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NATIONAL BUREAU OF STANDARDS REPORT

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RECOMMENDED SPECIFICATION FOR
TEST PROCEDURES TO DETERMINE SUITABILITY OF
DUCTS FOR USE IN RESIDENTIAL
WARM AIR HEATING AND AIR-CONDITIONING SYSTEMS

by

Selden D. Cole and Paul R. Achenbach

to
Federal Housing Administration
Washington, D.C.



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

RECOMMENDED SPECIFICATION FOR
TEST PROCEDURES TO DETERMINE SUITABILITY OF
DUCTS FOR USE IN RESIDENTIAL WARM AIR HEATING
AND AIR-CONDITIONING SYSTEMS

Section I. Requirements

The following requirements apply to ducts used in residential warm air heating and air-conditioning systems serving one or two family residences not over three stories in height. Requirements A through G apply to rigid, semi-rigid, and flexible ducts regardless of where they are located in the structure. Requirement H applies only to rigid or semi-rigid ducts installed in walls, attics, occupied spaces, or suspended from floor joists or beams. Requirement I applies only to ducts installed in or under concrete slabs-on-ground. Requirement J applies only to flexible ducts.

- A. Odor Emission Test (Section V)
- B. Micro-organism Resistance Test (Section VI)
- C. Erosion Test (Section VII)
- D. Impact Test (Section VIII)
- E. Air Leakage Test (Section IX)
- F. Deformation and Deterioration at High Temperature & Humidity (Section X)
- G. Collapse and Rupture Tests (Section XI)
- H. Bending and Permanent Deformation Test (Section XII)
- I. Bending and Crushing Test (Section XIII)
- J. Crushing Test for Flexible Ducts (Section XIV)

Section II. Labeling and Identification

Any duct material manufactured by one company and submitted for acceptance shall bear an identifying mark or symbol representing that material. Ducts offered under a contract as having met the test requirements shall bear the same identifying mark as the test specimens which met the requirements. If at any time a manufacturer changes a duct material or its fabrication procedures in a way that measurably affects any of the performance characteristics described in this specification, a different identification mark shall be assigned to the product, and this new product shall be tested for compliance with the performance requirements before acceptance.

Section III. Sampling and Rejection Procedures
for Test Specimens

- A. Sampling: Test specimens shall be new material selected from regular production stock and shall not be taken from the first or last part of a production run.
- B. Rejection: (1) Duct specimens shall not be accepted for test unless each test specimen bears a clearly visible identification mark or symbol which has been assigned to all identical duct material manufactured by that company. (2) If, during the tests, one specimen fails to meet a specific test requirement, a second specimen shall be subjected to the same test. If two specimens fail to meet any one test requirement, the duct material shall be rejected as not meeting the acceptance requirements.

Section IV. Specimen Size and Specimen Conditioning

- A. Each duct specimen shall be of nominal 8-inch diameter or of equivalent cross section area, if rectangular, and shall be at least six feet long.
 - A-1 In case a given test requires only a portion of a specimen, the portion shall be taken more than six inches from either end of the specimen.
 - A-2 In case more than one specimen is required for a test, the two or more specimens shall be joined by a method recommended for installation by the manufacturer of the duct.
- B. The duct specimens shall be conditioned to moisture equilibrium in room air at a relative humidity of 50 ± 5 percent and a temperature of $80 \pm 5^{\circ}\text{F}$ before subjection to specific test requirements.

Section V. Odor Emission Test

- A. Purpose: The purpose of this test is to determine whether or not a duct or duct material emits excessive objectionable or non-objectionable odor.
- B. Test Specimen: The test specimen shall consist of a 6-foot length of duct complying with Section III and Section IV, Paragraphs A and B.

C. Apparatus and Materials: The following materials shall be assembled to form an apparatus illustrated in Fig. 1:

1. Two centrifugal blowers and motors
2. Electric resistance heaters
3. New and clean sheet metal tubes with connecting elbows, tees, plugs, and a shutoff damper
4. An observation chamber
5. Thermocouples or thermometers
6. A thermostat with an adjustable temperature range up to 225°F and a differential of 5 degrees or less
7. Specimen supports
8. Pitot tube or orifice and pressure taps
9. Pipe or blanket type insulation
10. A panel of not less than 15 observers

In addition, three familiar sources of odor such as coffee, ammonia, apple, orange, garlic, or perfume shall be available.

D. Qualifying the Odor Panel: Each proposed observer on the odor panel shall be subjected to three familiar odors by drawing the odor into the outside air inlet indicated in Fig. 1. After the introduction of each odor, the system shall be purged for several minutes with outdoor air before introduction of the next odor. No observer shall be used on the 15-member panel who fails to recognize the three familiar odors in the observation chamber.

E. Test Procedure:

1. The test specimen shall be supported in the specimen-holding chamber. Heated air at a temperature of 200°F shall be recirculated over the duct specimen and the electric resistance heater for a period of 4 hours with the damper at the outlet side of the fresh-air blower closed.
2. After the four-hour preconditioning period at 200°F, the test specimen shall be cooled to ambient temperature. Outdoor air shall then be blown over the specimen for one hour to purge all parts of residual odors.
3. With the outdoor blower stopped and the damper closed, the duct specimen should then be reheated by recirculating air at a temperature of 200°F over the electric resistance heater for at least 30 minutes.
4. Immediately following this heating period, the first observer from a panel of 15 should be stationed in the observation chamber while outside air is passed over the heated duct at a velocity of 500 fpm as determined by the pitot tube or orifice and thence to the observation chamber

for a period of 2 minutes. The observer shall record whether or not an odor was detected, whether it was objectionable or not, and whether it was weak or strong. His observations shall not be revealed to other panel members.

5. Steps 3 and 4 should then be promptly repeated with each member on the odor panel except that the reheating period for all observers after the first shall be only 5 minutes.

F. Basis of Acceptance:

1. The odor panel shall consist of 15 members qualified by the procedures in Section V-D.

2. A specimen duct will not be considered acceptable if more than 5 members of the odor panel report an objectionable odor or if more than 10 members report a perceptible non-objectionable odor.

Section VI. Micro-Organism Resistance Test:

A. Purpose: The purpose of this test is to evaluate the resistance of samples of fabricated ducts to the growth of mold.

B. Test Specimens: Each unit of specimens shall consist of twelve samples of material each 1 1/2" x 1 1/2" square, selected as in Section III, Paragraph A, and Section IV, Paragraphs A & B.

C. Apparatus, Medium and Test Fungi:

1. Apparatus shall consist of:

- a. An autoclave, capable of maintaining an interior temperature of $122 \pm 2^{\circ}\text{C}$. ($251 \pm 3.6^{\circ}\text{F}$.) at a pressure of 15.5 ± 0.5 pounds per square inch gauge for the purpose of sterilizing glassware and the medium.
- b. Erlenmeyer flask, 100 CC capacity
- c. Glass beads, 1/4" in diameter, 5 pieces
- d. Glass pipettes, two required
- e. Wire loop, of nichrome wire
- f. Petri dishes, 10 centimeters in diameter with covers capable of being sealed with cellophane tape. One Petri dish is required for each of the twelve samples comprising a test unit.

- g. Filter paper, cellulosic
- h. An incubation chamber, capable of maintaining a temperature of $29 \pm 1^\circ\text{C}$. ($84.5 \pm 1.8^\circ\text{F}$.) and a relative humidity of at least 50 per cent.
- i. A sterile room, dust free, using sterilamps, antiseptic spray, or air filtration under pressure to maintain sterile conditions.

2. Test fungi:

- a. Chaetomium globosum shall be Chaetomium globosum, A.T.C.C. 6205.
- b. Aspergillus niger shall be Aspergillus niger A.T.C.C. 6275.

3. Medium: A culture medium of the following composition:

NH_3NO_3	3.0 grams
KH_2PO_4	2.5 "
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	2.0 "
K_2HPO_4	2.0 "
Agar	20.0 "

DISTILLED WATER to make 1000 milliliters

The pH shall be adjusted to a range of 6.4 to 6.8 with HCl or NaOH as required. This is the base medium for both fungi cultures. However, the medium to be used for the Aspergillus niger shall be specially enriched by the addition of 30 grams of brown sugar per liter of solution.

D. Test Procedure:

- 1. Medium as specified in Item 3 shall be prepared and poured in the required number of Petri dishes to a depth of 3/8".
- 2. Sterilize in the autoclave all of the apparatus in Paragraph C, Item 1.b through g including the medium contained in the Petri dishes by retention in the autoclave at the temperature and pressure prescribed in

Paragraph C, Item 1.a for 60 minutes. After sterilization remove to sterile room of Paragraph C, Item 1.i, taking care not to contaminate the sterilized equipment and medium. The sterile room shall be used for all preparation procedures.

3. Cultures, stock and substocks, and inoculum:

a. Chaetomium globosum fungus stock cultures shall be carefully maintained on strips or squares of sterile porous filter paper, or blotting paper, on a sterilized culture medium as specified in Paragraph C, Item 3, and Paragraph D, Item 2. If there is evidence of contamination, the culture shall be promptly renewed. The culture may be kept for not more than four months in a refrigerator at approximately 3° to 10°C.

(1) Subcultures shall be prepared from a stock culture by transferring spores from the stock culture to a sterilized covered Petri dish containing sterilized medium. The subculture shall then be incubated for a period of 7 to 21 days at $29 \pm 1^\circ\text{C}$. ($84.5 \pm 1.8^\circ\text{F}$.) in the incubation chamber until in a ripe fruiting condition.

(2) Inoculum shall be prepared by transferring the spores with the sterilized wire loop to a sterilized Ehrlenmeyer flask containing 5 sterilized glass beads and 10 ml. of distilled water. This mixture shall be shaken sufficiently to break up the spores after which the solution shall be diluted to 200 ml.

b. Aspergillus niger fungus stock cultures shall be carefully maintained as specified in Paragraph D, Item 3.a on a medium as specified in Paragraph C, Item 3 for this growth.

(1) Subcultures shall be prepared and incubated as in Paragraph D, Item 3.a(1) using a medium as specified in Paragraph C, Item 3.

(2) Inoculum shall be prepared as specified in Paragraph D, Item 3.a(2).

4. Six specimens of each test unit as defined in Section III, Paragraph A, and Section IV, Paragraphs A.1 & B, shall be inoculated with each of the two varieties of fungi. Three will be inoculated with the face side up; three, with the back side up.

- a. Preparation: Each specimen shall be handled under aseptic conditions and shall be sterilized by dipping in 70 per cent ethanol for a few seconds followed by a thorough rinse in distilled water after which each is put in place firmly in the center of the solidified agar medium in its respective Petri dish. Six of the specimens shall be tested with one fungi and six with the other. Also of each subunit of six, three shall have one surface in contact with the medium and three with the opposite surface as stated under Paragraph D, Item 4.
 - b. Controls shall be placed in each Petri dish along with the specimen. Each control shall be a strip of sterile blotting paper or filter paper, Paragraph C, Item 1.g, placed on the agar separated from the specimen. The purpose of the control is to provide a medium for the fungi, thus proving that the fungi is active.
 - c. Inoculation with a particular fungus shall be made by using a sterile pipette individual to the fungus. With the pipette, approximately 1.5 ml. of inoculum shall be distributed over the specimen, the control and the surrounding medium.
5. Incubation of the inoculated specimens shall be continued for a period of 28 days at a temperature of $29 \pm 1^{\circ}\text{C}$. ($84.5 \pm 1.8^{\circ}\text{F}$.) and a relative humidity of 90 percent. An approximate incubation condition is obtained by placing the covered and sealed Petri dishes in a room or chambers maintained at 85°F and 50 percent relative humidity.

E. Basis of Acceptance: Test dishes with controls that do not exhibit a substantial growth of fungi after 7 days of incubation shall be rejected and shall be started anew. A unit test, the controls of which indicate a substantial fungus growth, shall be examined after the required period of 28 days incubation. If after this period any one of the specimens shows evidence of evenly distributed or intense localized fungus growth under 10 X magnification on either side of the sample (excluding growth overlapping the edges), the test sample shall be considered to have failed under the test of Section VI. See Section III, Paragraph B for details on rejection procedure in event of failure to meet requirements.

Photographs of the specimen taken at the end of the 28-day incubation period are required as a part of the test on fungus resistance. Each photograph shall be taken with a scale laid

beside the specimen to indicate its size, and the light conditions shall be such that the photographs reveal the nature and height of the fungus growth on the surface of the material. The photographs should be enlarged so the specimen will be a 6" x 6" size in the enlargement.

Section VII. Erosion Test

- A. Purpose: The purpose of this test is to evaluate the air-erosion of a duct under accelerated conditions.
- B. Test Specimens: Each test specimen shall be selected according to Section III, Paragraph A, and Section IV, Paragraphs A & B.
- C. Apparatus and Materials: The following apparatus and materials shall be assembled as indicated in Figure 2:
1. A blower with sufficient capacity to provide an average air velocity of 4000 fpm through the duct specimens.
 2. High efficiency panel filters for fan inlet.
 3. Velocity measuring instruments.
 4. A collection chamber with U.S. Standard 200-mesh sieve screen.
 5. Cellophane tape, 3/4 inches wide.
 6. Microscope, Power 10X
- D. Test Procedure:
1. The apparatus shall be assembled as in Figure 2 without cellophane tapes and screen in place. Air shall be passed through the test unit at a velocity of 4000 fpm for a period of 10 minutes to purge the system.
 2. After purging, cellophane tapes shall be installed at the blower discharge and in the entrance to the collection chamber, the collection box shall be wiped clean, and the 200-mesh screen installed on the collection box.
 3. Air at a velocity of 4000 fpm shall be passed through the test specimens for a period of 4 hours.
 4. At the end of the four-hour period, the cellophane tapes from both stations shall be removed from the system and examined under the microscope, and the collection box shall carefully be cleaned with a soft hair brush. The 200-mesh screen shall be examined for foreign particles.

- E. Basis of Acceptance: The erosion properties of a duct specimen shall be unacceptable if:
1. The tapes removed from the collection box reveal more foreign particles adhering to the surfaces than on the tape removed from the duct at the fan air outlet when examined under the microscope.
 2. The collection box sweepings reveal macroscopic particles that can be identified with the duct specimens.
 3. The 200-mesh screen reveals visible particles adhering to its surface that can be identified with the duct specimens.

Section VIII. Impact Test

- A. Purpose: The purpose of this test is to determine the resistance of ducts to impact damage from falling objects.
- B. Test Specimens shall be selected according to Section III, Paragraph A, and Section IV, Paragraph A.
- C. Apparatus: The apparatus shall consist of:
1. One steel ball 2 inches in diameter and weighing 1.18 pounds
 2. Depth gage and steel rule
 3. An iris diaphragm and adjustable support for holding the steel ball at a predetermined height and releasing it without initial momentum
- D. Test Procedure:
1. The duct specimen shall be placed lengthwise on a flat surface.
 2. The support holding the steel ball shall be placed and adjusted so that the ball is exactly 30 inches above the high point of the outside surface of the specimen.
 3. Three drops of the steel ball should be made at the quarter points of the specimen with impact on the top surface of the specimen.
 4. The depth and size of the indentations shall be measured and recorded.
 5. If the test specimen is of rectangular cross section, the impact shall be made on the longer side of the duct.

- E. Basis of Acceptance: The impact resistance of a duct specimen shall be unacceptable if:
1. Any one of the three indentations caused by the falling ball is more than 3/4 inches deep measured to the nearest 1/16 inch.
 2. The inside vertical diameter is reduced by more than 10% of the initial diameter at the point of maximum indentation.
 3. The specimen is cracked or ruptured or delaminated at one of the three points of impact.

Section IX. Air Leakage Test

- A. Purpose: The purpose of this test is to determine the air leakage of duct specimens and the joints between specimens.
- B. Test Specimens: Each test specimen shall be selected according to Section III, Paragraph A, and Section IV, Paragraph A.2 and B, and shall be 6 feet long.
- C. Apparatus: The apparatus shall consist of:
1. Duct hangers
 2. A source of air pressure at about 1 inch W.G.
 3. A pressure tap at center of each end cap.
 4. A manometer with a range of 1 inch W.G.
 5. An integrating air flow meter with a range of 5 to 100 ft³/hr.
- D. Test Procedure:
1. Two test specimens, each six feet long, shall be connected by a jointing method recommended by the duct manufacturer, and shall be installed as shown in Figure 3.
 2. Apply a continuous internal static pressure of 0.50 inches water gage to the test specimens for a period of one hour.
 3. Record the air flow meter reading at the beginning and at the end of the one hour period to determine the total air leakage.
- E. Basis of Acceptance: The air leakage rate measured by the air flow meter, expressed in cubic feet per hour, should not exceed 20 (twenty) multiplied by the internal volume of the two joined specimens expressed in cubic feet.

Section X. Deformation and Deterioration
at High Temperature and Humidity

A. Purpose: The purpose of this test is to determine whether or not a duct will adequately retain its shape, rigidity, and physical integrity under exposure to high humidity and high temperature in an accelerated test.

B. Test Specimen: The test specimen shall be selected according to Section III, Paragraph A, and Section IV, Paragraphs A and B, and shall be 6 feet long.

C. Test Apparatus: The test apparatus shall consist of:

1. A fog room capable of maintaining 100 percent humidity at constant temperature in the range of 70°F to 75°F.
2. A unit heater with air delivery temperature controllable at 250°F and suitable for attaching a discharge duct.
3. A blower capable of delivering air at 1000 fpm through the unit heater and duct specimen.
4. Velocity measuring instruments (Pitot tube)
5. Temperature measuring devices
6. Duct hangers

D. Test Procedure:

1. A 6-foot duct specimen shall be suspended in the fog room by metal duct hangers from each end of the specimen. If the test specimen is rectangular in cross section, the longer dimension shall be placed horizontally. After mounting the specimen and before starting the test, the outside diameter in a vertical direction shall be measured at midlength and at each end. The distance between the bottom surface of the duct at the midpoint between hangers and a reference straight edge in contact with the two hangers at the bottom of the duct shall also be measured. A means shall be provided for identifying the orientation of the duct in the hangers.
2. The duct specimen unit shall remain suspended in the fog room for a period of 19 hours under saturation conditions at a controlled temperature between 70°F and 75°F.
3. After 19 hours in the fog room, the specimen shall be removed and installed as a part of the discharge duct system of the unit heater.
4. Air at a temperature of 250°F and a velocity of 1000 fpm shall be circulated through the duct for a period of 4 hours.

5. The specimen shall be supported in the fog room again with the same orientation as before.
6. The 19-hour exposure in the fog room followed by 4 hours' exposure to hot air in the unit heater system shall be repeated seven times.
7. The outside diameter and the distance between the bottom of the duct and the straight edge shall be measured at the positions described in D-1 above, after completion of the 7 exposure periods in the fog room, and while the specimen is still suspended in the fog room.

E. Basis of Acceptance:

1. The outside diameter at any of the three stations of measurement shall not change more than 1/2 inch.
2. The sag at midlength of the specimen shall not increase more than 1/2 inch as a result of the seven exposure cycles to high temperature and humidity.
3. There shall be no visual evidence of cracks, fractures, delamination, corrosion or deterioration inside or outside of the test specimen.

Section XI. Collapse and Rupture Tests

A. Purpose: The purpose of these tests is to determine whether or not duct specimens connected by typical jointing methods possess the strength and other physical characteristics necessary to prevent collapse, rupture, deterioration or excessive change in cross-section area under selected levels of positive and negative internal pressures.

B. Test Specimens: Two duct specimens 6-feet long and complying with Section III, Paragraph A, and Section IV, Paragraphs A-2 and B shall be used for the collapse and rupture tests. The same specimens may be used for the two tests if the first test produces no adverse effects, but separate specimens shall be used for the two tests if the first test produces measurable deterioration or permanent deformation.

C. Test Apparatus: The materials and apparatus required for the collapse and rupture tests are as follows:

1. Sources of air pressure and vacuum
2. A manometer with a range from 2 in. W.G. vacuum to 5 in. W.G. positive pressure
3. A cap for each end of the test duct fitted with a pressure connection
4. Duct hangers

D. Test Procedure:

1. Two test specimens, each 6 feet long, shall be connected by a jointing method recommended by the duct manufacturer and shall be supported as indicated in Fig. 4.
2. The end caps shall be fitted and sealed against air leakage.
3. The manometer shall be connected to the pressure connection on one end cap and the sources of vacuum and pressure shall be connected in separate tests to the pressure connection on the other end cap.
4. The cross-section area and length of the test unit should be measured and recorded.
5. For the rupture test, a positive pressure of 5 in. W.G. shall be maintained on the test unit for one hour, whereas for the collapse test, a vacuum of 2 in. W.G. shall be maintained on the test unit for one hour.
6. At the end of the rupture and collapse tests and while the test pressure is maintained on the interior of the test unit, the amount of distortion and increase or decrease in cross-section area of the duct shall be determined and recorded. The test specimens shall also be examined on the exterior for evidence of rupture, cracking, delamination, or other deterioration while they are still under the test pressure, and shall be similarly examined on the interior after release of the test pressure. Any change in the physical characteristics shall be described and recorded.

E. Basis for Acceptance:

1. The test specimens shall not collapse, rupture, crack, delaminate, or otherwise visibly deteriorate as a result of the application of the positive or negative test pressures.
2. The cross section area shall not decrease more than 15 percent of the initial cross section area in any plane at right angles to the center line throughout the length of

the test unit during the test with a negative internal pressure, nor shall the increase in cross-section area at any plane exceed 15 percent during the test with positive internal pressure.

Section XIII. Bending and Permanent Deformation Test

A. Purpose: The purpose of this test is to determine the deflection of a duct under externally-applied concentrated load and the permanent deformation upon load removal.

B. Test Specimen: The test specimen shall be selected in accordance with Section III, Paragraph A, and Section IV, Paragraphs A and B.

C. Test Apparatus: The apparatus and materials required are as follows:

1. Two duct hangers of a type recommended by the manufacturer; or alternately, two bearing blocks, 3/4 inch in thickness, shall be used and shall provide a clearance between the bottom of the duct and a reference surface of at least 2 inches. The bearing blocks for round ducts shall have a curved upper surface of a radius equal to the external radius of the duct, and shall contact a 120-degree arc on the duct circumference. The bearing blocks for rectangular ducts shall be flat and of a length at least equal to the width of the duct.

2. A loading block four inches long with a curved lower surface of a radius equal to the external radius of the duct shall be used for round ducts, and it shall contact an arc of 30 degrees on the top of the duct. The loading block for rectangular ducts shall extend across the face of the duct at right angles to the center line, and shall have a dimension of 4 inches parallel to the center line of the duct.

3. Metal weights totalling 10 lb including the weight of the loading block.

D. Test Procedure:

1. The test duct shall be supported six inches from each end of the specimen using either the hangers or the bearing blocks. If the duct specimen is rectangular in cross section, the longer dimension shall be placed in a horizontal position.

2. The vertical distance from a horizontal reference surface under the duct specimen to the bottom of the duct shall be measured at midlength.

3. The loading block and weights, totalling 10 lb, shall be placed on top of the duct at midlength and left there for 24 hours.

4. After 24 hours the distance between the horizontal reference surface under the duct and the bottom of the duct at midlength shall be measured again.

5. The 10-lb load shall be removed and the distance to the reference surface beneath the duct measured as before 5 minutes after load removal.

6. The horizontal and vertical outside diameters of the duct at midlength shall be measured not more than 10 minutes after load removal.

E. Basis of Acceptance:

1. The duct specimen shall withstand the load without damage.

2. The maximum change in deflection at the bottom of the duct as a result of the load application shall not exceed 1/2 inch after the load has been in place 24 hours, nor more than 3/8 inch five minutes after load removal.

3. After load removal, the vertical and horizontal outside diameters of the duct at midlength shall not differ from the original dimensions by more than 1/2 inch.

Section XIII. Bending and Crushing Tests

A. Purpose: The purpose of these tests is to determine the susceptibility of a duct to damage by bending or crushing during installation in concrete slabs.

B. Test Specimens: Test specimens shall be selected in accordance with Section III, Paragraph A, and Section IV, Paragraphs A and B. Separate specimens shall be used for the bending and crushing tests.

C. Test Apparatus: The apparatus and materials required are as follows:

1. A loading block 3 5/8 x 3 5/8 x 12 inches having two adjacent longer edges rounded to 1/2-inch radius.

2. Two bearing blocks 1 5/8 x 1 5/8 x 8 inches.

3. A horizontal flat surface at least 6 feet long.
4. Weights totalling 160 lb in increments of about 10 lb, or other means such as a testing machine for gradually applying load to the loading block.

D. Test Procedure:

1. For the bending test the duct specimen shall be supported on the bearing blocks laid crosswise to the duct 6 inches from either end, with the bearing blocks resting on the horizontal flat surface.
2. The loading block shall be placed crosswise on top of the duct at midlength.
3. Load shall be applied to the loading block in increments of about 10 lb to a total of 160 lb.
4. The deflection of the top and bottom surfaces of the duct shall be measured at midlength before loading started and after each increment of 10 lb additional load up to a total load of 160 lb.
5. After being loaded at 160 lb for one minute, the load shall be removed and the deflection of the top and bottom of the duct at midlength measured 5 minutes after load removal.
6. For the crushing test, a new duct specimen shall be supported directly on the horizontal flat surface and steps 2-5, inclusive, repeated.

E. Basis of Acceptance:

1. In the bending test, the duct shall be able to withstand a load of 160 lb without deflecting more than 1 inch at midlength on the bottom or deforming more than 3 inches at the station of load application on the top. Permanent deformation after load removal shall not exceed 1/4 inch at the bottom or 1/2 inch at the top.
2. In the crushing test, the duct shall be able to withstand a load of 160 lb without deforming more than 3 inches at the station of load application on the top. Permanent deformation after load removal shall not exceed 1/4 inch at the top.
3. There shall be no cracks, fractures, delamination or other visual permanent damage as a result of the bending or crushing tests.

Section XIV. Crushing Test for Flexible Ducts

- A. Purpose: The purpose of this test is to determine the temporary deflection and permanent deformation of flexible ducts under specified loading conditions.
- B. Test Specimen: The test specimen shall be selected in accordance with Section III, Paragraph A, and Section IV, Paragraphs A and B.
- C. Test Apparatus: The test apparatus is the same as that required for the crushing test in Section XIII.
- D. Test Procedure: The test procedure is the same as that specified for the crushing test in Section XIII except that the load shall be applied in increments of 5 lb instead of 10 lb.
- E. Basis of Acceptance:
1. The duct specimen shall be able to withstand a load of 40 lb without deforming more than 3 inches at the station of load application on the top. Permanent deformation after load removal shall not exceed 1/2 inch at the top.
 2. There shall be no cracks, fractures, delamination, or other visual permanent damage as a result of the crushing test.

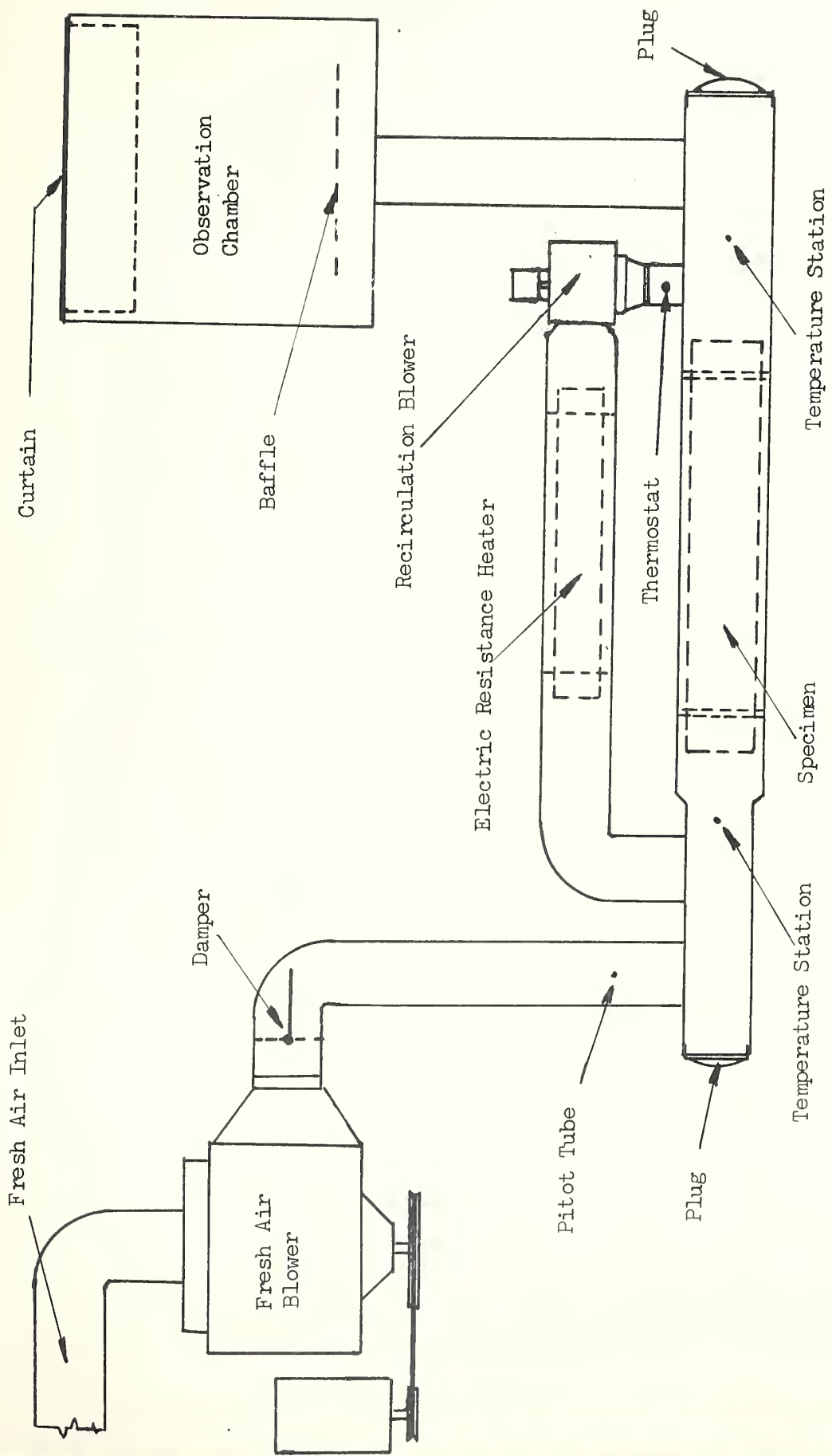


Fig. 1 - APPARATUS FOR ODOR TEST

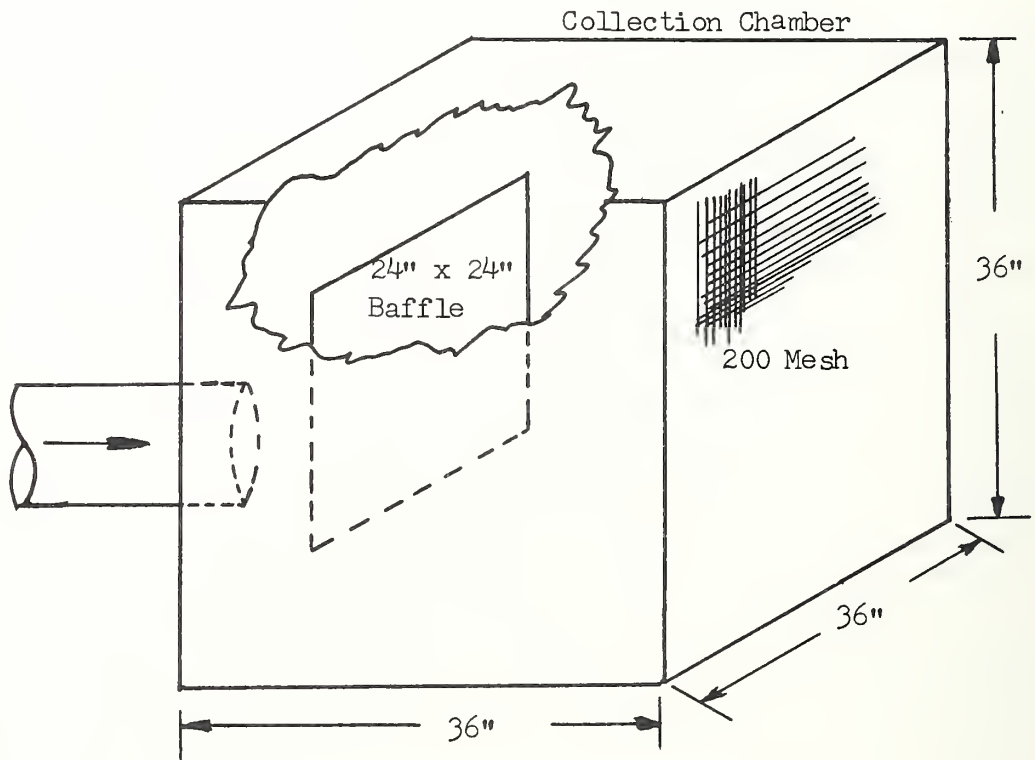
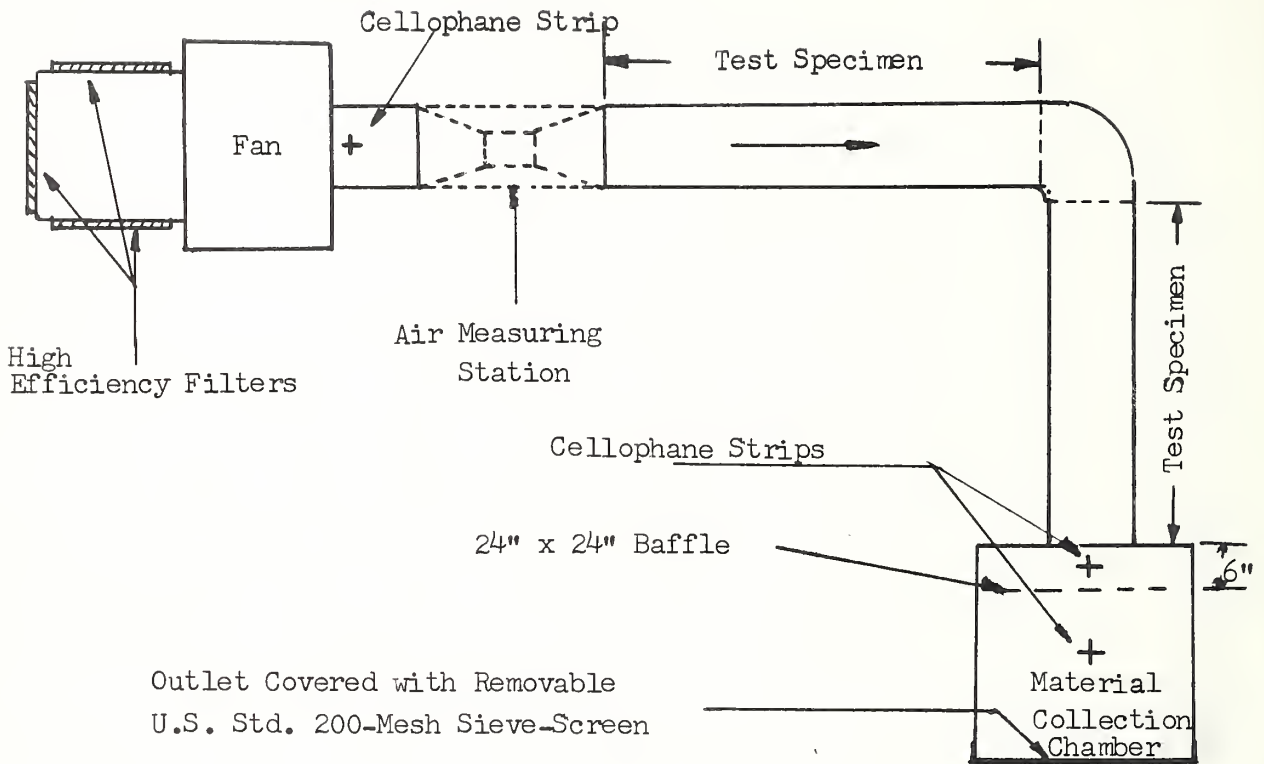


Fig. 2 - APPARATUS FOR EROSION TEST

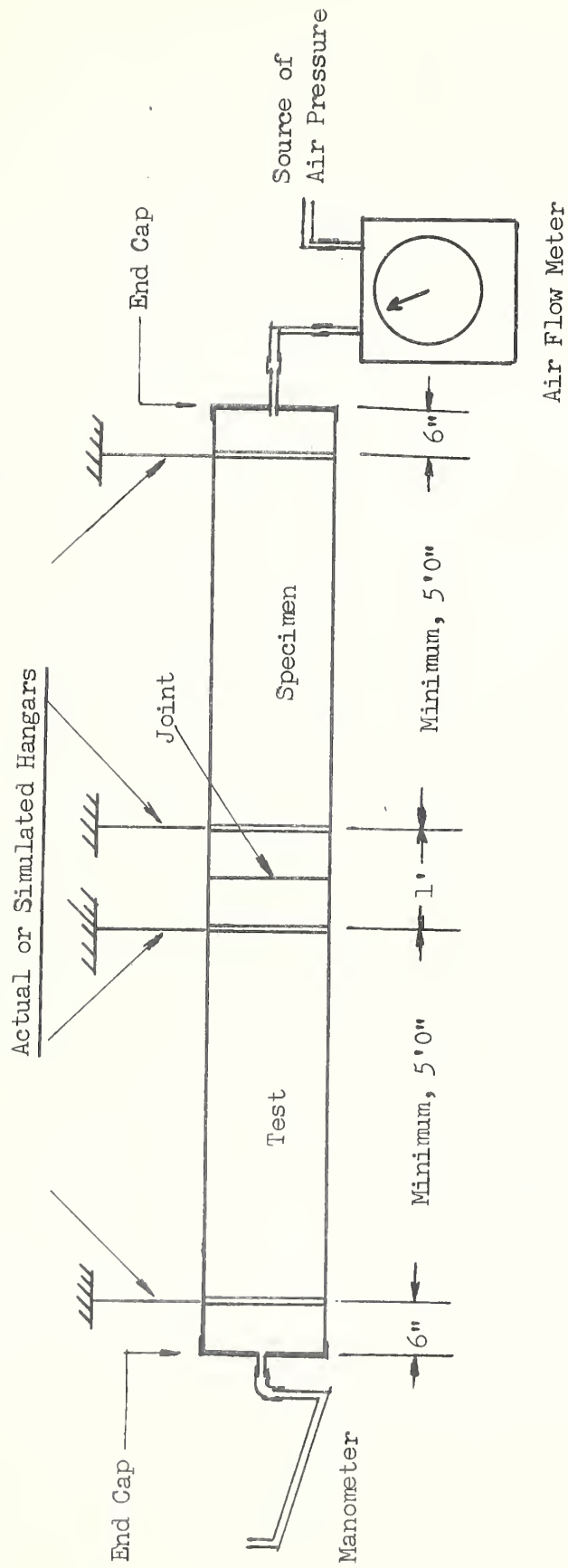


Fig. 3 - APPARATUS FOR AIR LEAKAGE TEST

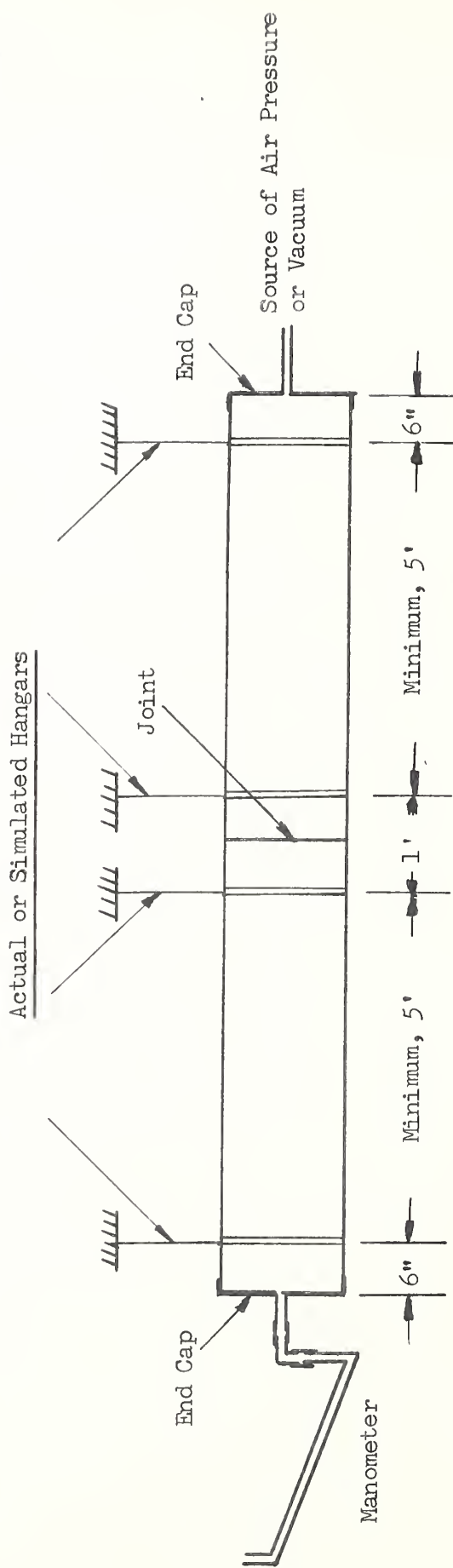


Fig. 4 - APPARATUS FOR RUPTURE AND COLLAPSE TESTS

