be braced and supported in such a manner that they shall not sag nor vibrate to any percebtible extent when fans are operating at maximum speed and with air duct velocity upto 10 m/s (2000 fpm).

6.4.1.6 Duct joints shall be airtight with fiber gaskets and fabricated per specified schedule.

6.4.1.7 Exhaust duct hood for kitchen range or other similar appliances shall be fabricated from preferably anodized aluminum sheet with construction, bracing and other details as specified.

6.4.1.8 To prevent contact between the metals and reduce noise, the joints of dissimilar metal in a ductwork shall be insulated with fiber gaskets, and bolts with fiber ferrules and washers.

6.4.1.9 Access door size shall be as per requirements flushed airtight to duct, fabricated as a steel famed panel preferably provided with two holding knobs and sponge gasket around the inside of the frame.

6.4.2 Duct supports

6.4.2.1 Horizontal ducts shall be supported with hangers spaced not more than 200 cm apart.

6.4.2.2 Vertical ducts shall be supported every 3 meters with angles or channels rivetted to steel ducts; channels shall be rested on floor slab or structural members upon consultant's approval.

6.4.2.3 All supports and its accesories shall be coated with anti-corrosive paint.

6.4.3 Ducting accesories

6.4.3.1 As a standard practice for fabrication of ducts, the following types and use of minimum requirements of hardwares shall be considered:

a) Bolts

For every meter of angle iron (Bolts at 15 cm pitch) eight 6 mm (¼") dia × 25 mm long bolts shall be used.

b) Rivets

For every meter of angle iron (Rivets at 10 cm pitch) eleven 3 mm (1/8") dia × 10 mm long rivets shall be used. (Around 750 Rivets weighs approx. 1Kg.)

c) Rope

A 10 mm dia rope per full frame length of angle iron shall be used.

d) Canvas

Normally for 25 to 30 cm wide canvas, not less than 10 cm between angles and 7 cms overlap top and bottom of duct shall be provided.

e) Wire

A 1 mm dia galvanized wire for use over the insulation material shall be provided.

6.4.3.2 The duct bracing shall be carried around all four sides rivetted with the ducts.

6.4.4 Duct system checks

The following checks are recommended wherever ductworks are installed:

a) Check that all outside air intake, return air and exhaust air dampers are in the proper position and operable for the TAB work.

b) Confirm that all system volume dampers and fire dampers have been installed, are in the full open position, and are accessible.

c) Inspect access doors and hardware for tightness and leakage and verify that all necessary access doors have been installed.

d) Verify that all air terminals and terminal units have been installed and that terminal dampers are fully open.

e) Inspect coils, duct heaters and terminals for leakage at duct connections and piping penetrations.

f) Confirm locations for Pitot tube traverse measurements and accessibility for TAB measurements in general.

g) Confirm that openings have been provided in walls and plenums for proper air passage.

h) Confirm that all architectural features such as doors, ceilings, and windows are installed and are functional with regard to airflow of the duct systems being balanced.

i) Inspect duct systems for proper construction, that all turning vanes have been installed, and that all joints have been sealed where specified.

6.4.5 Ductwork insulation

6.4.5.1 No insulation shall be applied to any ductwork or to any surface until all foreign matter has been removed from the surfaces to be insulated and until the ductwork has been tested, made airtight, cleaned and made operable.

6.4.5.2 Duct insulation shall be applied only on sheet metal ducting. The fibreglass ductboard and flexible ducts shall require no lagging on its outside or inside surfaces.

6.4.5.3 Insulations shall be continuous through floors, walls, partition etc.

6.4.5.4 Duct liners for sound absorption in the interior surface of ducts near equipment shall be insulated upto 2 meters in length with required thickness and shall not support heat and absorb moisture.

6.4.5.5 The insulation for flue ducting shall be with spun mineral fiber blanket cladded with copper steel wire mesh on the outside with a layer of asbestos, suitable for application upto 500°C temperature.

6.4.5.6 All exposed ductwork shall be insulated with suitable vaporproof barrier.

6.4.6 Access doors for ducts

The access doors shall be provided with duct markers or stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural, information.

6.4.7 Concealed doors for ducts

Where access doors are concealed above acoustical ceilings or similar concealment, a suitable plasticized tags may be installed for identification in lieu of specified signs, at installer's option.

6.5 Filter Installation Requirements

Failure of air filter installations to give satisfactory results, in most cases, may be traced to faulty installation or improper maintenance or both. The recommended requirements of a satisfactory and efficiently operating air filter installations are follows:

1) The filter must be of ample size for the amount of air and dust load it is expected to handle. An overload of 10 to 15 percent is regarded as the maximum allowable. When air volume is subject to future increase, a larger filter should be installed.

2) The filter must be suited to the operating conditions, such as degree of air cleanliness required, amount of dust in the entering air, type of duty, allowable pressure drop, operating temperatures, and maintenance facilities.

3) The filter type shall be the most economical for the specific application. The initial cost of the installation should be balanced against efficiency and depreciation as well as expense and convenience of maintenance.

6.6 Valve Installation Method

6.6.1 Examination

6.6.1.1 Prior to valve installation the valve interior through the end ports shall be examined for cleanliness, freedom from foreign matter and corrosion. Packing materials such as blocks used to prevent disc movement during shipping and handling shall be removed. Defective valves shall be replaced with new valves.

6.6.1.2 Valves shall be actuated through an open-close and close-open cycle. Significant features such as guides and seats made accessible by such actuation shall be functionally examined.

6.6.1.3 Threads on both the valve and the mating pipe for form shall be examined.

6.6.1.4 Flange bolting shall be checked for proper size, length and material. Mating flange faces shall be examined for conditions that might cause leakage. Gasket material shall be checked for proper size material composition suitable for service, and freedom from defects and damage.

6.6.2 Valve installations

6.6.2.1 For general application gate, ball and butterfly valves shall be used for shut-off duty. For throttling duty globe, ball and butterfly valves shall be used. For specifice valve applications and arrangement, due importance shall be given to piping system specification.

6.6.2.2 Valves shall be located for easy access and separate support where necessary shall be provided.

6.6.2.3 In order to allow equipment removal without system shutdown, valves and unions shall be installed for each fixture and item of equipment. Unions shall not be used on flanged devices.

6.6.2.4 For each control valve, three valve bypass arrangement shall be used.

6.6.2.5 On horizontal piping valves shall preferably be installed with stem above the center line of the pipe.

6.6.2.6 Valves shall be installed in a position to allow full stem movement.

6.6.2.7 For proper direction of flow, check valves shall be installed as follows:

a) Swing check at horizontal position with hinge pin level.
b) Wafer check at horizontal or vertical position between flanges.
c) Lift check with stem upright and plumb.

6.6.2.8 Before finish painting or insulation are applied, valves shall be cleaned from mill scale, grease and protective coatings from its exterior.

6.6.3 Recommended procedures

6.6.3.1 When installing a screwed valve, the wrench shall be placed on the hexagon nearest the pipe. This supports the valve, otherwise the applied torque can bend the valve.

6.6.3.2 Suitable hangers should be close to both sides of the valve in order to reduce stresses transmitted by the pipe. (Most valves may not be designed to cope with external stresses.)

6.6.3.3 Pipes shall be threaded to correct length so that joint is tight before the pipe end strikes the valve seat.

6.6.3.4 Pipe compound shall be put on the pipe end, not on the valve threads. This prevents it getting on to the valve seat where it may collect dirt and hinder a tight shut-off.

6.6.4 Valve types

6.6.4.1 The type of valves traditionally used for chilled water, condenser water, domestic hot and cold water, heating hot water and low-pressure (saturated) steam services related to HVAC&R are covered in this Standard. Direction of flow casted on valves shall indicate correct installation position.

6.6.4.2 Rising stem valves 2½" and larger shall have outside stem and yoke. The non-rising stem valves may be used where headroom prevents full extension of rising stems. For valves 2" and smaller upto 1" non-rising stem with screwed union rising bonnet shall be used. Where insulation is indicated or specified, stems shall be extended type arranged to receive insulation.

6.6.4.3 Gate valves and globe valves for size 2" and smaller shall be brass on bronze body screwed ends, non rising stem and 2½" and larger shall be cast iron body and bronze trim flanged ends with rising stem. Gate valves shall remain closed before installation.

Note:

Solder and brazed end valves shall not be used for hot water heating and steam piping application.

6.6.4.4 Bronze angle and needle valves shall be used from ¼" to 2" with screwed ends for working pressure upto 1378.8 kPa (200 psi) and temperature upto 200°C (392°F).

6.6.4.5 The check valves shall be of the following type:

a) Swing check ¼" to 2" shall be screwed ends with bronze or brass body.
b) Swing check and wafer check 2½" and larger shall be flanged ends with cast iron body.
c) Lift check ¼" to 2" shall be screwed ends with cast bronze body.

6.6.4.6 The plug (cock) valves 2" and smaller shall be screwed ends, non-lubricated type square head, bronze body, working pressure rated at 103 kPa (150 psi) WOG. Those 2½" and larger shall be lubricated type, semi-steel body working pressure rated at 1206 kPa (175 psi) WOG, wrench operated and flanged ends.

6.6.4.7 Butterfly valves, lug or wafer type 2½" and larger shall be flanged ends working pressure rated at 1379 kPa (200 psi) with cast iron body.

6.6.4.8 The ball valves 1¼" and smaller shall be working pressure rated at 1034 kPa (150 psi), threaded ends, bronze body with chrome plated brass ball.

6.6.4.9 The strainers shall be provided for full line size of connecting piping, with ends matching pipe system materials, and capable to deliver maximum strainer capacity with minimum pressure loss.

6.6.4.10 Strainer 2" and smaller shall be threaded ends, cast iron body with screwed screen retainer. Those 2½" and larger shall be flanged ends, cast iron body with bolted screen retainer.

6.6.4.11 Strainers shall preferably be installed on the supply side (upstream) of each pump, control valve, pressure reducing or regulating valve, solenoid valve and elsewhere as indicated.

6.6.4.12 Gasket materials shall be selected to suit the service of the piping system in which installed conforming to respective ANSI standards of A21.11, B16.20 or B16.21. The materials shall not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

6.6.4.13 Pipe flanges shall be welded to pipe ends in accordance with ASME B 31.1.0 Code for pressure piping, and for low pressure system shall be in accordance with AWWA C206.

6.7 Automatic Control System

6.7.1 General

The engineer and the technician shall work closely with the temperature control installer and ensure that all project items are correctly installed. The technician shall only verify its operation, while the adjustments, relocation and recaliberation of any controls shall be conducted in presence of project engineer and manufacturer's representative.

6.7.2 Verification

On completing the testing, adjusting, and balancing of all HVAC systems, the automatic control system(s) should be staged to prove its capability of matching system capacity to varying load conditions.

In the event all flow balancing is completed in a particular season of operation, such as the cooling cycle and the heating cycle, control verification should be implemented and completed prior to project acceptance.

6.7.3 Required procedures

1) Design drawings and specifications shall be obtained to become thoroughly acquainted with the design intent.
2) Copies of approved shop drawings of control diagrams shall be obtained.
3) Design to installed equipment and field installation shall be compared.
4) Manufacturer's recommended operating and testing procedure shall be implemented.
5) Calibration of all controllers shall be verified.
6) Proper location of transmitters and controllers shall be checked. Any adverse conditions that would affect control shall be noted and relocation shall be suggested, if necessary.

6.7.4 Pneumatic systems

The following precedures shall be executed at site:

1) Main control supply air shall be verified for proper pressure and compressor and drier operation shall be obsreved.

2) Calibration of all controllers and sensitivity of each controller, shall be verified, noting any overlap in controlled devices.

3) All control terminations with design drawings shall be compared.

4) Operation of all limiting controllers (i.e., firestats, freezestats, preheat thermostats, and high and low thermostats) shall be verified.

5) Control devices shall be activated to check for free travel and proper operation of dampers verifying proper application of Normally Open (NO) and Normally Closed (NC) positions.

6) Operation of pilot positioners, sequence of damper operators and operation of control valves shall be verified to ensure proper relationship.

7) Adjustments shall be made for all pressure/electric switches and mercury switches for proper setting and operation for the seasonal cycle of operation in effect. (Simulate conditions to activate sequences used in the opposite season.)

8) Level and zero of inclined gage or U-tube manometers shall be checked duly verifying proper location of sensors.

9) Operation of lockout or interlock system shall be verified.

10) The span of control from a normally closed position to a normally open position shall be verified observing any dead bands, excessive pressures, etc.

11) Sequence of operations (i.e., night setback, switchovers, resets, cooling tower control, etc.) shall be verified and confirmed.

6.7.5 Electric systems

The following procedures shall be executed at site:

1) With voltmeter, control voltage shall be verified.

2) Thermostat shall be set in cool position and turned to lowest setting. Proper operation of contactor, motorized valve, damper motor, etc. shall be verified.

3) Thermostat to highest setting shall be set and proper action of damper motors, end switches, and resistance heat sequences shall be verified.

4) Solenoid valves, low-limit thermostats, and lockout devices shall be activated to verify proper action.

6.7.6 Electronic systems

The following procedures shall be executed at site:

1) All control loops and their individual field points shall be checked for correct response.
2) Calibration of field sensors and response time of all transducers shall be checked.
3) Fail-safe modes [Normally Closed (NC), Normally Open (NO), etc.] of all control devices shall be checked.
4) Manually stroke each damper and control valve.
5) Check lightning protection.
6) With system in full operation, test each control loop at both ends of control range.

6.7.7 Direct digital control (DDC)

The following procedures shall be executed at site:

1) Sequence of operation for each control loop shall be checked for accuracy and correct application.
2) All control loops and their individual field points shall be checked for correct response.
3) Calibration of all field sensors including response time on transducers shall be checked.
4) Fail-safe modes [Normally Open (NO), Normally Closed (NC), etc.] of all control devices shall be checked.
5) Each damper and control valve shall be manually stroked.
6) Lightning protection and system battery backup and phone modem shall be checked.
7) With system in full operation, each control loop shall be tested at both ends of control range. All readings shall accordingly be displayed on monitor screen.

7. NOISE AND VIBRATION CONTROL

7.1 General

7.1.1 A crucial factor when conducting a proper and safe installation is the performance of vibration and noise control. Sound transmissions can be as important as vibration.

7.1.2 During execution the manufacturer's design data shall be given due consideration by the contractor.

7.2 Noise

7.2.1 General

7.2.1.1 The noise level of any installation is increasingly important particularly in motor applications.

7.2.1.2 Motors produce airborne sound and physical vibration as unavoidable by products of the conversion of electrical to mechanical energy. (The unavoidable manifestation of sound and vibration is termed noise. The human ear is sensitive to sound waves with frequencies ranging from 16000 to 20000 Hz. Sound waves with higher frequencies are generally referred to as ultrasonic waves).

7.2.2 Types

At testing stage the following building noises shall be checked by the contractor wherever necessary.

a) Airborne noise

Is produced by the vibrating part of the motor, and their initial sources are magnetic, mechanical and windage. Magnetic noise are produced by magnetic forces (flux) in the air gap and other parts of the magnetic circuit. The rotor may also be a source of noise in the case of hermetic units and close-coupled motor pumps. Mechanical may result from disrepair, unbalance or bearing disorder. Bearing noise may be differential between that of a sleeve type or ball type of bearing.

b) Ductborne noise

Is produced due to incorrect selection of sheet metal (gage) thickness, outlet air velocity (m/s) or absence of graphite rope squeezed between the flanges that connect two sections of fabricated ducts. Also improper installation and absence of splitter dampers and turning vanes may cause ductborne noise.

c) Structural borne noise

Structural noise are those noise that are produced by building fatigue and may not be too disturbing. It can be prevented by designing the equipment noise frequency higher than the frequency of construction structures.

7.3 Vibration Controls

7.3.1 General

7.3.1.1 Unless otherwise noted on the equipment schedule, all mechanical equipment shall be mounted on vibration isolators to prevent transmission of vibration and mechanically transmitted sound to the building structure.

7.3.1.2 Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflection. Deflections shall be as noted on the equipment schedule.

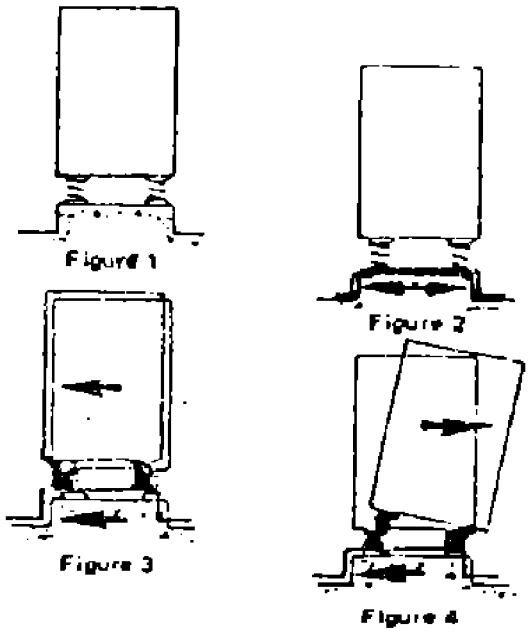
Note:

For general specification requirements and selection guide of various vibration controls, reference is made to IPS-M-AR-225. The vibration control selection guide relates the described materials to HVAC equipment and calls for a deflection on the basis of floor span and equipment requirements.

7.4 Seismic Controls

7.4.1 The term vibration isolation suggests the use of resilient materials between a structure and a machine. While this is a perfectly practical system for vibration control, when dealing with earthquakes, visualise what would happen to the mass, when the floor moves horizontally and vertically in random directions through a range of frequencies. If the floor frequency is very high in relation to the spring system the mass would be isolated and remain motionless in space as and if very low the mass would move with the structures.

7.4.2 During the most severe seismic events, however, the range of input frequencies includes the systems resonance so that the springs act as amplifiers with the mass developing enough motion to damage or fly free of the springs as shown in Fig. 1.



SPRING MOUNTED MASS MOVEMENTS
Fig. 1

7.4.3 Lockout devices

Isolated equipment must be mounted on resilient supports and the more flexible the isolator, the more difficult it is to visualize the equipment moving in phase with the support motion. One way to force it to do so would be to resort to earthquake actuated lockout devices.

8. TAB STANDARDS

8.1 ANSI/ASHRAE 111-1988

In order to make the system perform as the designer had intended them to do, the entire ANSI / ASHRAE Standard 111-1988 (Practices for Measurement Testing, Adjusting and Balancing of Building HVAC&R System) shall comply to this Standard.

8.2 General Recommendations for TAB Activities

8.2.1 Design considerations

8.2.1.1 Testing,adjusting, and balancing shall begin as design functions, with most of the devices required for adjustments being integral parts of the design and installation. To ensure that proper balance can be achieved, the engineer shall show and specify a sufficient number of dampers, valves, flow measuring locations, and flow balancing devices; these must be properly located in required straight lengths of pipe or duct for accurate measurement.

8.2.1.2 All activities, including organization, calibrated instrumentation, and execution of the actual work, should be scheduled. Because many systems function differently on a seasonal basis, and because temperature performance is significant, it is important to coordinate air-side with water-side work. Preparatory work shall include planning and scheduling all procedures, collecting necessary data (including all change orders), reviewing data, studying the system to be worked on, preparing forms, and making preliminary field inspections.

8.2.1.3 Duct systems shall be designed, constructed, and installed to minimize and control air leakage. All duct systems should be sealed and tested for air leakage and water piping should be tested during construction.

Note:

Jobs that are cost effective and simple to balance and operate are those initially designed with TAB procedures in mind, when drawings are made and specifications written.

8.2.2 Design requirements

Through proper procedures the design engineer shall clearly include TAB specifications so that the TAB execution crew can asses the functional performance of the system. The following functional procedures are recommended.

1) To simplify water circuit balancing all risers and branch water lines of reverse-return shall be provided with water flow metering and balancing devices.

2) The discharge lines of primary/secondary chilled water pump, hot water pump and condenser water pump shall be provided with water flow metering and balancing devices. Other pumps installed for HVAC systems shall be furnished with relevant devices.

3) For accurate readings, each pump shall be provided with single pressure gage with yoke piping connection through suitable needle valves to suction and discharge of the pump. To allow a differential test gage reading with test gage a quick-connect fitting shall be provided between each valve and the pump tapping.

4) Automatic Air Vents (AAV) with shut off valves shall be provided with bleed line to drain from all high points and air pocket in system.

5) Regular gage cocks shall be furnished close to all chilled and hot water coil connections and heat exchangers.

6) All air ducts, inlet & outlet water lines of chillers, heat exchangers, chilled/hot water coils and condensers shall be provided with thermometers with convertible test wells.

7) For accurate readings intermediate thermometers shall be placed after preheat coil, dehumidifiers, and reheat coils.

8) Draft gages shall be provided across all filters, coils and fans with probes where possible.

9) Sufficient space shall be provided between elements of all primary secondary air conditioning units for ease of testing adjusting and cleaning points.

10) For access to testing, check and cleaning points, tight fitting access doors, preferably with plenum lights shall be provided, for all balancing dampers, fire dampers, vents, valves, etc.

11) All air duct branches shall be provided with balancing dampers and all air take-offs with splitter dampers.

12) For ease of TAB, the plans and specifications shall be allowed to preferably show following settings and conditions:

a) Outdoor and indoor design conditions.

b) Settings, differentials and operating range of all control devices-microprocessor controls shall be furnished with supporting softwares.

c) Necessary air and water flow directions together with total pressures and rated capacities be shown at all terminal points particularly fans and pumps.

8.2.3 General requirements:

a) The equipment shall be ordered exactly as specified.

b) The shop drawing shall clearly indicate exact locations and position of all test points such as gages, thermometers, controllers, balancing devices and dampers, access panels, vents etc.

c) TAB test and probe points (through pitot readings etc.) shall be clearly shown on shop drawings.

d) A single line drawings of all air duct and water system. showing total branch and terminal air and water flows required with pressures and velocities at each point as specified and/or calculated shall be prepared and made available for ease of TAB.

e) A typical form and database shall be prepared where informations on equipment, water and indoor air design conditions and quality shall be inserted. (These are typical format approved by ASHRAE and MCAA*.)

f) All presentation assembled and binded, or compiled in a diskette shall represent following documents for on the job use during TAB activities:

1) Job plans and specifications.

2) Job field change orders.

3) Copies of purchase orders.

4) Submittal data sheet, performance curves & tables, manufacturer's instructions on installation and start-up.

5) Shop drawings with "as-built" notes.

6) One line colored graphic flow chart providing the flow routes of different mediums such as gas, water, electricity, refrigerant etc.

7) Control diagram with sequence of operation.

*** MCAA: Mechanical Contractors Association of America**

Notes:

In order to fulfill the requirement of item (f), the TAB personal in co-ordination with site superintendent will ensure:

i) Through routine inspection that interior of pipes and ducts are cleaned and sealed off from foreign matter before connections to fans, pumps etc.

ii) That placement of all controls and equipment are executed as specified.

iii) That a specification box be provided on job site with strict instructions by site manager that all papers received with equipment etc., be placed in this box. (It may turn up to be the only available copy prior to commencement of TAB procedures).

9. GUIDELINE FOR COMMISSIONING OF HVAC SYSTEM

9.1 The ASHRAE GUIDELINE No. 1-1989 shall be complied and accordingly applied to this Standard.

9.2 Supplementary Modification

The title of Appendix A of the subject standard shall be changed to "Commissioning Flow Chart".

9.3 Supplementary Additions

9.3.1 The following additions shall be made to this Guideline.

9.3.1.1 Spare parts (Add.)

Prior to pre-commissioning procedure a recommended list of spare parts shall be prepared representing strategic and consumable items of supplies for dependable operation of HVAC&R equipment and systems. The approved list shall be clearly labelled and identified, prior to submission to the project manager.

9.3.1.2 Tools (Add.)

Prior to TAB and commissioning procedures, a list of normal and special tools for measuring various readings, calibration, adjustments etc., shall be prepared and furnished to the project manager.

9.3.1.3 Retraining (Add.)

After final commissioning of HVAC&R projects, operation and maintenance personnel will be instructed on changes and reconfiguration which may have occurred during the commissioning process.