



TITUS REVOLUTION TFX INDOOR AIR-HANDLING UNIT SUBMITTAL SPECIFICATION

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Titus Revolution TFX indoor air handling units and components, as shown on product drawings and described in performance specifications.
- B. Motors, disconnects, starters, and variable frequency drives, as shown on product drawings and described in performance specifications.
- C. Product drawings, performance specifications, and other submittal documents show segments, components, options, and features furnished by Titus. Options listed in this specification will not necessarily be included.

1.02 QUALITY ASSURANCE

- A. Titus has more than 40 years of experience designing, manufacturing, and servicing air-handling units.
- B. Titus Revolution TFX units are designed and will be built to meet performance criteria of this specification.

1.03 COORDINATION

- A. Installing contractor will coordinate the following items with applicable trades:
 - 1. Structural supports for units.
 - 2. Size and location of concrete bases/housekeeping pads
 - 3. Location of unit supports
 - 4. Ductwork sizes and connection locations
 - 5. Piping size and connection/header locations
 - 6. Interference with existing or planned ductwork, piping and wiring
 - 7. Electrical power requirements and wire/conduit and over current protection sizes.
 - 8. Trap height requirements

1.04 RATINGS AND CERTIFICATIONS

- A. Unit will conform to AMCA 210 for fan performance ratings.
- B. Unit will conform to ETL standards. Unit will be ETL listed.
- C. Unit sound ratings will be reported in accordance with AHRI 260.
- D. Unit will conform to AHRI 410 for capacities, pressure drops, and selection procedures of air coils.
- E. Unit will conform to ANSI/AHRI 430 for all fabrication procedures of air handling units.
- F. Motors covered by the Federal Energy Policy Act (EPACT) will meet EPACT requirements.
- G. Damper performance will comply with AMCA 500.

- H. Airflow Monitoring Stations will be rated in accordance with AMCA 611-95 and bear a Certified Ratings Seal for Airflow Measurement Performance.
- I. Air-handling units will be ISO 9001 certified.
- J. Air-handling units will be manufactured in an ISO 9002 certified facility.

1.05 DELIVERY

- A. Unpainted units will be shrink-wrapped for protection during shipment. Painted units will be tarped for protection during shipment.
- B. Openings will be protected against damage during shipping
- C. Loose-shipped items will be packed, protected and secured with units. Detailed packing list of loose-shipped items, illustrations and instructions for application will be included.

1.06 WARRANTY

- A. Titus will warranty unit for eighteen (18) months from date of shipment. Warranty will be limited to manufacturer's defects on parts. Warranty does not include parts associated with routine maintenance, such as belts, air filters, etc. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician. Warranty does not extend to alterations, modifications, or external components installed after unit is shipped.

PART 2 PRODUCTS

2.01 GENERAL DESCRIPTION

- A. Titus Revolution TFX air-handling units are designed and built to meet performance detailed in this submittal.
- B. Unit will be complete with fans, motors, coils, dampers, access doors and other components/options, as shown on product drawings, wiring diagrams, and as described in performance specifications.
- C. Fans and drives will be balanced to limit vibration at operating speeds.
- D. Unit will ship in one (1) piece whenever possible. Shipping splits will be provided when necessary. Lifting lugs will be provided where required for proper lifting.
- E. Unit casing will be factory insulated.
- F. Units will be ETL labeled.

2.02 UNIT CASING

- A. Titus Revolution TFX unit is specifically designed for indoor applications.
- B. Unit casing will consist of a structural frame and insulated roof, wall, and floor panels.
- C. Removal of wall panels will not affect structural integrity of units.

- D. Unit casing will be insulated with spray injected foam to achieve a minimum thermal resistance of $R13 \text{ hr-ft}^2\text{-}^\circ\text{F}/\text{BTU}$. Insulation application will meet the requirements of NFPA 90A
- E. Insulation system will be resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338
- F. Unit casing leakage rate shall be no more than 0.5 cfm per square foot of cabinet area at design static pressure up to a maximum of +4 inches w.g. in positive pressure sections and -4 inches w.g. in negative pressure sections.
- G. Wall panels and access doors will deflect no more than $L/240$ when subjected to 1.5 times design static pressure up to a maximum of +6 inches w.g. in positive pressure sections and -6 inches w.g. in negative pressure sections. 'L' is the panel-span length and ' $L/240$ ' is the deflection at panel midpoint.
- H. Unit will have double wall, 2" insulated panels for walls, roof, and floor. Exterior skin will be galvanized sheet steel. Individual segments will have galvanized sheet steel, stainless sheet steel, or perforated galvanized interior liner, as described in performance specifications.
 - 1. Provide panels with optional perforated liner in the fan section and other sections as shown on the drawings. Interior liner will be perforated galvanized. Minimum perforated panel thermal resistance (R-Value) will be $R11 \text{ hr-ft}^2\text{-}^\circ\text{F}/\text{BTU}$.
- I. Floor panels will be double wall construction, designed to provide at most $L/240$ deflection when subjected to a 300 lb. load at mid-span.
- J. Double wall access doors will be provided on sections as shown on product drawings.
 - 1. Stainless steel hinges permit a 180° door swing.
 - 2. Access door will be of the same material type as exterior/interior casing.
 - 3. Access door latches will use a roller cam latching mechanism.
- K. View ports will be double-pane tempered glass.

2.03 DRAIN PANS

- A. Primary and auxiliary drain pans will be double wall with an insulation R-value of $6.25 \text{ hr-ft}^2\text{-}^\circ\text{F}/(\text{BTU-in})$.
- B. Drain pans comply with the guidelines of ASHRAE 62.
 - 1. Drain pans will be double sloped at least $1/8$ " per foot, and have no horizontal surfaces.
 - 2. Drain connection material will be the same as drain pan.
 - 3. Drain pans drain to one point.
 - 4. Drain connections will be welded to drain pans
 - 5. Drain pans will have at least 1" clearance between pan and coil supports.

2.04 FANS

- A. Fans will provide CFM and static pressure, as shown in performance specifications.

- B. Fans will be Class I, II, or III, as required to meet selected RPM and horsepower shown in performance specifications.
- C. Fans will be DWDI (housed) or SWSI (plenum), as shown on product drawings.
- D. Fans will have forward curve or airfoil blades, as shown in performance specifications.
- E. Airfoil fans will bear the AMCA Seal. Airfoil fan performance will be based on tests in accordance with AMCA standard 210 and will comply with the requirements of AMCA certified ratings programs for air and sound. Airfoil wheels will comply with AMCA standards 99-2408-69 and 99-2401-82.
- F. Fans shafts will be polished steel and sized such that the first critical speed will be at least 125% of the maximum operating speed for the fan pressure class. Shaft will be coated with an anti-corrosion coating.
- G. Fan and motor assembly will be internally mounted on a common base. Fan and motor base will be spring isolated on a full width isolator support channel.
 - 1. Fan motor will be on an adjustable base.
 - 2. Fan discharge will be connected to cabinet via a flexible connection.
 - 3. Access doors will be provided as shown on product drawing.

2.05 BEARINGS AND DRIVES

- A. Fan bearings will have average life (L50) of at least 200,000 hours. Bearing fatigue life ratings will comply with ANSI/AFBMA 9.
- B. DWDI fans will be belt-driven. SWSI fans will be belt driven or direct driven, as shown on product drawings.
- C. Re-greaseable fan bearings will be factory lubricated and equipped with standard hydraulic grease fittings and lube lines extended to the motor side of the fan. Fan drives will be selected for a 1.5 service factor and will be furnished with anti-static belts.
 - 1. Drives 15 hp or smaller on constant volume fans will be adjustable pitch.
 - 2. Drives 20 hp or larger or drives on fans with VFDs will be fixed pitch.
 - 3. Sheaves will be machined from close grain cast iron and statically balanced.
 - 4. Drive belts will be V type, precision molded, raw edge construction, anti-static, oil and heat resistant.

2.06 ELECTRICAL MOTORS

- A. Fan motors will be built in accordance with the latest NEMA and IEEE standards.
- B. Fan motors comply with ASHRAE Standard 90.1.
- C. Fan motors will be furnished in sizes, electrical power and starting characteristics as shown in performance specifications.
 - 1. Fan motors will be rated for continuous, full load duty at 104°F (40°C) ambient temperature and 1.15 service factor.
 - a. Exception: 1.5 hp and 3 hp, dual voltage (230/460V), 900 RPM, TEFC motors will have a 1.0 service factor.
 - 2. Fan motors will be NEMA design ball bearing type.

- a. Direct drive plenum fans will be coupled with motors that closely match required fan RPM.
- 3. Fan motors will be Open drip proof (ODP) or totally enclosed, fan cooled (TEFC)
- 4. Premium Efficiency Inverter ready per NEMA STD MG1 PART 31.4.4.2
- 5. Motors will be suitable for use with variable frequency drives, per NEMA MG-1 Part 30.

2.07 FAN-MOTOR DISCONNECTS

- A. Fan motor disconnects will be provided with unit, as shown in performance specifications.
- B. Disconnect will be housed in a NEMA 1 enclosure, and will be mounted on the primary access side of segment.
- C. Disconnect will be suitable for use as an OSHA lockout/tagout disconnect when applied in accordance with part IV, Department of Labor OSHA 29 CFR Part 1910, Control of Hazardous Energy Source (lockout/tagout): final rule.
- D. Disconnect handles can be padlocked in the “off” position with up to three padlocks. Switch mechanism can be directly padlocked in the “off” position when door is open.
- E. Disconnects will be provided with an integral ground lug.
 - 1. 16A to 100A disconnects will have two (2) #14 ground wires.
 - 2. 200A to 400A disconnects will have one (1) #6-250 ground wire.

2.08 ACROSS-THE-LINE FAN MOTOR STARTERS

- A. Constant speed motor starters will be furnished (shipped loose) or provided (factory mounted and wired to motor) with units, as shown in submittal documents.
- B. Motor starters will be housed in a dedicated, weather resistant compartment.
 - 1. Shipped loose starters and starters provided on units without single point power will be housed in a NEMA 3R enclosure.
 - 2. Weatherproof compartments will be provided on units with single point power.
- C. Motor starter panels will include:
 - 1. Main power block
 - 2. Motor contactor(s)
 - 3. Individual short circuit and overload protection
 - 4. 120 volt control power transformer with primary and secondary protection
 - 5. 5 point terminal strip for field connections
 - 6. Main power disconnect
 - 7. Hand-Off-Auto switch

2.09 FAN VARIABLE FREQUENCY DRIVES

- A. Variable frequency drives will be provided (factory mounted and wired to motor) with units, as shown in submittal documents.
- B. VFDs will be UL or ETL listed and comply with applicable provisions of the National Electric Code.
- C. VFDs provided with units will be programmed and started by an ABB trained and employed technician.

- D. VFD will include harmonic distortion feedback protection:
 - 1. Swinging DC Line Choke (equivalent to 5% input line reactor)
 - 2. Integral RFI/EMI filtering to meet EMC EN61800-3 for First Environment

- E. User interface will include:
 - 1. 30 Character multi-lingual alphanumeric display
 - 2. Parameter set-up and operating data
 - 3. Display data includes:
 - a. output frequency (Hz)
 - b. speed (RPM)
 - c. motor current
 - d. calculated % motor torque
 - e. calculated motor power (kW)
 - f. DC bus voltage
 - g. output voltage
 - h. heat sink temperature
 - i. elapsed time meter (re-settable)
 - j. kWh (re-settable)
 - k. input / output terminal monitor
 - l. PID actual value (feedback) & error
 - m. fault text
 - n. warning text
 - o. scalable process variable display

- F. VFD protection circuits will include:
 - 1. over current
 - 2. ground fault
 - 3. over voltage
 - 4. under voltage
 - 5. over temperature
 - 6. input power loss of phase
 - 7. loss of reference/feedback
 - 8. adjustable current limit regulator

- G. VFD will be UL 508C approved for electronic motor overload (12t).

- H. VFD will include high input transient protection and surge suppression:
 - 1. 4 MOVs ahead of diode bridge
 - 2. 120 Joule rated 1600V diode module
 - 3. Compliant with UL 1449 / ANSI 61.4

- I. VFD communication features include:
 - 1. Two programmable analog inputs
 - 2. Six programmable digital inputs
 - 3. Two programmable analog outputs
 - 4. Three programmable digital relay outputs
 - 5. Modbus RTU Communications protocol
 - 6. Adjustable filters on analog inputs and outputs
 - 7. Input speed signals, including 4-20 mA and 0-10 VDC
 - 8. Acceleration/Deceleration contacts (floating point control)
 - 9. Auto restart (customer selectable and adjustable)

10. Start/Stop options will include 2 wire (dry contact closure), 3 wire (momentary contacts), application of input power, and application of reference signal (PID sleep/wake-up)
11. Integrated control interface for Siemens FLN, Johnson N2, Modbus RTU, and BACnet MS/TP
 - a. Optional LONworks over RS-485.

J. VFD will have the following functions:

1. Premagnetization on start
2. DC braking/hold at stop
3. Ramp or coast to stop
4. Seven preset speeds
5. Three critical frequency lockout bands
6. Start function will include ramp, flying start, automatic torque boost, and automatic torque boost with flying start

2.10 Johnson Controls MANUFACTURED HEATING AND COOLING COILS

A. Johnson Controls manufactured coils described in this specification will not include:

1. Electric Heat coils
2. Integral face and bypass coils

- B. Water, direct expansion (DX), and steam coil capacity and pressure drop performance will be certified in accordance with AHRI Standard 410, when selected within fluid velocity, inlet fluid temperature, and entering air temperature ranges specified by AHRI 410.
- C. Cooling coil segments will have a full-width IAQ drain pan that extends at least 6" downstream of the last coil in the section.
- D. Coils will be removable from the side of unit, via removable AHU panels. No more than one panel must be removed to remove a coil.
- E. Coils will have frames constructed of galvanized steel. Casing channels will be free-draining and do not block fin area.
- F. Cooling coils with finned height greater than 48" will have an intermediate drain pan with downspout to drain condensate to main drain pan. Intermediate drain pan material will match coil frame material.
- G. Coil segment door clearances will allow for at least 2-inches of field installed piping insulation.
- H. Coil bulkheads and blank-offs will prevent air from bypassing coils.
- I. Coil segment casing to accommodate full-face or reduced-face coils will be provided. Provide face and bypass coil segments with factory installed bypass damper
- J. A 1/4" FPT plugged vent/drain tap will be provided on each connection. Vent, drain, and coil connections will be extended to outside of AHU casing.
- K. Staggered Coil bank will be provided. A 1/4" FPT plugged vent/drain tap will be provided on each connection. Vent, drain, and coil connections will be supplied within 10" of the header.
- L. Spool shaped coil grommets will be provided to insulate and seal coil penetrations.

- M. Water and glycol coils will be designed to operate at 250 psig and up to 300° F and will be factory tested with 325 psig compressed air under water.
- N. Direct expansion (DX) coils will conform to ANSI B9.1 (Safety Code for Mechanical Refrigeration) when operating with a refrigerant pressure not exceeding 250 psig. Coils will be factory tested with 325 psig compressed air under water. DX coils will be dehydrated and sealed prior to installation.
- O. Steam distributing coils will be designed for operation at 50 psig pressure, and a corresponding saturated steam temperature of 298° F. Coils will be factory tested with 315 psig compressed air under water. Coils will be dehydrated and sealed prior to shipping.
- P. DX coils will have brass distributor with solder-type connections. Suction and discharge connections will be on the same end. DX liquid lines will extend outside the unit. Provide DX coils with a hot gas bypass port on distributor.
- Q. Water, glycol and DX coils tubes will be mandrel expanded to form fin bond and burnished, work-hardened interior surface.
- R. Steam coil tubes will have outer tube outside diameter of 1" and inner distribution tube outside diameter of 5/8". Circuiting will be non-trapping, drainable, suitable for a gravity drain. Steam will discharge in direction of condensate flow to ensure even heat transfer across each tube.
- S. Coil fins will be die-formed, continuous aluminum and have fully drawn collars to accurately space fins, and form a protective sheath for tubes.

2.11 FILTERS

- A. Filter segments will be provided, as shown on product drawings. Filter tracks/frames will be an integral part of the unit.
- B. Filter media for Titus Revolution TFX delivered in the continental United States will not be shipped with units. Filters will be shipped to a customer defined location. Coordinate filter delivery with Titus sales representatives.
- C. Filter types, nominal sizes, efficiencies, and performance characteristics will be as shown in performance specifications.
- D. Filter access will be provided via access doors on filter segments or adjacent segments as required by filter loading scheme. See product drawings for details.
- E. Flush mounted, factory installed differential pressure gauge on the drive side of unit to measure pressure drop across filters will be provided as shown on submittal documents.

2.12 DAMPERS

- A. Dampers will be factory installed.
 - 1. Multizone damper assemblies may be shipped loose when shipping restrictions require.
- B. Dampers will have airfoil blades with extruded vinyl edge seals and flexible metal compressible jamb seals.

- C. Dampers will have a maximum leakage rate of 4 CFM/square foot at 1" w.g. and comply with ASHRAE 90.1.
- D. Maximum damper torque requirement will be 7 in. lbs./ft².
- E. Damper blades will be parallel acting unless submitted otherwise.
- F. Damper blades will be galvanized steel or aluminum.

2.13 UVC FIXTURES

- A. Fixtures have been tested, listed and labeled as UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards: 153, 1598 & 1995 respectively.
- B. Fixtures meet the "UL" drip proof design and each fixture is equipped with an electrical interlock.
- C. Each lamp contains no more than 5.5 milligrams of mercury consistent with current environmental practices while producing the specified output at 500 fpm in temperatures of 55-135° F.
- D. Useful lamp life will be 9000 hours with no more than a 20% output loss at the end of one year of continuous use. They are constructed with UVC proof metal bases and will not produce ozone.

2.14 AIR FLOW MONITORING STATIONS

- A. Optional airflow monitoring stations will be provided on air inlets, as shown in performance specifications.
- B. Airflow monitoring stations will bear the AMCA Certified Ratings Seal for Airflow Measurement Performance.
- C. Airflow monitoring station dampers will comply with leakage rates per ASHRAE 90.1.
- D. Airflow monitoring stations will be accurate within 5% of actual airflow between 300 FPM and 3000 FPM free area velocity.

2.15 DIFFUSERS

- A. Diffuser segments will be provided, as shown on product drawings.
- B. Perforated steel diffuser plates will be installed between fans and downstream components when required to ensure proper velocity profiles across downstream components.

2.16 APPURTENANCES

- A. Safety grates capable of supporting a 300 lb. center load will be provided over bottom openings, as shown in performance specifications.
- B. Formed **Welded structural** steel base rails suitable for rigging and lifting will be provided, as shown on product drawings.

C. Lifting lugs will be provided where required for proper lifting.

2.17 FINISHES

A. External unit surfaces will be factory cleaned prior to finishing or shipping.

B. Unpainted air-handling units constructed of galvanized steel will pass the ASTM B-117 test for 220-hour salt spray solution (5%) without any sign of red rust.

C. Unit will be painted, as shown in performance specifications.

1. Painted units will be prime-coated prior to painting.

2. Paint will be acrylic polyurethane.

3. Painted unit will exceed 500-hour salt spray test, with (5%) solution, without any sign of red rust when tested in accordance with ASTM B-117.

2.18 TESTS AND INSPECTIONS

A. Fan skid will be run-balanced at specified speed to insure smooth operation.

1. Constant volume fan assemblies will be balanced at design RPM.

2. Variable volume fan assemblies will be balanced from 10% to 100% of design RPM.

3. Filter-in measurements will be taken in horizontal and vertical axes on drive and opposite-drive sides of fan shafts.

4. Constant speed fan vibration limits: filter-in measurements will not exceed 4 mils.

5. Variable speed fan vibration limits: filter-in measurements will not exceed 7 mils.

B. Unit wiring with voltage greater than 30VAC will be hipot tested prior to shipping.