Modify *heading of Part .01 and delete text under subpart A and replace with new text in Section 23 31 00* per the following (deletions are shown struck through and additions are double underlined). Remainder of section is unchanged.

23 31 00 HVAC DUCTS AND CASINGS

.01 Ductwork

A. General

1. Duct sizes shown shall be inside clear dimension.
2. Use ASHRAE and SMACNA guidelines.
3. Ductwork pressure classification shall be specified in the contract documents.
4. All metal ductwork shall be cross-broken to insure rigidity.
5. All rectangular elbows shall have double thickness turning vanes. The use of radius elbows with double thickness turning vanes over rectangular elbows is encouraged.
6. Every branch duct should be provided with an expanded take-off from the main duct. A manual balancing damper shall be installed at the take-off.
7. Fume hood exhaust duct work shall be specified for Type 316 welded or galvanized steel coated with PVS.
8. Fiberglass ductboard will not be permitted.
9. In ductwork carrying steam or high humidity, all seams shall be welded or sealed.

Replace with following text.

.01 General

A. Ducts and Plenums

1. Design and construction of duct systems shall comply with the following standards and guidelines:
    a. ASHRAE Fundamentals Handbook – Duct Design
    b. ASHRAE Systems and Equipment Handbook – Duct Construction
    c. Duct design and construction, including selection of acceptable materials, sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

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d. Clearly indicate specific ductwork pressure classifications on the contract documents.

    1) The pressure classifications of various duct sections throughout each system shall be fully defined.

    2) All modes of operation must be considered, especially in systems used for smoke management and those with fire or smoke dampers that must close when the system is running.

e. Use round ducts wherever feasible. Round ducts are inherently strong and rigid, and are generally the most efficient and economical ducts for air systems. Round duct is also recommended for any horizontal exterior ductwork due to inherent strength and to minimize rain or snow collecting on upper surfaces.

f. All metal rectangular ductwork shall be cross-broken to insure rigidity.

g. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

    1) In general, the use of internal fiberglass duct liner is prohibited.

    2) Where acoustic liner is required, use Flexible Elastomeric Duct Liner.

        a) Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

        b) Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

h. Fiberglass ductboard is prohibited.

2. All duct systems shall be designed and constructed to minimize air leakage in order to achieve required air flows and pressure relationships with minimal heating, cooling and fan energy waste. All ducts and plenums shall be sealed to **Seal Level A** to comply with requirements in High Performance Building Standard ASHRAE 189.1.

    a. All duct/terminal connections shall be sealed.

    b. Representative duct leakage tests shall be conducted in compliance with SMACNA's HVAC Air Duct Leakage Test Manual to verify the intent of the designer and the workmanship of the installing contractor. Leakage tests used to confirm leakage class shall be conducted at the pressure class for which the duct is constructed. Minimum representative leakage testing is addressed in ASHRAE Standard 90.1 and the International Energy Conservation Code. If a test

indicates excess leakage, corrective measures shall be taken to ensure quality. Final test results shall be reviewed and approved by the designer demonstrating that the required representative sections have been tested and that all tested sections meet the requirements.

c. Test for leaks before applying external insulation.

d. Lower pressure class ducts that do not require duct leakage tests, shall at a minimum be visually inspected for compliance prior to being insulated.

e. Include specifications that contractor shall give adequate advance notice for Design Professional and Owner's representative to observe testing.

3. Air systems shall be designed to minimize pressure drops through each component, fitting, and the total system to minimize associated fan energy. The total allowable **fan power limitation** for each system shall comply with ASHRAE Standard 189.1 (**10% less** than the limits set by ASHRAE 90.1).

    a. Minimize fan System Effects:

        1) Avoid poor fan inlet and outlet conditions that reduce fan performance and increase energy waste. Always consult manufacturer's installation guidelines.

        2) Rules of thumb: AMCA Publication 201 quantifies System Effect for a number of the more common causes, and offers recommendations for avoiding System Effect.

            a) On the fan's inlet side, AMCA Publication 201 recommends that elbows near the fan's inlet be located at least three duct diameters upstream of the fan, while acknowledging that elbows can cause System Effect when they are located up to five diameters upstream.

            b) On the fan's outlet side, AMCA Publication 201 introduces the term "Effective Duct Length." Effective Duct Length is 2.5 duct diameters when duct velocities are 2500 fpm or less, with one duct diameter added for each additional 1000 fpm. A centrifugal fan needs 100% of an Effective Duct Length on its outlet to avoid System Effect, while a vaneaxial fan needs 50% Effective Duct Length.

    b. Design ductwork to minimize 90 degree elbows and sharp transitions.

c. Select all air distribution fittings and components that offer the lowest pressure drop. Use fittings with low pressure drop characteristics such as long radius elbows (radius of 1.5 times duct width), smooth radius elbow with minimum radius of 0.75 times duct width with splitter vane, 45° laterals or Wyes in direction of flow for branches, tapered transitions, and bell-mouth inlets.

d. Where radius elbows do not fit, rectangular mitered elbows shall have turning vanes of type and spacing selected for the duct classification to minimize pressure drop. Exceptions: Elbows in dishwasher, kitchen grease-laden, and laundry exhaust or other dirty industrial or special process applications shall be unvaned, smooth radius construction with minimum radius equal to 1.5 times the width of the duct.

e. Do not use fittings with abrupt changes that cause high pressure drops such as non-tapered transitions or inlets/discharges from plenums or headers, or bullhead tee connections (either two streams connected to each end of a tee with the discharge on the branch, or the main flow coming into the branch connection and discharging at each end).

4. Follow the general duct layout and sizing requirements below.

   a. Show duct sizes as inside clear dimensions.

   b. Wherever space allows, conservatively upsize ducts to reduce pressure drop and allow future flexibility if increased airflow is required.

   c. Typically design ducts to be installed vertically and horizontally, and parallel and perpendicular to building lines.

   d. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

   e. Change only one rectangular duct dimension at a time so transitions are easier to fabricate and install and therefore generally less expensive.

   f. Make sure bell-mouth branch takeoffs and associated mains have coordinated sizes so taps can be properly installed and fully sealed to the main duct.

   g. Ensure there are adequate lengths of straight runs of properly sized ductwork before and after airflow measuring devices per manufacturer's installation instructions in order to get accurate readings.

   h. Every runout duct shall be provided with a low-loss rectangular 45° tap or round bell-mouth tap from the main duct. A manual balancing damper shall be

installed at the take-off and used for balancing rather than relying on damper at air distribution devices in the space.

i. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

5. Include necessary specific materials and details for special exhaust duct systems.

    a. In ductwork carrying steam or high humidity (dishwasher, sterilizer, cagewashers, shower rooms, etc.), all seams shall be welded or sealed liquid-tight. Indicate sloping of horizontal runs and any intermediate condensation drain requirements.

    b. Duct material for handling corrosive gases, vapors, or mists must be selected carefully. For the application of metals and use of protective coatings in corrosive environments, consult SMACNA Rectangular and Round Industrial Duct Construction Standards.

6. Provide protection from water entry and damage at exterior air intake and discharge openings and associated plenums.

    a. Give particular consideration to locate and design intake and discharge openings to minimize the penetration of wind driven rain and snow at all times.

    b. Include construction details inside such openings to contain and drain away any precipitation at points of entry so that rainwater or melted snow does not accumulate and leak into and damage surrounding building construction.

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) *To add miscellaneous general design requirements.*
2) *To clarify requirement to define specific duct pressure classifications in each associated section of ductwork throughout the system to assure proper construction and reinforcement.*
3) *To add recommendations for using round duct as much as possible.*
4) *To add requirements for Seal Level A per ASHRAE 189.1 and associated duct leak testing.*
5) *To add requirements for low pressure drop systems with respect to achieving fan power limitation in ASHRAE 189.1*

6) *To rename headings and improve order.*