



**INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS**

**HIGH PRESSURE AIR CONTENT OF
HARDENED PORTLAND CEMENT CONCRETE
ITM No. 401-15**

1.0 SCOPE.

- 1.1** This test method covers the procedures for laboratory determination of the air content of hardened Portland cement concrete with the use of the High Pressure Air Meter. This determination is made from the observation of change in linear piston movement with a specimen in the test chamber, from that of the linear piston movement with no specimen in the test chamber. This change is due to a specific volume of compressible entrained air being replaced with a specific volume of incompressible water. This test method also covers the determination of the plastic air content of concrete tested using the high pressure method based on a statistical relationship between hardened and plastic air content.
- 1.2** This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCED DOCUMENTS.

2.1 AASHTO Standards.

T 152 Air Content of Freshly Mixed Concrete by the Pressure Method.

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101, except as follows.

- 3.1** Linear Piston Movement, LPM. The linear piston movement is the travel of the hydraulic piston with a specimen in the test chamber.
- 3.2** Initial Value, INIT. The initial value is the stabilized travel of the hydraulic piston with no specimen in the test chamber.

4.0 SIGNIFICANCE AND USE. This test method covers determination of the air content of hardened concrete exclusive of any air that may be inside the voids within the aggregate particles. The determination of an aggregate correction factor in accordance with the applicable requirements of AASHTO T 152 is required.

5.0 APPARATUS.

5.1 High Pressure Air Meter.

5.1.1 Hydraulic Pump and Hydraulic Cylinder. A specially designed unit combining a hydraulic pump and a hydraulic cylinder employed to supply the 5000 psi load required to force water into a concrete specimen in the test chamber. The unit is supplied air pressure, which is converted to water pressure by movement of the hydraulic piston.

5.1.2 Test Chamber. A specially designed stainless steel seamless tube secured with a stainless steel plate, at the bottom, and a stainless steel lid, at the top. This chamber is designed to contain water under pressure.

5.1.3 The System. The hydraulic cylinder, of known volume, is attached to the test chamber, of known volume, that is completely filled with deionized water. This is done in order to enable the load from the hydraulic pump to be applied to the test chamber. The system is equipped with a dial gage accurate to 0.001 in. in order to measure the movement of the hydraulic piston. Volume displacement is determined by the measured movement of the hydraulic piston.

6.0 SAMPLING. Obtain a sound concrete sample free of steel reinforcement. The sample is required to be of suitable size to fit into the test chamber. The diameter of the stainless steel lid is 6.8 in. and the depth of the seamless tube is 16.9 in.

7.0 PREPARATION OF THE TEST SPECIMEN.

7.1 Oven Drying. To ensure uniformity of each concrete sample, the specimen is oven dried for 72 h at 280-300°F.

7.2 Saturation. Air voids in concrete capable of absorbing water easily is considered entrapped air and cannot be included as entrained air. The air content determination is required to be made on concrete in the fully saturated condition. For this reason, after the specimens are oven dried, the specimens are required to be saturated in $72 \pm 2^\circ\text{F}$ water for a period of 40 - 48 h.

7.3 Unit Mass (Weight). Determine the unit weight of the concrete sample in accordance with T 121.

8.0 PREPARATION OF TEST EQUIPMENT.

8.1 Preconditioning the Water.

- 8.1.1** Prior to opening the test chamber, close all valves except the valve positioned between the test chamber and the hydraulic cylinder. Remove the lid of the test chamber by loosening the wing nut, at the top, thereby releasing the steel cross bar used to secure the lid. Tilt the lid and remove from the chamber by aligning the flat sides of the lid with the flat sides of the test chamber.
- 8.1.2** Completely fill the test chamber with deionized water. Remove the pressure gauge and replace the gauge with a plug capable of withstanding a 30 psi vacuum. Apply teflon tape to the plug, prior to installation. Place the vacuum lid over the top of the test chamber. The application of vacuum grease to the O ring of the vacuum lid may be necessary to prevent leakage.
- 8.1.3** Engage the vacuum by turning on the power and opening the valves connecting the vacuum lid to the vacuum hose and the vacuum hose to the vacuum. The pressure gauge should read at least 25 psi. Apply the vacuum until the air bubbles being pulled to the surface are no longer visible. This step may be done overnight. The vacuum is applied to remove as much air as possible prior to the determination of the initial value.
- 8.1.4** Disengage the vacuum by closing the valves previously opened and turning off the power. The gauge should return to zero. Apply teflon tape to the pressure gage and replace the plug with the pressure gage. Replace the vacuum lid with the test chamber lid; however, do not secure the lid.

8.2 Bleeding the System. The system is bled to remove all entrapped air bubbles that may have developed throughout the workings of the high pressure air meter. This is done by forcing water through the system.

- 8.2.1** Close the valve positioned between the test chamber and the hydraulic cylinder. Open the drainage valve positioned at the bottom of the test chamber. Allow water to freely flow from the drainage hose to ensure no entrapped air. Close the drainage valve and secure the chamber lid by placing cross bar over the top of the lid and tightening the wing nut.
- 8.2.2** Open the valve connected to the graduated cylinder located at the top of the test chamber. Fill the graduated cylinder with water. Open the valve opposite this valve and allow gravity to force water through the test chamber. Do not allow the water to splatter onto the high pressure air meter. Continue until no air bubbles are visible and the height of the

water in the graduated cylinder reads 50 ml or below. Do not allow the water to completely drain. If the water drains return to 8.2.1 and repeat the procedure. Close the valve opposite the valve attached to the graduated cylinder.

- 8.2.3** Open the valve positioned between the test chamber and the hydraulic cylinder. Use the hydraulic pump in the load position to force water through the system. The water will be forced into the graduated cylinder. Continue in the load position until the graduated cylinder is filled. Reverse the hydraulic pump to release position and drain the graduated cylinder. Continue this process until no air bubbles appear in the graduated cylinder. Close the valve attached to the graduated cylinder. The valve positioned between the test chamber and the hydraulic cylinder is required to remain open.

9.0 PROCEDURE.

9.1 Determination of the Initial Value.

- 9.1.1** Place the hydraulic pump in the load position. Apply the load until the pressure in the test chamber is exactly 5000 psi. Record the value read from the dial indicator attached to the hydraulic ram on the form in Appendix A. Release the load very slowly. If the load is released too quickly the well holding the hydraulic fluid will overflow. Bleed the system as identified in 8.2, beginning at 8.2.2.

- 9.1.2** Repeat this process until the difference in subsequent LPM is 0.003 in. or less. This value is considered the INIT, record all readings on the form in Appendix A

9.2 Testing Hardened Concrete Specimen.

- 9.2.1** Remove the lid of the test chamber. Open the drainage valve to release the volume of water approximately equal to the volume of the test specimen. Place the test specimen in the test chamber using forceps. The water in the test chamber should be disturbed as little as possible. This procedure prevents introduction of air into the water within the test chamber. Bleed the system as identified in 8.2 beginning at 8.2.2. Place the lid on the test chamber and secure.

- 9.2.2** Check all valves, except the valve positioned between the test chamber and the hydraulic cylinder, to make certain that they are tightly closed. The valve positioned between the test chamber and the hydraulic cylinder shall remain open. Apply a load until the pressure in the test chamber is exactly 5000 psi.

9.2.3 Immediately record the value read from the dial indicator identifying the LPM. Record the time of the reading and hold the 5000 psi (34,470 kPa) load. The LPM measured by the dial indicator is required to be recorded at 5 minute intervals. This value should only be read when the pressure in the test chamber is at 5000 psi.

9.2.4 The pressure lost due to the compression of air in the test specimen is required to be reapplied within the first 5 minutes of testing. Reapplying pressure at subsequent 5 minute time intervals may be necessary to maintain the 5000 psi load. Maintain the 5000 psi load until the movement of the piston remains the same for 15 minutes. Record this stabilized LPM on the form in Appendix B.

9.2.5 Record the INIT value obtained in 9.1 on the form in Appendix B.

10.0 COMPLETION OF THE TEST PROCEDURE. Open the lid of the test chamber and remove the specimen from the test chamber. If testing is complete, replace water removed from the test chamber and close the lid of the test chamber. If additional testing is required, repeat process beginning with 8.2.

11.0 CALCULATION.

11.1 Calculate the volume of the test specimen as follows:

English

$$\text{Volume, in.}^3 = \frac{\text{SSD, kg}}{0.4535924 \text{ kg/lb}} \times (12 \text{ in./ft})^3$$

11.2 Calculate the hardened air content of the test specimen as follows:

English

$$\text{Hardened Air Content, \%} = \left(\frac{716.29 \times (\text{LPM} - \text{INIT})}{\text{Volume}} \right) + 1.46 - \text{Aggregate Correction}$$

11.3 Calculate the plastic air content of the test specimen as follows:

$$\text{Plastic Air Content, \%} = \frac{\text{Hardened Air Content} - 1.53}{0.9}$$

12.0 REPORT.

12.1 The percent hardened concrete air content is reported to the nearest 0.1%.

12.2 The percent plastic concrete air content is reported to the nearest 0.1%.

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