

SECTION 231101 – LEAK TEST HVAC PIPE AND DUCT SYSTEMS

Latest Update: 12-17-2021 See Underlined Text for Edits.

(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specification and adding any additional specifications that may be required by the project. Also turn off all “Underlines”.)

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

- A. This section includes the requirements for leak testing of the following systems:

<Delete piping and duct systems not applicable to the project, or add piping and duct systems not listed that are applicable to the project.>

1. Fuel oil piping.
2. Natural gas piping.
3. Hydronic piping (all water and glycol piping systems).
4. Steam and condensate piping.
5. Refrigerant piping.
6. Supply ductwork.
7. Return air ductwork.
8. Exhaust ductwork.
9. Fresh air ductwork.

1.3 SUBMITTALS

- A. General: Submit completed certified test reports in “pdf” format for each item in this Section according to the conditions of the contract and Division 01 Specification Sections.

1.4 QUALITY ASSURANCE

- A. Testing shall be performed by the installer of system being tested in presence of the UMB Representative.

1.5 WARRANTY/GUARANTEE

- A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

PART 2 – PRODUCTS

2.1 PIPE SYSTEM LEAK TEST APPARATUS

- A. The contractor conducting the test shall arrange for and provide all temporary services, all test apparatus, all gages, hoses and qualified personnel necessary to conduct the required testing. All leak tests shall be witnessed by UMB's Representative. UMB requires a minimum of seven (7) business days' notice of all leak test procedures. Prior to scheduling the test with the University the contractor shall pretest the system or segment to ensure all joints, connections etc. are leak free.
- B. Test apparatus shall include a pump of appropriate size and pressure for all pressurized systems and an oil free air compressor or gaseous nitrogen to pressurize all gaseous piping systems to the required test pressures. Gauges used for testing shall be as follows:
1. Gauges shall be four (4) inch diameter dial type gauges.
 2. Tests requiring a pressure of 10 pounds per square inch (psi) or less shall utilize a testing gauge having increments of 0.10 psi or less.
 3. Tests requiring a pressure of greater than 10 psi but less than or equal to 100 psi shall utilize a testing gauge having increments of 1 psi or less.
 4. Tests requiring a pressure of greater than 100 psi shall utilize a testing gauge having increments of 2 psi or less.
 5. Pressure gauges used for the test shall be in the required range and increment of the appropriate test.
 6. All gauges must be calibrated and set at zero (0) before pressure is applied to the test segment.
- C. The contractor conducting the test shall utilize the "UMB Standard Pipe System Leak Test Summary Form" for each pipe test to record the test results. Where multiple tests are conducted on the same pipe section a summary report of each test (pass and failed test) shall be prepared. Each summary report shall be signed by each of the parties witnessing the test. The completed reports shall be forwarded to the Construction Manager (CM). The CM or GC shall provide a copy of the reports to UMB Project Manager.

2.2 DUCT SYSTEM LEAK APPARATUS

- A. The contractor conducting the test shall arrange for and provide all temporary services, all test apparatus, all temporary seals and qualified personnel necessary to conduct the required testing. All test shall be witnessed by UMB Personnel and selected test shall be witnessed by the balancing contractor. UMB requires a minimum of seven (7) business days' notice for all test procedures. Prior to scheduling the test with the University the contractor shall pretest the system or segment to ensure all joints, connections etc. are leak free.
- B. Test apparatus shall include an airflow measuring device consisting of an orifice assembly, straightening vanes and a orifice plate mounted in a straight tube, a flow producing unit consisting of a fan and an inlet damper, and pressure indicating devices

consisting of a u-tube manometer (#2) across the orifice plate, a duct test pressure u-tube manometer (#1), an inclined manometer for reading orifice differential pressures below on (1) inch water gauge and accessories necessary to connect the metering system to the test specimen. The test procedure shall be as outlined in Part 3 – Execution. A copy of the certified performance curve indicating flow versus differential pressure shall be permanently attached to the test apparatus.

- C. Test apparatus shall have calibration data and certificate signifying manufacturer of the meter in conformance with the ASME Requirements for Fluid Meters.
- D. Orifice Plates in the test tubes shall be steel or stainless steel. Orifice openings shall be centered in the metal tube. The plates shall be flat and have holes with square edges (90 degrees) that are free of burrs. Plates shall be perpendicular to the flow path and shall be free of leaks at points of attachment.
- E. Taps for static pressure indication across orifices shall be made with one sixteenth (1/16) inch to one eighth (1/8) inch diameter holes drilled neatly in the meter tube wall. The interior of the tube shall be smooth and free of projections at the drilled holes.
- F. Pressure differential sensing instruments shall be readable to 0.05 inch scale division for flow rates below ten (10) cfm or 0.5 inch wg differential. For higher flow scale divisions of 0.1 inch are appropriate. U tube manometers should not be used for readings less than one (1) inch of water.
- G. Liquid for manometers shall have a specific gravity of one (1) (as water) unless the scale is calibrated to read in inches of water contingent on the use of a liquid of another specific gravity, in which case the associated gage fluid must be used.
- H. The duct test pressure shall be sensed only from an opening in the duct.
- I. Instruments must be adjusted to zero (0) reading before pressure is applied.
- J. The contractor conducting the test shall utilize the “UMB Standard Air Duct Leak Test Summary Form” for each duct test to record the test results of each test. Where multiple tests are conducted on the same duct section a summary report of each test (pass and failed test) shall be prepared. Each summary report shall be signed by each of the parties witnessing the test. The completed reports shall be forwarded to the Construction Manager (CM) or the General Contractor (GC). The CM or GC shall provide a copy of the reports to UMB Project Manager.

PART 3 – EXECUTION

3.1 PRO PRESS PIPING SYSTEMS

- A. Systems using Pro-Press piping connectors shall perform a pre-test at 30 psi for 10 minutes. After the hydrostatic test pressure has been applied for ten (10) minutes and

with no allowable drop in pressure, the tested system or segment has passed the Pro-Press leak pre-test. If after the ten (10) minute test period there is a loss in pressure below the initial test pressure, the test has failed and the contractor shall examine piping, joints, and connections for leakage. After all leaks have been corrected by tightening, repairing, and/or replacing components as appropriate, the hydrostatic test shall be rescheduled with the University. The test procedure shall be repeated as specified above until there are no leaks and there is no loss in pressure.

3.2 NATURAL GAS PIPING SYSTEM

- A. The contractor conducting the test shall use this Test Procedure for natural Gas Piping Systems. Test each pipe system as a whole or in segments as required by progress of the work. Cap and fill each system, with oil-free, dry air or dry nitrogen, to pressure of one and one half (1.5) times the system operating pressure, but not less than fifty (50) psig. Isolate the test source and let stand for four (4) hours to equalize temperature. Refill system, if required, to test pressure and hold pressure for one (1) hour with no allowable drop in pressure.
- B. Inspect and purge natural gas systems in accordance with NFPA 54, and local utility requirements.
- C. After erection of the tubing, but before installation of outlet valves, the line shall be blown clear by means of dry nitrogen.
- D. After installation of outlet valves, each section shall be subject to a test pressure of at least one and one half (1-1/2) time the maximum working pressure, but not less than 50 psi by means of dry nitrogen. This test pressure shall be maintained until each joint has been examined for leakage by means of Oxweld No. 23 Lake Test Solution of other non-fothing solutions approved for this purpose.
- E. Where leakage or other defects are located in each system, the affected portion of the piping system shall be repaired or replaced in that section of piping. After the leaks have been corrected by tightening, repairing or replacing components as appropriate the test shall be rescheduled with the University. The test procedure shall be repeated as specified above until there are no leaks and there is no allowable drop in pressure.
- F. Before the installation of outlet valves and placing the system in service each laboratory gas piping system shall be purged with dry nitrogen.

3.3 FUEL OIL PIPING SYSTEM

- A. Test Fuel Oil Piping as Follows:
 1. The Contractor conducting the test shall use this Test Procedure for Fuel Oil Systems. Test the pipe system as a complete system. After installation and before

being covered, or concealed, piping shall be tested for leaks. Piping shall be tested pneumatically with air at not less than twelve (12) times its maximum working pressure, but not less than 5 psig measured at the highest point of the system.

2. The test shall be made so as not to impose a pressure of more than 10 psig on any tank connected to the piping.
3. Pressure shall be maintained for one (1) hour and complete visual inspection of all joints and connections.
4. Suction lines shall be permitted to be tested under a vacuum of not less than 20 inches Hg maintained for four (4) hours.
5. Where the vertical length of the fill and vent pipes is such that, when filled with liquid, the static head imposed exceeds 10 psig, the piping shall be tested hydrostatically to a pressure equal to the static head thus imposed.

B. General:

1. Prior to acceptance and initial operation, all piping installations shall be inspected and pressure tested to determine that the materials, design, fabrication, and installation practices comply with the requirements of this specification.
2. Inspection shall consist of visual examination, during or after fabrication, assembly, or pressure tests as appropriate.

C. Test Medium: The test medium shall be an inert gas. OXYGEN SHALL NEVER BE USED.

D. Test Preparation:

1. Pipe joints, including welds, shall be left exposed for examination during the test.
2. Expansion joints shall be provided with temporary restraints, if required, for the additional thrust load under test.
3. Appliances and equipment that are not to be included in the test shall be either disconnected from the piping or isolated by blanks, blind flanges, or caps. Flanged joints at which blinds are inserted to blank off other equipment during the test shall not be required to be tested.
4. Where the piping system is connected to appliances, equipment, or equipment components, such appliances, equipment or equipment components shall be isolated from the piping system by disconnecting them and capping the outlets(s).
5. All testing of piping systems shall be done with due regard for the safety of employees and the public during the test. Bulkheads, anchorage, and bracing suitably designed to resist test pressures shall be installed if necessary. Prior to testing, the interior of the pipe shall be cleared of all foreign material.

E. Test Procedure:

1. Test procedure shall be measured with a manometer or with a pressure measuring device designed and calibrated to read, record, or indicate a pressure loss due to

- leakage during the pressure test period. The source of pressure shall be isolated before the pressure tests are made.
2. The test pressure to be used shall be no less than twelve (12) times the proposed maximum working pressure, but not less than 3 psi and no more than 125 psig.
 3. Test duration shall be one (1) hour.
- F. Detection of Leaks and Defects:
1. The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak unless such reduction can be readily attributed to some other cause.
 2. The leakage shall be located by means of an approved gas detector, a noncorrosive leak detection fluid, or other approved leak detection method. Matches, candles, open flames, or other methods that provide a source of ignition shall not be used.
 3. After Leaks have been corrected by tightening, repairing, and/or replacing components as appropriate the hydrostatic test shall be rescheduled with the University. The test procedure shall be repeated as specified above until there are no leaks and there is no allowable drop in pressure.
- G. Placing Equipment in Operation. Oil fired utilization equipment shall not be placed in operation until after the piping system has been tested and purged.

3.4 HYDRONIC AND STEAM AND CONDENSATE PIPING SYSTEMS

- A. The Contractor conducting the test shall use this Test Procedure for Hydronic, and Steam and Condensate Piping Systems. Test each pipe system as a whole or in segments as required by progress of the work. Perform tests prior to installation of piping insulation.
- B. All Piping Systems include piping exposed and concealed above grade within the building, piping below floor slabs within the building, piping below grade five (5) feet beyond the exterior foundation wall, and/or piping above the building roof elevation and are defined as follows:
1. Hydronic Piping Systems include all Chilled Water, Condenser Water, Heating Hot Water, Energy Recovery Piping, Discharge Piping from Sump Pumps and Sewage Ejectors.
 2. Steam and Condensate Piping Systems include all medium Pressure and Low Pressure Piping and Steam Relief Valve Piping.
 3. Fuel oil piping system when required.
- C. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.

- D. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at low points for complete removal of the liquid.
- E. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.
- F. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than one and one half (1-1/2) times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90% of specified minimum yield strength, or 1.7 times the “SE” value in Appendix A of ASME B31.9, Code for Pressure Piping, Building Services Piping.
- G. After the hydrostatic test pressure has been applied for one (1) hour and with no allowable drop in pressure, the tested system or segment has passed the leak test. If after the one (1) hour test period there is a loss in pressure below the initial test pressure, the test has failed and the contractor shall examine piping, joints, and connections for leakage. After all leaks have been corrected by tightening, repairing, and/or replacing components as appropriate, the hydrostatic test shall be rescheduled with the University. The test procedure shall be repeated as specified above until there are no leaks and there is no loss in pressure.
- H. Where backflow preventers are installed in piping systems scheduled for testing isolate the backflow preventer from the piping to be tested.

3.5 REFRIGERANT PIPING SYSTEMS

- A. The Contractor conducting the test shall use this Test Procedure for Refrigerant Piping Systems. Test each pipe system as a complete system. Testing this piping system in segments is not permitted. Test shall include both the high- and low-pressure sides of each system. Inspect, test and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI and as follows:
 - 1. All refrigerant tubing shall be tested before tube insulation is applied.
 - 2. Tests shall be performed with dry nitrogen. Oxygen, air, combustible gasses and mixtures containing such gases shall not be used.
 - 3. Refrigerant relief valves, if installed, shall be removed prior to pressure testing and shell openings plugged. After system is tested and found to be completely tight, relief valves shall be reinstalled prior to system evacuation.
 - 4. Each tubing system shall be pressure tested with dry nitrogen. Leaks shall be repaired by removing and remaking the defective joint. No caulking will be permitted. After repair of leaks, system shall be retested and proved tight.

5. Refrigerant pipe tests shall include both the high- and low-pressure sides of each system at not less than the lower of the design pressures or the setting of the pressure relief device(s) for four (4) hours. The design pressures for testing shall be those listed on the condensing unit, compressor or compressor unit nameplate as required by ASHRAE 15.
6. Test apparatus. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gauge on the outlet side.
7. Declaration: A certificate of test shall be provided for all systems tested under this requirement. The certificate shall give the name of the refrigerant and the field test pressure applied to the high side and low side of the system. The certification of test shall be signed by the installer and be made part of the project documentation.

3.6 AIR DISTRIBUTION DUCT SYSTEMS

- A. General: The Contractor conducting the test shall use this Test Procedure for all new duct systems. All new pressurized duct systems (positive and negative) shall be leak tested prior to the duct insulation being installed and/or the duct systems being concealed in shafts and/or above hard ceilings where indicated on the drawings. Where duct systems are indicated to be concealed, these duct systems shall not be enclosed until each system as successfully passed its leak test. Test each duct system as a whole or in segments as required by progress of the work. Use test pressure of pressure velocity classification as follows:

<Engineer shall verify the duct systems and test pressures indicated below are include in the project and edit as required>

1. Medium/High Pressure Supply Duct Systems Test Pressure: Positive Six (6) inches wg.
 2. Medium/High Pressure Return, Fresh Air and Exhaust Duct Systems test Pressure: Negative Six (6) inches wg.
 3. Low Pressure Supply Duct System Test Pressure: Positive Two (2) inches wg.
 4. Low Pressure Return and Exhaust Duct Systems Test Pressure: Negative Two (2) inches wg.
- B. Duct Construction and Seal Class: All ductwork will be constructed to meet the requirements of SMACNA Seal Class A and shall be leak tested to meet the requirements of SMACNA Leak Class 2.
- C. Leak Test Requirements: Unless otherwise directed by UMB, 100% of each duct system shall be leak tested following the outlines and classifications in “The SMACNA HVAC Air Duct Leakage Test Manual” 2012 or latest edition or 1% duct leakage, whichever is greater. The total allowable leakage shall not exceed SMACNA Leak Class 2 for all duct construction. This UMB requirement exceeds standard SMACNA requirements.

- D. Pressure test all non-welded duct systems (Supply, Return, Exhaust, Fresh Air, and Relief Air) from the Primary Air Handler, Return Air or Exhaust Fan to the diffusers, grilles exhaust hoods and/or fume hoods. All Low, Medium, High Pressure duct systems shall be pressure tested prior to the duct insulation being installed or the duct systems being concealed in shafts.
- E. Pre Test Procedure:
1. Prior to testing, the Sheet Metal Contractor shall manually remove all debris from inside ductwork, plenums, and equipment. Do not use Fans to remove the debris. Verify that all duct mounted equipment, access doors, accessories, components are installed complete as specified. Set all Fire Dampers, Smoke Dampers, or Combination Fire/Smoke Dampers in their proper position with “Fire Links” or other devices required for operation, in place and set.
 2. When testing each duct system in segments, if using 1% leakage factor, use the following proportioning method to determine allowable losses for each segment tested:
 - a. $ALS = (SFS/SFW) (ALW)$ where:
 - 1) ALS = Allowable Loss, Segment in Cubic Feet per Minute (CFM)
 - 2) ALW = Allowable Loss, Whole System in Cubic Feet per Minute (CFM) (1% of the total system design flow)
 - 3) SFS = Square Foot (Sq. Ft.) Surface Area, Segment of Ductwork.
 - 4) SFW = Square Foot (Sq. Ft.) Surface Area, of the Whole System of Ductwork.
- F. Leak Test Procedure:
1. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 2. Calculate the allowable leakage rate for the duct system or duct segment to be tested using the specified allowable leakage rate and the air volume
 3. Start the blower with its inlet control damper closed.
 4. Gradually open the inlet control damper until the pressure in the duct reaches the design duct operating pressure/class. Read and record the test pressure indicated on manometer (#1). Read and record the pressure differential across the orifice indicated on manometer (#2). Read and record the duct leakage rate in CFM from the appropriate calibration curve. If there is no leakage, the pressure differential will be zero (0).

5. If the test results indicate a leakage rate that exceeds the specified leakage rate the contractor and UMB Personnel shall survey all joints for audible leaks. Mark each location and repair the joints after shutting down the blower. After the sealant has set for at least twenty four (24) to thirty six (36) hours the contractor shall reschedule the test with all appropriate parties. Follow the procedures outlined in paragraphs 1, 2, 3 and 4 above. If the pressure test fails again the contractor shall repeat the entire process until the tested section passes the leak test.

3.7 COMPLETED HYDROSTATIC/LEAK TEST FORMS

- A. Upon completion of each hydrostatic/leak test, the contractor shall upload the signed leak test forms to the Project File, in ebuilder, in Folder 11.06 Test Reports.

3.8 UMB STANDARD HYDROSTATIC/LEAK TEST SUMMARY FORMS

- A. General: Contractors shall use the UMB Standard Forms for Recording the Leak Test Results for all Duct and Pipe Systems Tested on this Project.
 1. Pipe System Sample Form: See the following page for a sample of the UMB Standard Pipe System Hydrostatic/Leak Test Summary Form.
 2. Availability: The standard test summary form is available on the UMB Web Site at:
<http://www.umaryland.edu/designandconstruction/https://www.umaryland.edu/designandconstruction/design-and-construction-documents/umb-standard-project-forms---current-editions/>
 3. Field Testing: For field testing download and copy the forms from the UMB web site. <Do not use attached “Sample Forms” for testing>

UMB STANDARD AIR DUCT SYSTEM LEAK TEST SUMMARY FORM

Project Name: _____ Project Number: _____ Page ___ of ___

Air System: _____ Specified Test Pressure: _____

Total System CFM: _____ Duct Construction Pressure Class: _____

Date of Test: _____

DESIGN DATA					FIELD TEST DATA RECORD				
Subject Duct	Surface Area (ft. ²)	Leakage Criteria			Measured CFM	Test Data ΔP (inches wg)	Test Result Pass/Fail	Test Performed By	Test Witnessed By
		Leakage Class	Leakage Factor (CFM/100ft.)	Test Section CFM					

UMB STANDARD PIPE SYSTEM HYDROSTATIC/LEAK TEST SUMMARY FORM

TEST DATA:

Date: _____ Project Number: _____

Location: _____

Pipe System Tested (Service): _____

Location and Description: _____

Pipe Materials: _____

Operating Pressure: _____

Specified Test Pressure: _____

Actual Test Pressure: _____

Pressure Test Type: _____

Test Start Time: _____ Recorded Test Pressure: _____

Test Completion Time: _____ Recorded Test Pressure: _____

Test Duration: _____ Pressure Drop or Rise: _____

Test Result (Pass/Fail): _____

SIGNATURES:

Construction Manager: _____

Construction Manager Representative: _____

Mechanical Contractor: _____

Mechanical Contractor Forman: _____

UMB Division: _____

UMB Witness: _____

Remarks: _____

END OF SECTION