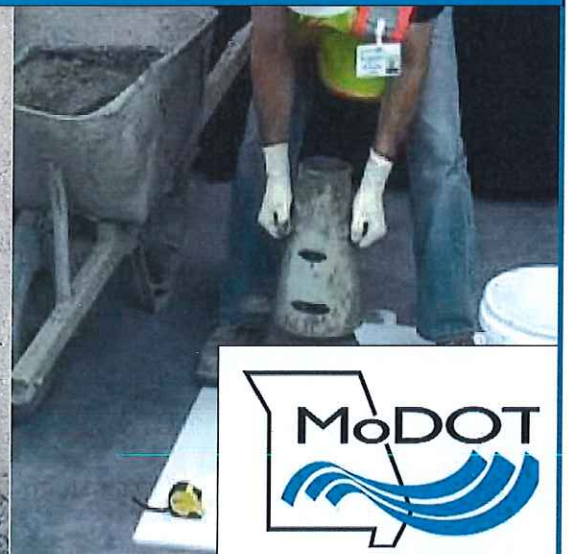


2020 Edition



CONCRETE FIELD



Concrete Field

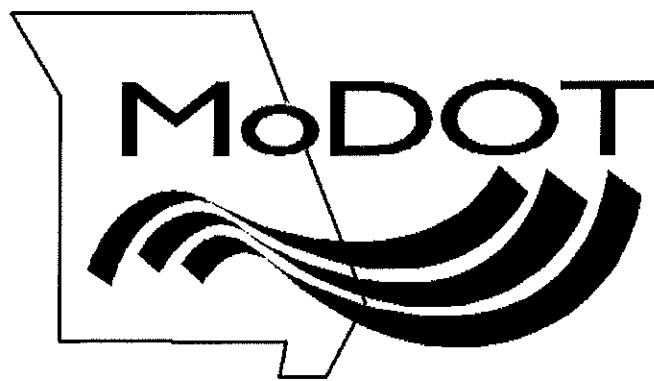
2020 – Updates

- **AUDIT NOTIFICATION SLIDE ADDED TO ALL MANUALS:** To all material testers, who work on Missouri Highways, this includes Consultants, Contractors, City, County, and MoDOT workers; you will be audited by **MoDOT IAS Inspectors** and sometimes **FHWA** personnel.
- **Added Updates page**
- **No Method updates for 2020.**

COURSE CONTENT

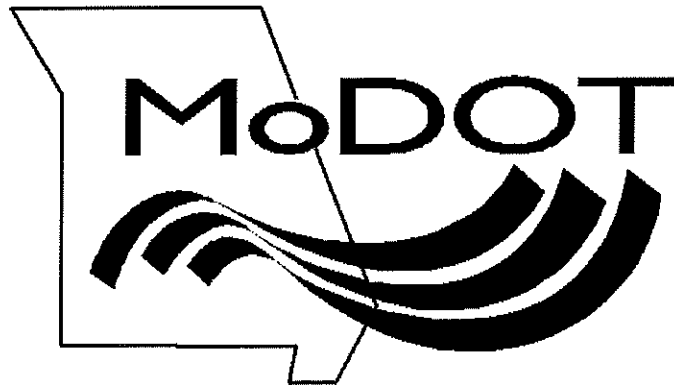
CONCRETE FIELD

MoDOT TM 20	Measurement of Air, Surface or Asphalt Mixture Temperature
AASHTO R 60 ASTM C172	Sampling Freshly Mixed Concrete
ASTM C 1064	Temperature of Freshly-Mixed Hydraulic-Cement Concrete
AASHTO T 119 ASTM C143	Test for Slump of Hydraulic Cement Concrete
AASHTO T 152 ASTM C231	Test for Air Content of Freshly Mixed Concrete by the Pressure Method
AASHTO T 23 ASTM C31	Test for Making and Curing Concrete Test Specimens in the Field
APPENDIX	
GLOSSARY	



MoDOT TM 20

Measurement of Air, Surface, or Asphalt Mixture Temperature



Required Audits

All testers on Federal-Aid Projects (MoDOT or Off-System) are required by the FHWA to be audited at least once per year.

Reasons:

- To ensure proper test procedures are being utilized.
- To ensure testing equipment is calibrated and operating properly.
- **Types of Audits;** procedure or comparison.
- **Be Proactive;** schedule your audit as early as possible with MoDOT Materials in district offices, do NOT wait till the end of the year.
- **Provide Proof;** when audited, present a MoDOT Certification Card, or a MoDOT Letter.

MoDOT TM 20

Measurement of Air, Surface, or Asphalt
Mixture Temperature

2

11/20/2019

WHY IS TEMPERATURE IMPORTANT?

- The temperature is required of many AASHTO specifications in testing of asphalt materials as well as concrete.
- Temperature is used to provide quality assurance and to prevent early pavement deterioration.

3

EQUIPMENT CALIBRATION

- Calibrate thermometers **annually**.
- Calibration of a thermometer will establish a **correction factor** to adjust the thermometer reading to the true temperature.
- Information on how MoDOT owned thermometers are verified may be obtained from the District Materials Staff.
- Thermometers can be sent to the manufacturer on a yearly basis to be verified/calibrated.

4

A Record of calibration/verification that is traceable to
National Institute of Standards and Technology (NIST) Traceable Standards is needed for thermometers.
Keep a copy of this record in the Laboratory's Quality Control Manual.



5

Infrared Thermometer

Surface, Asphalt Mixture
Range: 20° F to 400° F
Increment: 2° F



6

Mercury Thermometer

Air and Surface

Range: 20° F to 130° F

Increment: 2° F

Note: Mercury Thermometers are **rarely** used due to the potential of mercury contamination if broken. Most technicians use digital type thermometers with a metal probe.



7

Digital Thermometers

Air, Surface, Asphalt Mixture

Range: 0°F to 400°F,

Increment: 1°F



8

Max-Min Thermometer

Air, Surface

Range: 20° F to 130° F

Increment: 2° F



9

Spot Check Disc Thermometer

Surface

Range: 32° F to 250° F

Increment: 2° F



BI-Therm Dial Thermometer

Asphalt Mixture

Range: 50° F to 400° F

Increment: 5° F



Armored Thermometer

Asphalt Mixture

Range: 50° F to 400° F

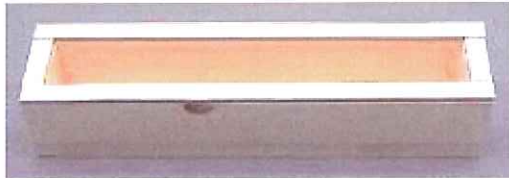
Increment: 5° F



Wooden Box

Surface

See EPG Test Method [TM 20](#) for dimensions.
(included in this manual)



13

PRECAUTIONS

- Do not use BI-Therm Dial thermometer (poker) for surface or air temperature.
- Infrared thermometers are for surface or asphalt mixture temperature only.
- Do not check surface temperature of asphalt immediately after roller has passed.
- Always check surface temperatures on a stationary target.

14

PROCEDURE

Air Temperature

- Thermometers: Mercury, Digital, Max-Min
- Location:
 - Shaded area
(Not exposed to direct sunlight).
 - Safe area
- Position: 4.5 ft. above the surface

15

Surface Temperature

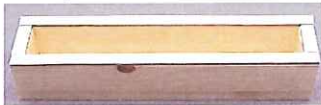
- Infrared Thermometer
 - Follow the manufacturer's recommendations
- Spot Check Disc Thermometer
 - Place on surface
 - Read when needle stops moving

Procedure

16

Surface Temperature (continued)

- Max-Min or Mercury Thermometer
 - Place thermometer on surface
 - Place wooden box over top (open side down covering thermometer)
 - Leave thermometer under box for a minimum of 5 minutes
 - Lift the box enough to read the temperature.



Procedure

17

Asphalt Mixture Temperature

- Digital, Armored or BI-Therm Dial Thermometer
 - Place stem in loose asphalt mixture.
 - Do not disturb until reading has stabilized.
 - Read temperature.



Procedure

18

• **Asphalt Mixture Temperature**
(continued)

- Infrared Thermometer
 - Follow manufacturers instructions.
 - Direct reading of asphalt loose mix located in truck, a receiving hopper, or material at the end of the paver augers.
 - Read temperature.



Procedure

19

DOCUMENTATION

- Read and record the air, surface or asphalt mixture temperature to the accuracy listed below in a bound field book.
 - Air, nearest 2° F
 - Surface, nearest 2° F
 - Asphalt Mixture, nearest 5° F

20

106.3.2.20 TM-20, Measurement of Air, Surface or Bituminous Mixture Temperature

From Engineering Policy Guide

Jump to: [navigation](#), [search](#)

This method describes the equipment and procedures required to determine air temperature, surface temperature of a base or pavement, and bituminous mixture temperature in the loose state.

106.3.2.20.1 Apparatus

Infrared Thermometer. Used for surface and loose bituminous mixture temperature determination. The thermometer should register in the range of 20° F to 400° F, with a maximum increment of 2 °F. Operation of this instrument should be based on the manufacturer's instructions.

Mercury Thermometer. Used for air or surface temperature determination. Typically a straight glass thermometer or a U-shaped glass thermometer in a plastic housing commonly referred to as a MAX-MIN thermometer. The thermometer should register in the range of 20° F to 130° F, with a maximum increment of 2 °F.

Armored Thermometer. Used for loose bituminous mixture temperature determination. The thermometer should register in the range of 50° F to 400° F, with a maximum increment of 5 °F.

Bi-Therm Dial Thermometer. Used for loose bituminous mixture temperature determination. The thermometer should register in the range of 50° F to 400° F, with a maximum increment of 5 °F.

Spot Check Disc Thermometer. Used for surface temperature determination. The thermometer should register in the range of 32° F to 250° F, with a maximum increment of 2 °F.

Digital Thermometer. Used for air surface or bituminous mixture temperature determination. Thermometer will measure temperature in the range of 0° F to 400° F as a minimum with a maximum increment of 1° F. Thermometer will have a remote probe and may have recording capabilities of maximum and minimum temperature reading. Thermometer, when purchased, shall have a record of calibration to NIST Traceable Standards provided.

Wooden Box. Used to cover a mercury thermometer when determining the temperature of a base or pavement. The box will be wooden with a material thickness of not less than 3/8 in. The minimum inside dimensions will be 2 in. tall, 3 in. wide and 14 in. long. The bottom side of the box is to be left open. The bottom edge of the sides and ends shall have attached a strip of foam rubber 3/16 in. thick and the same width as the thickness of the side and end boards. The outside of the box shall be painted with aluminum paint. See Fig. 106.3.2.1.20, below, for a pictorial description.

Calibration of Thermometers. Thermometers shall be calibrated **annually** against a known standard.

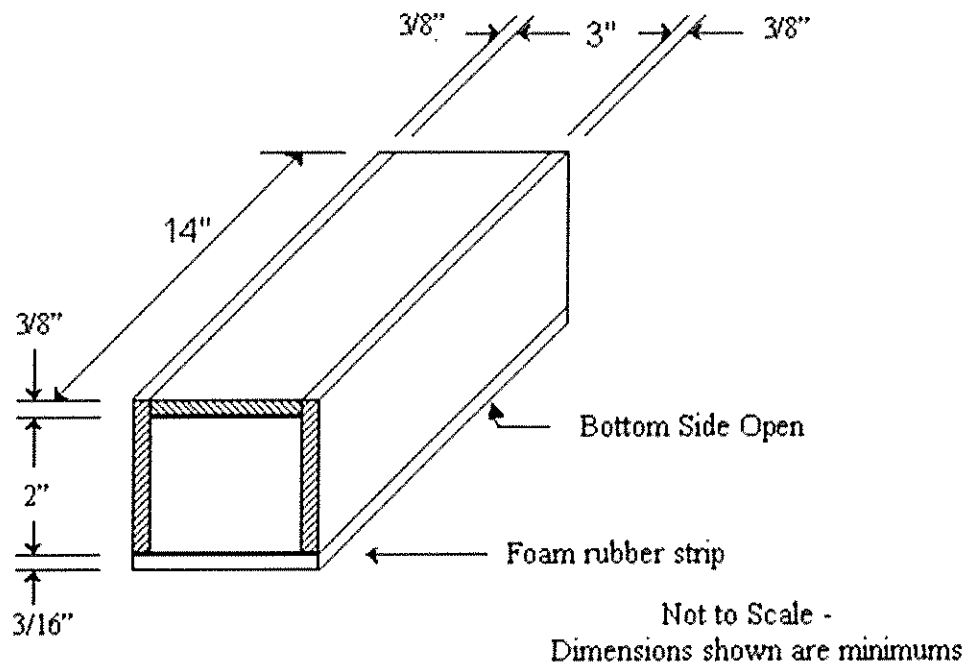


Fig. 106.3.2.1.20

106.3.2.20.2 Procedure

Air Temperature. The mercury thermometer or digital thermometer probe shall be positioned in a shaded area and shall not be exposed to direct sunlight. The thermometer shall be 4.5 ft. above surface level, measured from the surface to the bulb of the thermometer. Care should be taken to ensure no artificial heating or cooling occurs near the thermometer. The thermometer will be left in this location until the reading stabilizes. Air temperature shall be recorded to the nearest 2 °F.

Surface Temperature, mercury thermometer. The thermometer cannot be disturbed for at least 5 minutes while conducting this test, so select a location where this criteria can be met. Place the thermometer on the test surface and place the wooden box firmly over the thermometer ensuring the foam rubber strips are in contact with the test surface. The box should remain over the thermometer for a minimum of five minutes. After the 5 minutes, tip the box on edge only far enough to read the thermometer. The surface temperature shall be recorded to the nearest 2 °F.

Surface Temperature, infrared thermometer. When using an infrared thermometer, follow the manufacturer's recommended procedure. When obtaining the temperature of a surface, make sure air currents do not affect the reading. The surface temperature shall be recorded to the nearest 2 °F.

Surface Temperature, spot check disc thermometer. Place the thermometer on the surface and wait until the needle stops moving. Read the temperature. The surface temperature should be recorded to the nearest 2 °F.

Surface Temperature, digital thermometer. The thermometer probe cannot be disturbed for at least 5 minutes while conducting this test, so select a location where this criteria can be met. Place the thermometer probe on the test surface and place the wooden box firmly over the thermometer probe ensuring the foam rubber strips are in contact with the test surface. The box should remain over the thermometer probe for a minimum of five minutes. After the 5 minutes, read display of thermometer. The surface temperature shall be recorded to the nearest 2 °F.

Bituminous Mixture Temperature, armored or Bi-Therm Dial - The thermometer shall have the stem of the thermometer embedded in the loose bituminous mixture. The thermometer should not be disturbed until the thermometer reading has stabilized. When the thermometer has stabilized, read the thermometer. The bituminous mixture temperature shall be recorded to the nearest 5 °F. A digital thermometer that has a range capable of measuring the bituminous mixture temperature and a probe that can withstand the mixture temperature can be used in lieu of an armored or bi-therm dial thermometer.

Bituminous Mixture Temperature, infrared - The thermometer shall be used as recommended by the manufacturer. The location for determining the temperature of the loose bituminous material shall be either in the delivery truck bed, the receiving hopper of the paver or MTV, or at the material head at the end of the paver augers prior to entering the paver screed. The bituminous mixture temperature shall be recorded to the nearest 5 °F.

MoDOT TM 20: Measurement of Air, Surface and Asphalt Mixture Temperature PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial #	1	2
Certificates or Report of Verification of Accuracy (Annual calibration) available?		
AIR		
1. Pick correct thermometer		
2. Location <ul style="list-style-type: none"> - <i>Mercury, Digital, Max-Min thermometers</i> - shade, no direct sunlight - position 4.5 feet above surface - safe location 		
3. Document to nearest 2° F		
SURFACE		
4. Pick correct thermometer		
5. Procedure <ul style="list-style-type: none"> - <i>Spot Check Disc</i>; place on surface until needle stops moving - <i>Infrared</i>; follow manufacturer recommendations - <i>Mercury or Max-Min</i>; place under wooden box wait 5 minutes - <i>Digital</i> ; follow manufacturer recommendations 		
6. Document to nearest 2° F		
ASPHALT MIXTURE		
7. Pick correct thermometer		
8. Procedure <ul style="list-style-type: none"> - <i>Infrared</i>; follow manufacturer recommendations - <i>Armored , BI-Therm Dial, or Digital</i>; place stem into mixture and wait until thermometer reading has stabilized 		
9. Document to nearest 5° F		

PASS PASS

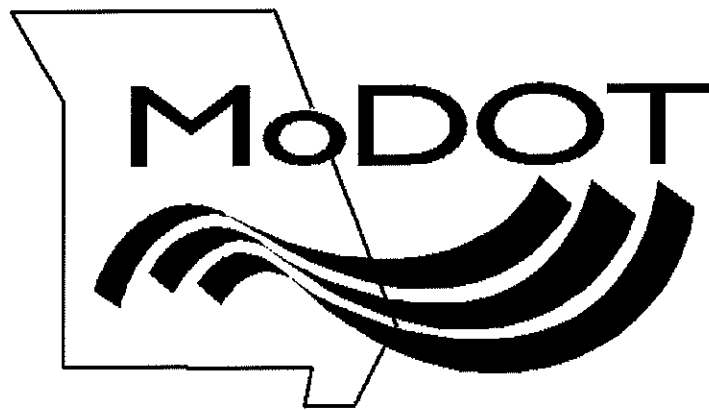
FAIL FAIL

Examiner: _____ Date: _____

AASHTO R60

ASTM C172

Sampling of Freshly Mixed Concrete



AASHTO R 60

Sampling Freshly Mixed Concrete



Rev 01/06/2020

SCOPE

- This method covers the procedures for obtaining representative samples of fresh concrete as delivered to the project site and which tests are to be performed to determine compliance with quality requirements of the specifications under which the concrete is furnished.
- This method includes sampling from stationary, paving, and truck mixers and from agitating and non-agitating equipment used to transport central mixed concrete.

2

TERMINOLOGY

- Composite Sample - A sample which is made by combining samples from two or more locations/parts.

3

SIGNIFICANCE AND USE

- This practice is intended to provide standard requirements and procedures for sampling freshly mixed concrete from different containers used in the production or transportation of concrete.



4

- The detailed requirements as to materials mixtures, air content, temperature, number of specimens, slump, Interpretation of results, precision and bias are described in specific test methods.

5

Significance and Use

Fresh concrete will be sampled from one of the mixers listed below;

- *Stationary Mixers, Except Paving Mixers*
- *Paving Mixers*
- *Revolving Drum Truck Mixers or Agitators*

6

MoDOT – Sampling Note

- EPG = Engineering Policy Guide
- EPG, section **501.4 Sampling** – Sampling of fresh concrete will be in accordance with AASHTO R60, except for central or truck mixed concrete.
- This will be discussed after AASHTO R60.

7

EQUIPMENT

- Square nose shovel
- Scoop
- Testing equipment
- Sample container
- Tags, molds
- Safety equipment – Personal Protective Equipment (PPE)



8

Six things to take care of before sampling begins...



9

1. Check ticket information on the load when the truck arrives on the job site.

Take note of the following...

- Name of concrete plant
- Serial number of ticket
- Truck number when a truck mixer is utilized
- Name of Contractor
- Job Number, route and county designation
- Specific class of concrete
- Quantity of concrete in cubic yards
- Date and time when batch was loaded or of first mixing of cement and aggregate
- Number of revolutions when truck mixed

Before Sampling

10

2. Communicate with the contractor to coordinate sampling and to talk about SAFETY.



Before Sampling

11

3. Set-up a testing area close to the site of sampling, with all testing equipment ready.



Before Sampling

12

4. Wait until all additives and water have been added and mixed into the load.

5. Wait a minimum of 30 revolutions, after final change to mix, to make sure all is mixed well.. (MoDOT)

6. Discharge approximately 1 cubic yard before sampling. (MoDOT)

NOTES:

- Do not obtain the sample from the very first or last part of the batch discharge.
- Collect enough fresh concrete to complete all tests.

Before Sampling

13

SAMPLING



14

- Sample the concrete by passing the sample container through the entire concrete stream or move the shoot into the container.



15

AASHTO Sampling

- The elapsed time shall not exceed **15min** between obtaining the first and final portions of obtaining the composite sample.



AASHTO Sampling

16

- Transport the samples to the place that was set-up earlier for testing fresh concrete and molding specimens.



AASHTO Sampling

17



- The concrete sample portions shall be mixed with a shovel just enough to ensure uniformity.



AASHTO Sampling

18

- Protect the sample from the **sun**, **wind**, **moisture**, and other sources of rapid evaporation and from contamination.

AASHTO Sampling

19

- After mixing with a shovel, start tests for slump, temperature, and air content within **5 minutes**.
- **Complete these tests quickly!**



TESTING: SLUMP, TEMP, AIR

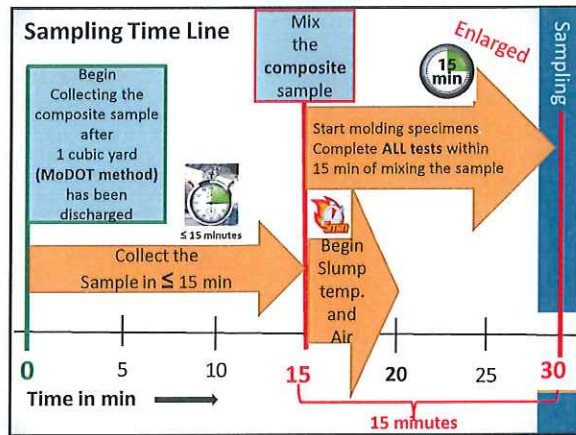
20

- Start molding specimens for strength tests (cylinders and beams).
- Complete all required tests within **15 min** after fabricating the composite sample.




MOLDING SPECIMENS

21



PROCEDURE

- **Size of Sample** – The sample to be used for strength tests, will need at least a minimum of 1 cubic foot. (1ft³).
- **MODOT:** Sample enough to do all tests.
- **Exception:** Smaller samples could be used if air content and slump tests are the only tests.

23

MIXERS

- **Stationary Mixers** (Except Paving Mixers)
- **Paving Mixers**
- **Revolving Drum Truck Mixers or Agitators**

24

STATIONARY MIXERS



25

Sampling from Stationary Mixers (Except Paving Mixers)

- Obtain two or more portions taken at regularly spaced intervals during discharge of the middle of the batch.
- Obtain these portions within the time limit of 15 min.
- Combine the portions into the composite sample for testing purposes.

Stationary Mixers

26

- Perform sampling by passing a receptacle completely through the discharge stream or by completely diverting the discharge into a sample container.
- If the discharge of the concrete is too rapid to divert the complete discharge stream, discharge the concrete into a container or transportation unit sufficiently large to accommodate the entire batch and then accomplish the sampling.

Stationary Mixers

27

- Take care not to restrict the flow of concrete from the mixer, container, or transportation unit so as to cause segregation.
- These requirements apply to both tilting and non-tilting mixers.

28

- **NOTE:** No sample should be taken before 10 percent or after 90 percent of the batch has been discharged. Due to the difficulty of determining the actual quantity of concrete discharged, the intent is to provide samples that are representative of widely separated portions but not the beginning or end of the load.

29

PAVING MIXERS



30

- For Central Mixed concrete delivered to a paving operation:
- Sample the concrete after the contents of the paving mixer have been discharged.
- Obtain samples from at least **FIVE** different locations of the pile after the concrete is on the sub-grade and then combine them into one sample for test purposes.

Paving Mixers

31

- Avoid contamination with subgrade material. To preclude contamination or absorption by the subgrade:
- Sample the concrete by placing three shallow containers on the subgrade and discharging concrete across the containers.

Paving Mixers

32

- Combine the samples into one sample for test purposes.
- Mix your sample with a **square nose** shovel to insure uniformity and eliminate segregation.
- The containers shall be of a size sufficient to provide a composite sample size that is in agreement with the maximum aggregate size.

Paving Mixers

33

REVOLVING DRUM TRUCK MIXERS or AGITATORS



34

- Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch.
- Take the samples obtained within the time limit specified and combine them into one sample for test purposes.

Revolving Drum Truck Mixers

35

- Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container.

Regulate the rate of discharge of the batch by the rate of revolution of the drum, **not** by the size of the gate opening.



Revolving Drum Truck Mixers

36

WET – SIEVING CONCRETE

(Only when necessary)

- When the concrete contains aggregate larger than the appropriate size for the molds or equipment to be used, Wet-Sieve the sample.

37

Additional Procedure for Large, Maximum-Size Aggregate Concrete

- If the sample consists of large maximum-sized aggregate, perform this procedure before running tests.
- **Exception:** Perform density (unit weight) tests for use in yield computations on the full mix.

38

Wet-Sieving Concrete

- **Equipment** for wet-sieving concrete shall be a sieve of suitable size and conveniently arranged and supported so that one can shake it rapidly by either hand or mechanical means. Generally, a horizontal back-and-forth motion is preferred.
- **Receptacle;** a container of suitable size having a nonabsorbent surface.

39

Wet-Sieving Concrete

Wet-Sieving Video



Wet-Sieving Concrete

40

• **How to Perform Wet –Sieving:**

- After sampling the concrete and before remixing, pass the concrete over the designated sieve.
- Shake or vibrate the sieve by hand or mechanical means until no undersize material remains on the sieve.
- Remove and discard the aggregate retained.

NOTE: Do not wipe off the mortar on the retained aggregate.

Wet-Sieving Concrete

41

- Place only enough concrete on the sieve at any one time so that, after sieving, the thickness of the layer of retained aggregate is not more than one particle thick.
- The concrete that passes the sieve shall fall into a batch pan of suitable size that has been dampened before use or onto a clean, moist, nonabsorbent surface.

Wet-Sieving Concrete


42

Wet-Sieving Concrete

- Scrape any mortar adhering to the sides of the wet-sieving equipment into the batch.
- After removing the larger aggregate particles by wet-sieving, remix the batch with a shovel in the minimum amount necessary to ensure uniformity and proceed testing immediately.

43

**MoDOT Sampling
Category 501 - Concrete
Engineering Policy Guide**



44

MoDOT - Collection for Truck Mixed or Truck Delivered – Concrete Sampling

- EPG, section 501.4 ***Fresh Concrete Sampling*** – Sampling of fresh concrete shall be in accordance with AASHTO R60, except for central or truck mixed concrete.
- For central or truck mixed concrete the entire sample for temperature, slump, air-content and for molding compressive strength specimens may be taken at one time after all additives and water have been mixed and approximately one cubic yard of concrete has been discharged.

45

MoDOT - Collection for Truck Mixed or Truck Delivered – Concrete Sampling

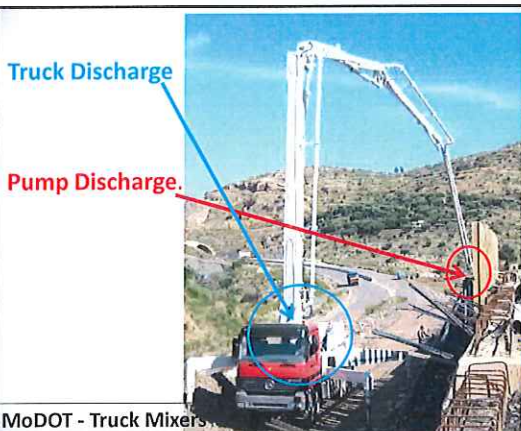
- Each time water or any admixture is added, the drum shall be turned an additional 30 revolutions, minimum, to mix water into concrete (Standard Specification Section 501.8.6)
- Move the concrete chute so concrete flows into your sample container or passes your sample catcher completely through the stream of concrete.

46

- When a **Concrete Pump Truck** is being used
 - The designated location to obtain your concrete sample is at the point of truck discharge for quality control (see EPG section 501.1.3, section 501.4).
 - Slump and Air Content will be checked when a pump is first used and periodically, at the truck discharge as well as the pump discharge to compare properties.

47

MoDOT – Pump Truck



48

MoDOT – Pump Truck

Common Errors

- Sample taken before water is added and all mixing is completed.
- Letting sample set too long before testing.
- Sample contains mud, debris, base rock, unmixed materials.
- Unclean equipment.
- Not periodically checking the difference in properties between the truck discharge and the pump discharge.

49

Sampling Time Line

Begin
Collecting the
composite sample
after
1 cubic yard
(MoDOT method)
has been
discharged



≤ 15 minutes

Collect the
Sample in ≤ 15 min

Mix
the
composite
sample

Enlarged



Start molding specimens.
Complete ALL tests within
15 min of mixing the sample



Begin
Slump
temp.
and
Air

0

5

10

15

20

25

30

Time in min →

Sampling

15 minutes

Category: 501 Concrete – Engineering Policy Guide

501.1.3 Sampling (Sec 501.4 Standard Specifications)

Sampling of fresh concrete by these instructions will meet the requirements of Section 501.4 of the Standard Specifications. Each sample should be large enough to permit completion of all necessary tests. Methods described should be tempered with judgment to assure that samples are as nearly as possible representative of the true nature and condition of the concrete sampled. For safety reasons, sampling should always be coordinated through contractor personnel.

501.1.3.1 Pumping Concrete

There has been discussion about the proper place to sample concrete when it is being pumped. The following guidelines will assure uniformity of contract enforcement statewide.

Ordinarily the most representative sample will be taken at the point of final discharge. For safety reasons, however, it is not always practical to do so. When concrete is being pumped our procedure has been to take samples at the truck chute. Usually there is no significant difference unless a new or reconditioned pump is being used, the concrete is being pumped a long distance or if there are high vertical drops in the line.

The first load should be checked at both points. The difference between the truck and the pump should be checked regularly, especially if there are significant changes in drop or distance, and certainly if a different pump is used.

Consider the change in air content when determining specification compliance. If you find that the air drops by 0.3%, subtract that from the reading at the truck. If you are on the low side at the truck the air should be adjusted accordingly. The correction factor from loss through pumping would also apply to the slump. The reported slump and air content should be what is at the point of placement.

The concrete truck boom shall be configured to minimize the free fall of concrete of the point of discharge. This is to minimize segregation, and loss of air and slump.

501.1.3.2 Sampling from Stationary Mixers Except Paving Mixers

The sample is to be obtained by passing a receptacle completely through the discharge stream of the mixer at about the middle of the batch, or by diverting the stream completely so that it discharges into a container. Do not restrict flow from the mixer in a way that can cause concrete to segregate. This method should be used for both tilting and non-tilting mixers.

501.1.3.3 Sampling Central or Truck Mixed Concrete

The entire sample for slump and air tests and for molding compressive strength specimens may be taken at one time, after approximately one cubic yard of concrete has been discharged. The sample shall be taken from at least 5 different parts of the pile. Acceptability of concrete for slump and air content and, when applicable, for strength requirements, will be determined by tests on these samples.

Category: 501 Concrete – Engineering Policy Guide

501.1.3.4 Protection of sample

After the sample has been obtained, it must be protected from direct sunlight and wind until it is used, which must not be more than 15 minutes after sampling. When the sample has been moved to the place where the test is to be made or specimens are to be molded it should be mixed with a shovel if necessary to assure uniformity of the mixed sample.

501.1.3.5 Compressive Strength

Compressive tests are performed both in the field and in the laboratory on cylindrical specimens of concrete, 6 in. diameter and 12 in. tall (6x12) or 4 in. diameter and 8 in. tall (4x8). The Standard Specifications require use of compressive specimens for job control of concrete production.

All concrete for air and slump tests as well as preparation of the specimens should be secured from a single batch of concrete. Air and slump tests should always be made on samples of concrete used for preparation of compressive specimens.

Cylinder forms shall be filled with fresh concrete in accordance with the instructions provided by AASHTO T 23 (ASTM C 31). Care should be taken when placing the caps on the molds to avoid damage to the surface of the concrete. The lids should be kept on tight to prevent moisture loss.

501.1.3.5.1 Curing

Curing of compressive specimens will depend on whether they are for standard cure or field cure.

Standard Cure is defined as 1) specified strength for 28-day testing; 2) Check of mixture proportions or design strength; 3) Quality control (i.e. monitoring mix variability) or 4) Maturity meter curve.

Standard curing involves two phases of curing: initial and final.

Each set of compressive test specimens for standard cure consists of two 6x12 cylinders or three 4x8 cylinders. Standard Cure specimens shall be cured in accordance with AASHTO T23 (ASTM C31) for initial and final curing.

Standard Cure – Initial

If specimens cannot be molded at the place where they will receive initial curing, immediately after finishing move the specimens to an initial curing place for storage. Recommended method for initial curing is keeping the specimen in the plastic mold covered with a plastic lid or place in a damp sand pit for a maximum of 48 hours in a temperature range from 60° F to 80° F and an environment preventing moisture loss.

AASHTO R 60 Sampling Freshly Mixed Concrete PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial#	1	2
1. Checked for required equipment: Square nose shovel, scoop, sample container, testing equipment for Slump, Air-Content, Temperature, & Strength tests, safety equipment, PPE, tags, molds.		
2. Collected ticket information on the load, name of concrete plant, serial #, etc.		
3. Coordinated with the contractor about the operation of collecting samples and safety purposes		
4. Set-up a testing area with all testing equipment		
5. Waited until all additives and water were added and mixed into the load		
6. Collected the fresh sample(s) within 15 minutes from one of the following sources: -Truck Mixed- Revolving Drum per MoDOT Method *Discharged a minimum of 1 cubic yard *Passed a receptacle completely through the discharge stream or by diverting the discharge chute into a sample container *Collected enough fresh concrete to do all tests *Did not restrict the flow of concrete -Stationary Mixers *Sampled at the middle of the batch *Obtained 2 or more portions at regular spaced intervals (combined to make composite sample) *Did not restrict flow *Collected enough fresh concrete to do all tests -Paving Mixers at a paving operation *After the contents of the mixer have been discharged *Obtained samples from at least 5 locations (combined to make composite sample) *Collected enough fresh concrete to do all tests *Avoided contamination from subgrade		
7. Performed Wet-Sieving as needed (Except for concrete used for unit weight)		
8. Transported the composite sample to the testing area and remixed with a square nose shovel		
9. Within 5 minutes of mixing the composite sample started tests for Temperature, Air-Content, and Slump		
10. Started molding specimens for strength tests and completed all tests within 15 minutes of mixing the composite sample.		

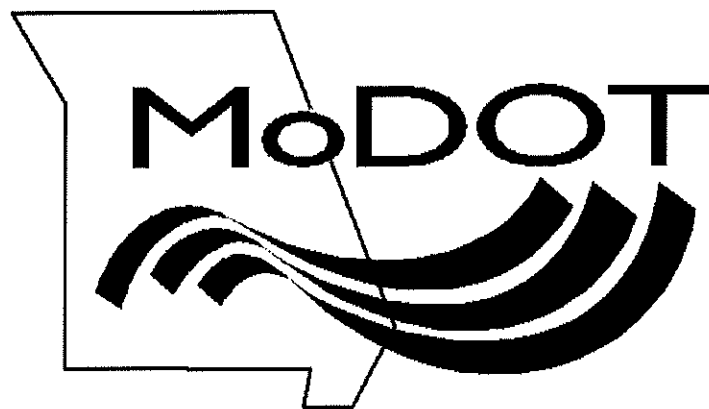
PASS PASS

FAIL FAIL

Examiner: _____ Date: _____

ASTM C 1064

Temperature of Freshly-Mixed Hydraulic-Cement Concrete



ASTM C 1064

Temperature of Freshly Mixed Hydraulic-Cement Concrete



Rev 01/06/2020

SCOPE

- This test method covers the determination of temperature of freshly mixed hydraulic-cement concrete.

2

TERMINOLOGY

- **NIST** - **National Institute of Standards and Technology**, is a laboratory, of the United States Department of Commerce.
- **Thermometer** – For this method; refers to any of the devices listed below that are used to measure the temperature of concrete. (Unless the method calls for a specific type of thermometer).
 - Liquid-in-Glass Thermometer (mercury, alcohol, etc.)
 - Electronic Thermometer with probe
 - Dial Thermometer

See the glossary for more definitions.

3

SIGNIFICANCE AND USE

- This test method provides a means for measuring the temperature of freshly mixed concrete. The measured temperature represents the temperature at the time of testing and may not be an indication of the temperature of the freshly mixed concrete at a later time. It may be used to verify conformance to a specified requirement for temperature of concrete.

4

- Concrete containing aggregate of a nominal maximum size greater than **3 inches**, may require up to **20 min.** for the transfer of heat from aggregate to mortar.

Significance and Use

5

EQUIPMENT

- **Container**
 - Will be large enough to provide at least **3"** of concrete in all directions around the sensor of the thermometer; concrete cover must also be at least **three** times the nominal maximum size of the coarse aggregate.
 - **Container examples:** 6" cylinder mold, wheelbarrow, forms, drop bucket, non-mixing transport vehicle etc.
 - **Do not** check temperature inside of a mixer truck, for safety concerns

6

Container: 6" Cylinder Mold



- A cylinder mold that is 6" in diameter is acceptable for the required 3" coverage around the bulb of the thermometer as long as the thermometer bulb is in the center.

Equipment

7

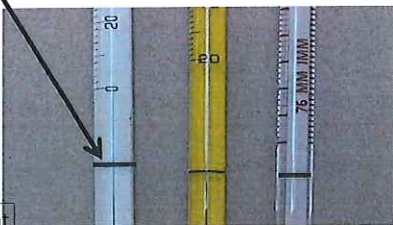
• Thermometer

- Capable of accurately measuring the temperature of the freshly mixed concrete to $\pm 1^\circ\text{F}$ ($\pm 0.5^\circ\text{C}$) throughout a range of 30° to 120°F (0° to 50°C).
- Allows 3" or more immersion during operation.
- Verified annually, or whenever there is a question of accuracy.

Equipment

8

- **Partial immersion liquid-in-glass thermometers:** (and possibly other types) shall have a **permanent mark** to which the device must be immersed without applying a correction factor.



Equipment

9

Reference Thermometers; These thermometers are mainly used for verifying other thermometers, and are NIST traceable. Keep all certificates in the lab for viewing.



Verification of the Accuracy of Thermometers

Thermometers used in testing Concrete must be verified against an NIST traceable Reference Thermometer **every year** or whenever there is a question of accuracy.

Equipment



- A company may send the thermometers off to another company to be verified.

OR

- A company may verify the thermometers in house, **see appendix** for more information on verifying the accuracy of thermometers.

- **MoDOT personnel:** Check with your supervisor for information on verifying thermometers.

Equipment

12

SAMPLING

- It is acceptable to measure the temperature of freshly mixed concrete in either the transporting equipment or the forms after discharge provided the sensor of the temperature measuring device has at least 3" of concrete cover in all directions.
- If the transporting equipment or placement forms are not used as the container, a sample shall be prepared as follows:

13

- Immediately, prior to sampling the freshly mixed concrete, dampen the container with water.
- Sample the freshly mixed concrete in accordance with ASSHTO R 60, with the composite samples are not required if the only purpose for obtaining the sample is to determine temperature.
- Place the freshly mixed concrete into the container.

Sampling Concrete

14

PROCEDURE

- Position the thermometer so that the end of the temperature sensing portion is submerged a minimum of 3" into the freshly mixed concrete.
- Close the void around the thermometer by gently pressing the concrete against the thermometer at the surface of the concrete to prevent ambient air temperature from affecting the reading.

15

TESTING - Temperature of Concrete



Procedure

16

- Leave the temperature measuring device in the freshly mixed concrete from **2 to 5 min.**
- Read and record the temperature to the nearest **1°F (0.5°C).**

NOTE: Do not remove the device from the concrete when reading the temperature.

Procedure

17

REPORT

- Report the measured temperature of the freshly mixed concrete to the nearest **1°F (0.5°C).**

18

occasionally necessary to loosen the insulation to balance the temperature rise.

3. In severely cold weather, to prevent the conduction of cold by the protruding reinforcing steel, it may be necessary to provide supplemental heat at critical points.

4. Care should be taken to check the temperature periodically at critical points until the concrete has reached its required strength.

703.2.11 Hot Weather Concreting

Placement of superstructure concrete shall not be done when the ambient temperature is above 85°F.

The internal temperature of the concrete shall not be greater than 85°F at the time of placement in the forms, regardless of ambient temperature.

Procedures For Checking Surface And Ambient Temperatures - MoDOT Test Method TM-20
Measurement of Air, Surface or Bituminous Mixture Temperature describes the methods for checking surface temperatures and air temperatures in the immediate vicinity of the work.

703.2.12 Checklist

The following checklist is provided as a guide to the inspector during the sequence of operations associated with a deck pour.

Checklist For Pouring Bridge Slab

Prior to Pour

Concrete

Where is it to be obtained?

Has batching equipment been checked?

Have truck mixers been checked?

How many yards are in the pour?

Does the contractor have sufficient quantities of inspected-air-entraining agent, cement, sand, stone and water?

Has moisture test been run?

Who is the plant inspector?

Read the specifications on this phase of the work?

Is plant inspector familiar with the plant?

Falsework and Forms

Do we have falsework drawings?

Did the contractor follow these drawings?

Has splicing and blocking been kept to a minimum?

Is the falsework on sound footing?

Was acceptable form lumber used?

Will form ties break behind concrete surface?

Are all forms nailed down?

Do the forms fit tight?

Was a mill cut molding used for bevels?

Have the forms been oiled?

Is there an excess of oil on forms?

Is a method of checking settlement provided?

Has line and grade of forms been checked?

Are all jacks tight and secured?

Read specifications for all material and equipment requirements.

**ASTM C 1064 Temperature of Freshly Mixed
Hydraulic-Cement Concrete
PROFICIENCY CHECKLIST**

Applicant: _____

Employer: _____

	Trial#	1	2
1.	Thermometer verified annually		
2.	Sensing portion of thermometer submerged a minimum of 3 inches into concrete		
3.	Concrete gently pressed around thermometer at surface of concrete		
4.	Thermometer left in concrete for at least 2 minutes but not more than 5 minutes		
5.	Read and reported the temperature to the nearest 1°F (0.5°C)		

PASS PASS

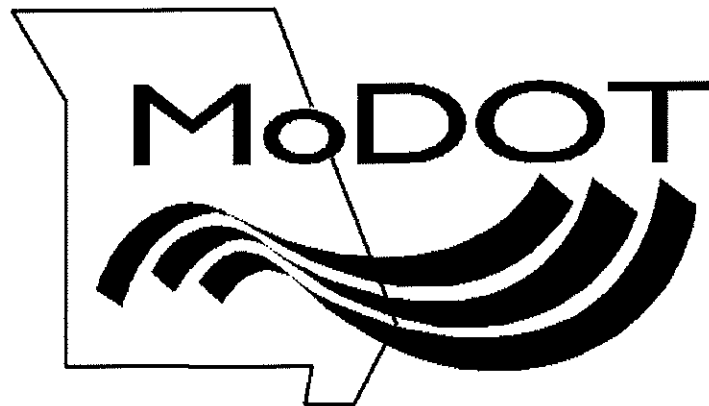
FAIL FAIL

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AASHTO T 119

ASTM C143

Test for Slump of Hydraulic Cement Concrete



AASHTO T 119

Test for Slump Of Hydraulic Cement Concrete



Rev 01/06/2020

SCOPE

- This test method covers determination of slump of concrete, both in the laboratory and in the field.
- **NOTE:** Concretes having slumps less than 0.5 inches may not be adequately plastic and concretes having slumps greater than about 9 inches may not be adequately cohesive for this test to have significance.

2

SUMMARY

- A sample of freshly mixed concrete is placed and compacted by rodding in a mold in the shape of a cone in 3 layers, each approximately $\frac{1}{3}$ of the volume of the mold.
- The mold is raised and the concrete allowed to subside.
- The vertical distance between the original and the displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete.

3

SIGNIFICANCE AND USE

- This test method is intended to provide the user with a procedure to determine the slump of plastic hydraulic cement concretes.
- This test method is considered applicable to plastic concrete having coarse aggregate passing the 1½ (37.5mm) inch sieve.
- If the plastic concrete includes aggregate larger than 1½ inch (37.5mm), the larger aggregate particles are to be removed using **wet-sieving** as explained in R60.

4

- This test method is not considered applicable to non-plastic and non-cohesive concrete.



Zero Slump
Potentially
non-plastic



Collapsed Slump
Potentially
non-cohesive



Significance and Use

5

EQUIPMENT

Mold – "Slump Cone"

- #16 gage metal
- Top diameter of 4±1/8"
- Bottom diameter of 8±1/8"
- Height of 12±1/8"
- Foot pieces & Handles
- Clamps to nonabsorbent base plate
- Large enough to contain all of the slumped concrete



NOTE: Information on Cone molds made from material other than metal see AASHTO T119, Section 5.

6

<ul style="list-style-type: none"> • Tamping Rod – <ul style="list-style-type: none"> – straight steel rod – circular x-section – $\frac{5}{8} \pm \frac{1}{16}$" diameter – 24 ± 4" in length – one end shall be rounded to a Hemispherical shape $\frac{5}{8}$" in diameter. 	<ul style="list-style-type: none"> • Measuring Device– <ul style="list-style-type: none"> – Rigid Ruler – Metal roll-up tape – Marked in $\frac{1}{4}$" increments • Scoop– <ul style="list-style-type: none"> – Large enough to obtain a sample but small enough not to spill during testing. • Base Plate– <ul style="list-style-type: none"> – Flat, level, rigid, and nonabsorbent
Equipment	7

<p style="text-align: center;"><u>SAMPLE</u></p> <ul style="list-style-type: none"> • Obtain a representative sample of cement concrete according to AASHTO R60. <p>NOTE:</p> <ul style="list-style-type: none"> • Particles larger than 37.5mm (1½ in.), remove according to Section 6 of AASHTO R60. • Slump testing shall begin within 5 minutes of obtaining the sample. 	8
---	---

<p style="text-align: center;"><u>PROCEDURE</u></p> <ul style="list-style-type: none"> • MoDOT: Concrete slump is to be determined prior to each air-entrainment test taken, and as necessary to maintain proper control of the concrete consistency. See EPG sec 501. • Dampen the inside of the mold and place it on a dampened, rigid, nonabsorbent surface that is level and firm. <p>NOTE: <u>During the test prevent movement of the cone until the lift is performed.</u></p>	9
---	---

Hold the mold firmly in place during filling and perimeter cleaning by standing on the two foot pieces or by clamping the foot pieces to a base plate.



Procedure

Stand on it

10

- **(1st Layer)** Using the scoop, fill the mold **one-third full** by volume, to a depth of approximately **2.75 in. (70mm)**.
- Consolidate the layer with **25 strokes** of the tamping rod, using the rounded end, being careful to completely remove rod from concrete between strokes.
- Distribute the strokes evenly over the entire cross section of the concrete.
- For the bottom layer, incline the rod slightly and make approximately half the strokes near the perimeter, then progress with vertical strokes, spiraling toward the center.

Equipment

11

- **(2nd Layer)** Use the scoop to fill the mold **two-thirds full** by volume, to a depth of approximately **6.5 in. (160mm)**.
- Consolidate this layer with **25 strokes** of the tamping rod; penetrate approximately **1 inch** into the bottom layer.
- Distribute the strokes evenly.

Procedure

12

(3rd Layer) Fill the mold to overflowing. Consolidate this layer with **25 strokes** of the tamping rod; penetrate approximately **1 inch** into the 2nd layer. Distribute the strokes evenly.

If the concrete falls below the top of the mold, stop, add more concrete, and continue rodding for a total of 25 strokes.

Keep an excess of concrete above the top of the mold at all times.

Distribute the strokes evenly.

Procedure



- After the top layer has been rodded, strike off the top using a screeding and rolling motion of the tamping rod.



Procedure

14

- Clean around the base of the mold; carefully raise the mold vertically 12 inches in **5 ± 2 seconds** by a steady upward lift with no lateral or twisting motion.

- Complete the test from filling to mold removal in **≤ 2 ½ minutes**.



Procedure

15

- Immediately turn the mold upside down next to the specimen.
- Place the tamping rod across the mold so that it is over the test specimen.
- Measure the distance between the bottom of the rod and the **displaced original center** of the top of the specimen to the nearest $\frac{1}{4}$ " (5mm).



Note: Do Not reuse the tested specimen for project related materials.

Procedure

16

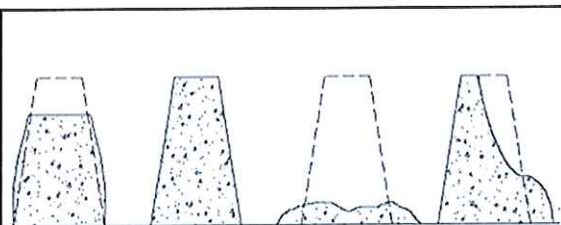
- If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample.

NOTE: If two consecutive tests on a sample of concrete show a falling away or shearing off, the concrete probably lacks necessary plasticity and cohesiveness for the slump test to be applicable.



Procedure

17



True Slump	Zero Slump	Collapsed Slump	Shear Slump
	potentially non-plastic	potentially non-cohesive	no displaced center potentially non-cohesive

Types of Slump

Procedure

18

Enlarged



This concrete is a bit too stiff it will be difficult to pour and vibrate properly, raising the risk of voids.

ZERO-SLUMP



This concrete has about a 3.5 inch Slump. It's wet enough to be poured and vibrated properly yet dry enough that, as it cures, it will reach maximum strength.

TRUE-SLUMP



Excessive slump means the concrete has too much water. It's likely to shrink excessively and crack. It will be significantly weaker than properly hydrated concrete.

COLAPSED-SLUMP

Procedure
19

REPORT

- Record the slump in terms of inches to the **nearest 1/4 inch** (5mm) of subsidence of the off set center of the specimen during the test.
- See MoDOT EPG sec 501 for additional information.

20

What's Wrong with these tests?

Not a good test!



21







GREAT JOB TESTING SLUMP!



25

Enlarged



This concrete is a bit too stiff it will be difficult to pour and vibrate properly, raising the risk of voids.

ZERO-SLUMP



This concrete has about a 3.5 inch Slump. It's wet enough to be poured and vibrated properly yet dry enough that, as it cures, it will reach maximum strength.

TRUE-SLUMP



Excessive slump means the concrete has too much water. It's likely to shrink excessively and crack. It will be significantly weaker than properly hydrated concrete.

COLAPSED-SLUMP

501.1.4 Consistency (Sec 501.5)

Consistency (slump) of concrete should be determined each time an air-entrainment test is made. Other tests for consistency of concrete should be made as necessary to maintain proper control of the concrete. Placement of concrete should not be permitted until tests for both air entrainment and consistency have been made and results show that specification requirements have been met. When routine tests indicate a deviation from specifications for consistency, placement should be suspended until adjustments have been made and additional tests completed which show concrete to be within specifications limits. Consistency tests are to be made according to the following instructions which will comply with the specification requirements pertaining to AASHTO designation T-119.

A considerable number of tests have been completed comparing results of testing air entrained concrete samples at the truck discharge point and the pump discharge point. The tests, with few exceptions, indicated that there are only minor variations in the results of the tests, with the tests from the pump discharge location usually slightly lower in air content and slump. If slump goes up drastically there probably would have to be a foreign liquid entering the system from somewhere. A high slump above the 6 to 7 in. range, [according to AASHTO guidelines](#), normally indicates a risk of segregation. Timing in taking slump tests is important. The designated location for quality control sampling to determine air content and slump is the point of truck discharge. When any of the following conditions occur, it may be necessary to obtain a check sample at the point of pump discharge to assure that there is no significant variation in test results:

1. When a new or reconditioned concrete pump is placed into operation.
2. When there are any indications that a substantial change in air content or slump has occurred between the two points of discharge.

The mold for use in the performance of the slump test is available on requisition. It will be made of galvanized steel, not thinner than #16 gauge and will have the shape of a frustum of a right circular cone with approximate inside diameters at the top of 4 in. and at the bottom of 8 in. Height will be approximately 12 in. The mold is satisfactory if the above dimensions are within 1/16 in. The mold will have foot pieces, and handles for moving mold at end of the test. A mold which clamps to a nonabsorbent base plate is acceptable.

The tamping rod which is used to consolidate the material in the cone shall be a round, straight, steel rod 5/8 inch in diameter, with one end rounded to a hemispherical tip. Length should be approximately 2 feet.

A sample of concrete from which consistency tests are to be made must be representative of the entire batch. Samples should be obtained in accordance with the method of sampling fresh concrete, Section 501.4 of the Standard Specifications.

The mold, which must be clean, should be dampened and placed on a flat, moist, nonabsorbent rigid surface. ~~A sheet of 3/4 inch plywood is frequently used for this purpose.~~ Hold the mold firmly in place during filling, by standing on the foot pieces.

From the sample of concrete, fill the mold in three layers, each layer being approximately 1/3 the volume of the mold. One-third of the volume fills it to a depth of about 2-5/8 in., 2/3 of the volume fills it to a depth of about 6-1/8 in.

Rod each layer with 25 strokes of the tamping rod. Distribute strokes uniformly over entire cross section of the layer. For the bottom layer this will necessitate inclining the rod slightly and making approximately one-half of the strokes near the perimeter and then progressing with vertical strokes spiraling toward the center. Rod the bottom layer throughout its depth. The other two layers are to be rodded throughout their depth so that strokes just penetrate into the underlying layer **approximately 1 inch.**

In filling and rodding the top layer, heap concrete above the mold before rodding is started. If during the rodding operation concrete subsides below top of the mold, add additional concrete to keep an excess of concrete above top of the mold. After rodding has been completed, strike off the surface of concrete by means of a screeding and rolling motion of the tamping rod.

Immediately remove the mold from the concrete by carefully raising it in a vertical direction. This should be done in approximately 5 seconds by a steady upward lift with no sideways or twisting motion being imparted to the concrete. The entire operation from start of filling through removal of mold should be carried out without interruption. It should be completed within an elapsed time of approximately 2 ½ minutes.

Immediately measure the slump determining the difference between height of the mold and height over the displaced original center of the top surface of the specimen. Slump is measured to the nearest ¼ inch of subsidence below top of the mold.

~~A record of each slump test performed should be entered in a bound field book by the inspector. The form of entry should be such as to provide date, time, mixing unit (such as truck mixer number, central mix unit number, etc.) and name of inspector.~~

A record of each slump test performed should be recorded in Site Manger.

AASHTO T 119

Slump of Hydraulic Cement Concrete

PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial#	1	2
1. A Clean Slump Cone damped and placed on a moist, flat, level, nonabsorbent rigid surface		
2. Cone secured by clamps or by standing on foot pieces while filling the cone in three equal layers and while rodding		
3. Each layer approximately $\frac{1}{3}$ the volume of the mold		
4. Each layer rodded 25 times		
5. Layers rodded properly <ul style="list-style-type: none"> a. First layer rodded through entire depth while inclining the rod & spiraling toward center b. Second layer rodded approximately 1" into underlying layer c. Third layer was kept heaped above the cone while rodding approximately 1" into the underlying layer 		
6. Used a tamping rod to strike off level with the top of the mold		
7. Cone filled and removed within 2 $\frac{1}{2}$ minutes		
8. Excess concrete cleaned away from the bottom of the mold and plate		
9. Movement/vibration of cone restricted until lift was performed		
10. Cone was lifted vertically without twisting, within 5 ± 2 seconds		
11. Immediately placed the mold upside-down next to the slumped concrete		
12. Placed the tamping rod on top of the cone, measured the vertical distance of the displaced original center of the slump to the rod		
13. Slump measured and recorded to the nearest $\frac{1}{4}$ inch		

PASS PASS

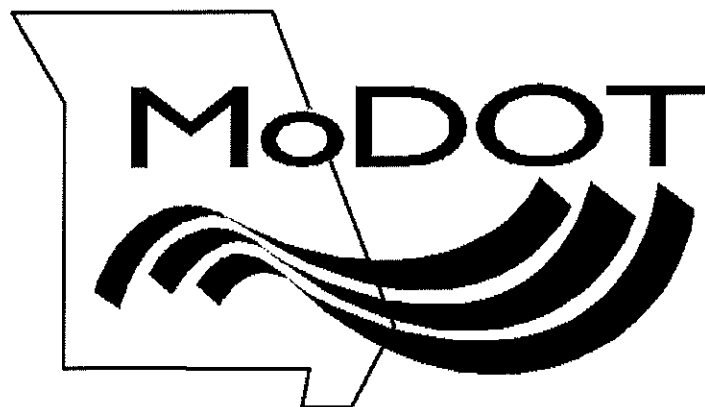
FAIL FAIL

Examiner: _____ Date: _____

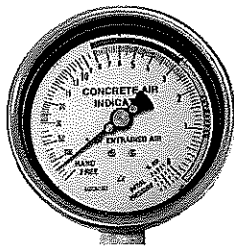
AASHTO T 152

ASTM C231

Air Content of Freshly-Mixed Concrete by the Pressure Method



AASHTO T 152



Air Content of Freshly Mixed Concrete by the Pressure Method

Revised 01/06/2020

SCOPE

- This method covers determination of the air content of freshly mixed concrete from observation of the change in volume of concrete with a change in pressure.
- Having the correct amount of air in the mix makes the concrete more durable and more resistant to freezing and thawing. Too much air reduces the durability and compressive strength, too little air reduces the durability.

2

SIGNIFICANCE AND USE

- This test method covers the determination of the air content of freshly mixed concrete.
 - The test determines the air content of freshly mixed concrete exclusive of any air that exists inside voids within aggregate particles.
 - For this reason, it is applicable to concrete made with relatively dense aggregate particles and requires determination of an aggregate correction factor.
- **NOTE:** Concrete with light weight aggregates or aggregates with high porosity may NOT be tested by this method

3

- The three AASHTO methods that provide **gravimetric**, **volumetric**, and **pressure** procedures, respectively, for determining the air content of freshly mixed concrete are:

1. AASHTO T152

Air Content by **pressure** testing

- Uses an Air Meter Type A or B
- For Dense aggregate
- Uses a correction factor for the air inside of aggregates

Significance and Use

4

2. AASHTO T121M

Air Content by **gravimetric** testing

- Uses a Unit Measure for density
- For "Yield" and "Air" content of concrete

3. AASHTO T196M

Air Content by **volumetric** testing

- Uses a Volumetric Air Meter (Roll-a-Meter)
- For all types of aggregate
- Is not affected by air inside of aggregates

NOTE: Concrete Field Certification covers T152. Advanced Concrete Certification covers T121M and T 196M.

Significance and Use

5

- The pressure procedure (AASHTO T152) gives substantially the same air content as the other two test methods for concrete made with dense aggregates.
- The air content of hardened concrete may be either higher or lower than that determined by this test method. This depends on the methods and amount of consolidation effort applied to the concrete from which the hardened concrete specimen is taken.

Significance and Use

6

- Items that affect the air content in hardened concrete:
- A. Uniformity and stability of the air bubbles in the fresh and hardened concrete
- B. Time of comparison
- C. Environmental exposure
- D. The stage in delivery
- E. Placement
- F. Consolidation processes at which the air is determined, that is, before or after the concrete goes through a pump; and other factors.

Significance and Use

7

EQUIPMENT/APPARATUS

- Air Meter Type A or B (Typical vol. is 0.25 ft³)
- Tamping rod
 $\frac{5}{8} \pm \frac{1}{16}$ " x 20 ± 4"
- Mallet
- Water Supply
- Strike off bar/plate
- Scoop or shovel
- Rubber syringe
- Vibrator



More information can be found in the Appendix.

8

Internal Vibrators:

- ≥ 9000 vpm (150hz) while in operation
 - Check periodically with a vibrating – reed tachometer
- Vibrator element must be ≤ ¼ of the diameter of the cylinder mold or beam width
- Combined length of vibrator element and shaft ≥ 3" longer than depth of section being vibrated



Equipment

9

External Vibrators:

- The two types of external vibrators permitted are either table or plank.
- The external vibrator frequency shall be 3600 vpm (60Hz) or higher.



Equipment

10

Type A Air-Meters



More information can be found in the Appendix.

Apparatus

11

Type "B" Air-Meters

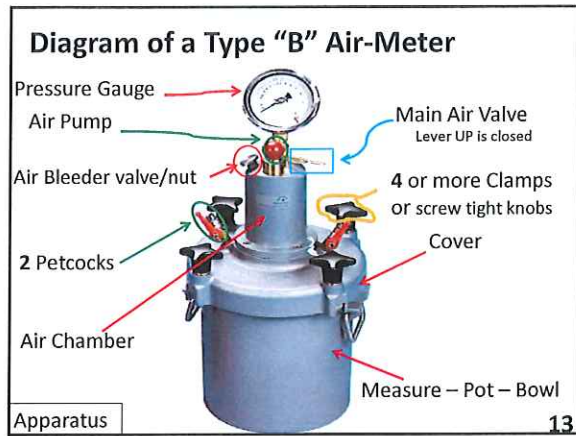
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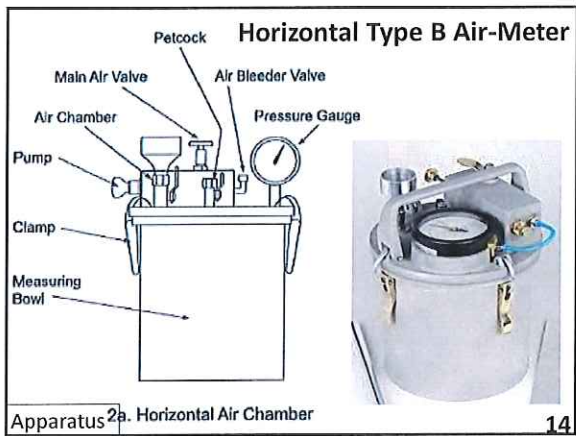


More information on equipment can be found in the Appendix.

Apparatus

12







- Unless otherwise specified, follow the requirements and intervals for equipment calibrations, standardizations, and checks in AASHTO R 18, and procedures in AASHTO R 61.
- Rough handling will affect the standardization of both type A and Type B meters. Barometric pressure will affect the standardization of only type A meter.

Calibration of Apparatus

16

- **Annual Calibration must be performed at 5% Air.**

– The quick field check using 1.2% air is **NOT** acceptable as calibration.



Calibration of Apparatus

17



5%



See Annex and MoDOT EPG for more information on Calibration and Standardization.

Calibration of Apparatus

18

VIDEO



Calibration of Apparatus

19

Air Meter Check

- If needed for a spot check in-between the annual calibration, use one of the “Air Meter Calibrators (5%)” below.
- Verify the calibrator with the calibration of the Air Meter. In comparing results, note if there is a small off-set to apply to the calibrator.

Follow manufacturers instructions on how to use these devices.



Calibration of Apparatus

20

- **Calibration/Standardization Records –** Information to be maintained in the records shall include determination of expansion factor, size of the standardization vessel used, and the reading of the meter at the standardization test point(s).

Calibration of Apparatus

21

DETERMINATION OF THE AGGREGATE CORRECTION FACTOR



22

Procedure – Determine the aggregate correction factor on a combined sample of fine and coarse aggregate. It is determined independently by applying the standardized pressure to a sample of fine and coarse aggregate covered in water in approximately the same moisture condition, amount, and proportions occurring in the concrete sample under test.

Aggregate Sample Size – Calculate the weights of fine and coarse aggregate present in the sample of fresh concrete whose air content is to be determined, as follows:

Aggregate Correction Factor

23

Aggregate Correction Factor – Fine Aggregate

$$F_s = \frac{S \times F_b}{B}$$

F_s = weight of the fine aggregate used in the aggregate correction factor test, in pounds.

S = volume of the air meter measuring bowl; for MoDOT gauges **0.25** cubic feet.

B = volume of concrete produced per batch, this should be 27 cubic feet (1 cubic yard).

F_b = total weight of fine aggregate used in one cubic yard of concrete. This will be the scale weight, in lbs., taken from the pouring report.

24

Aggregate Correction Factor – Coarse Aggregate

$$C_s = \frac{S \times C_b}{B}$$

C_s = weight of the coarse aggregate used in the aggregate correction factor test, in pounds.

S = volume of the air meter measuring bowl; for MoDOT gauges **0.25** cubic feet.

B = volume of concrete produced per batch, this should be 27 cubic feet (1 cubic yard).

C_b = total weight of coarse aggregate used in one cubic yard of concrete. This will be the scale weight, in lbs., taken from the pouring report.

25

Placement of Aggregate in the Measuring Bowl

- Mix representative samples of fine aggregate F_s , and coarse aggregate C_s , and place in the measuring bowl filled one-third full with water.
- Place the mixed aggregate, a small amount at a time, into the measuring bowl; if necessary, add additional water to submerge all of the aggregate.
- Add each scoopful in a manner that will entrap as little air as possible and remove accumulations of foam promptly.
- Tap around the perimeter of the measuring bowl and lightly rod the upper 1 inch of the aggregate about 8-12 times. Stir after each addition of aggregate to eliminate entrapped air.

Aggregate Correction Factor

26

Initial Procedure for Type A and Type B Meters

- After all the aggregate is in the measuring bowl, remove excess foam and keep the aggregate covered in water for a period of time approximately equal to the time between introduction of the water into the mixer and the time of performing the test for air content before proceeding with the determination as directed per AASHTO T152.

Aggregate Correction Factor

27

Type A Meter – Complete the test for the Determination of Aggregate Correction Factor as described in the Appendix.

Type B Meter – Perform the procedure for Determining Air Content.

Remove a volume of water from the assembled and filled apparatus approximately equivalent to the volume of air that would be contained in a typical concrete sample. (generally 5%) See Annex A1.9 for this procedure.

Aggregate Correction Factor

28

Classroom Exercise

- Given Scale weights from Concrete Mix Design:

Fine Aggregate – 1281 lbs./yd.³

Coarse Aggregate – 1843 lbs./yd.³

- Report** both the weight of Fine and Coarse aggregate to the nearest **0.01 pound**, used to determine Aggregate Correction Factor.

Aggregate Correction Factor

29

Classroom Exercise

Determine the weight of the coarse and fine aggregate that will be in the air meter for testing using the following formulas to calculate the weights.

$$\text{Fine Agg. } F_s = \frac{S \times F_b}{B} \text{ OR } F_s = (S/B) \times F_b$$

$$\text{Coarse Agg. } C_s = \frac{S \times C_b}{B} \text{ OR } C_s = (S/B) \times C_b$$

Aggregate Correction Factor

30

$$F_b = 1281 \text{ lb yd}^3$$

$$C_b = 1843 \text{ lb yd}^3$$

$$S = 0.25$$

$$B = 27$$

Answer

S = Volume of the air meter measuring bowl; for MoDOT gauges 0.25 cubic feet.

B = Volume of concrete produced per batch, this should be 27 cubic feet (1 cubic yard).

$$F_s = \frac{0.25 \times 1281}{27} = 11.861 = 11.86 \text{ lb.}$$

$$C_s = \frac{0.25 \times 1843}{27} = 17.0648 = 17.06 \text{ lb.}$$

31

MoDOT

EPG Section 501

Air tests are to be made at the beginning of each pour on structures and for each 100 cubic yards there after.

Aggregate correction factors shall be made available by the district to the Central laboratory when coarse aggregate samples are submitted for AASHTO T161 testing.

NOTE: See the EPG for additional information on MoDOT practices for testing Air Content of Concrete.

32

PREPARATION AND PROCEDURE FOR DETERMINING AIR CONTENT OF CONCRETE



33

PREPARATION

- Obtain a sample of freshly mixed concrete in accordance with applicable procedures of AASHTO R 60.



34

- If the concrete contains coarse aggregate particles that would be retained on a 2 inch sieve, wet-sieve a sufficient amount of the representative sample over a 1½ inch sieve, as described in AASHTO R60, to yield somewhat more than enough material to fill the measuring bowl of the size selected for use.
- Take caution to minimize disturbing the mortar when wet sieving.

Preparation

35

PROCEDURE

- **Dampen the interior** of the measuring bowl and place it on a flat, level, firm surface.



36

- Place a **representative sample** of concrete in the measuring bowl in **3** equal layers using a scoop.



Procedure

37

- Consolidate each layer by rodding or by vibration.

A slump greater than **3** inches = **ROD**

A slump of **1** to **3** inches = **ROD** or **VIBRATE**

A slump less than **1** inch = **VIBRATE**

NOTE: Self-Consolidating Concrete (SCC) prohibits rodding and internal vibration, so slightly overfill the measure with SCC in one continuous lift.

Procedure

38

Consolidation by Rodding

- When rodding the concrete, place the concrete in three equal layers. Rod each layer 25 times with the tamping rod.
- The strokes should be evenly dispersed across the area of the concrete.



Procedure - Rodding

39

- Rod the bottom layer throughout its depth, but do not forcibly strike the bottom of the bowl.
- When rodding the second and final layers only allow the rod to penetrate the previous layer about 1 inch.
- When the final layer of concrete is added, be careful to avoid excessive overfilling. (1/8 inch is optimum)



Procedure - Rodding

40

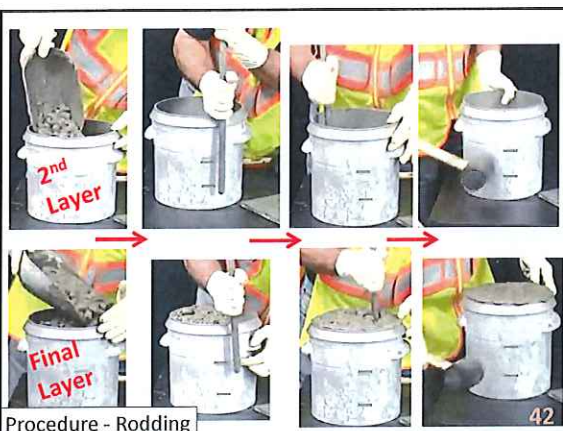
- **Tap the side with a mallet.**

– After each layer is rodded, sharply tap the side of the bowl with the mallet 10 to 15 times. This will close the voids left by the tamping rod and will release any entrapped air.



Procedure - Rodding

41



Procedure - Rodding

42

Consolidation by Vibrating

When vibrating the concrete, place the concrete in 2 approximately equal layers.

- Vibrate each layer by inserting the vibrator in 3 places evenly dispersed across the area of the concrete.
- Avoid excessive overfilling with the final layer.
- When vibrating the bottom layer, do not let the vibrator touch the bottom or sides of the bowl.

Procedure - Vibrating

43

- Always be careful when removing the vibrator so that air voids are not left in the concrete.
- Do not over vibrate the concrete.
- Vibration should stop when the concrete becomes relatively smooth and has a glazed appearance.

If froth begins to form on top of the concrete, then the concrete has been vibrated too long; Redo the test.



Procedure - Vibrating

44

CONSOLIDATION SUMMARY

Rodding

3 layers
25 strokes/layer
10-15 sharp taps/layer



Procedure

Vibration

2 layers
3 insertions per layer
Evenly distributed over cross section



45

- **Strike Off**

- After consolidation, Strike Off the top surface with the strike off bar using a sawing motion until the bowl is just level full. Removal of approximately $\frac{1}{8}$ inch is optimum.

- A small quantity of concrete may be added to fill any voids in the surface.
- Large excesses of concrete should be removed with a scoop before the strike off.



Do Not use the tamping rod to strike off the bowl.

Procedure

46

- **Clean the rims** of the bowl and cover.

- To ensure a tight pressure seal is made when the cover is placed on the bowl.

- **Moisten the bottom of the cover**

- **Secure the cover** on the bowl.



Procedure

47

- **Close the air valve** between the air chamber and the measuring bowl and open both petcocks on the holes through the cover.

- **Introduce water** through one petcock until it comes out the opposite petcock.



Procedure

48

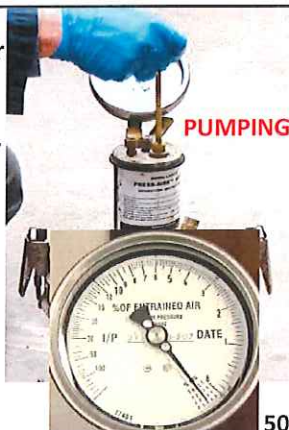
- **Jar the meter** gently until all air is expelled from this same petcock.



Procedure

49

- **Pump air into the air chamber** until the gauge hand is on the initial pressure (IP) line.
 - » *IP is found written on the dial face*
 - » *IP marks are below 0%*



- **Wait a few seconds** for the gauge to stabilize at the initial gauge line.

Procedure

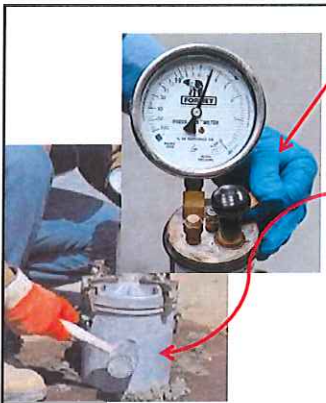
50

- **Tap the gauge lightly** with fingers until reading stabilizes
- **Adjust air to initial pressure line.**
 - *Bleed air off by loosening the air bleeder nut.*
 - *Pump additional air if needed.*
 - *Tap gauge lightly after adjustments.*
- **Close both petcocks.**



Procedure

51




- **Open the air valve** between the air chamber and the measuring bowl.
- **Tap the sides** of the measuring bowl sharply with the mallet to relieve local restraints.

Procedure

52

- **Lightly tap the pressure gauge** by hand and read the percentage of air on the dial of the pressure gauge.
- This reading **minus the aggregate correction factor** is the air content of the concrete mixture.



Procedure

53

CALCULATION – AIR CONTENT

- Calculate the air content of the concrete in the measuring bowl as follows:

$$A_s = A_1 - G$$

A_s = Air content of sample tested, percent.
 A_1 = Apparent Air content of the sample tested, percent.
 G = Aggregate correction factor, percent.

54

REPORT

Report the air content of the concrete sample to the **nearest 0.1 percent** after subtracting the aggregate correction factor, unless the gauge reading of the meter exceeds 8 percent, in this case the corrected reading shall be reported to the **nearest ½ scale** division on the dial.

Example, to the nearest 0.1% or 0.05%.

Report the date and time of the test

(For MoDOT See EPG Section 501.1.8.2.)

55

Common Testing Errors:

- Failure to close the main air valve before releasing the pressure from either the container or the air chamber will result in water being drawn into the air chamber, thus introducing error in subsequent measurements.
- Not having a tight pressure seal between the cover and the bowl due to not cleaning the rim of the pot or meter top.
- Not tapping the pot between layers.
- Not rodding or vibrating each layer.

56

ANNEX**(Mandatory Information)****A1—STANDARDIZATION OF APPARATUS**

A1.1 – Standardization tests shall be performed in accordance with the following procedures as applicable to the meter type being employed.

A1.2 – standardization of the standardization vessel – Determine accurately the weight of water required to fill the standardization vessel, w , using a scale accurate to 0.1 percent of the weight of the vessel filled with water. This step shall be performed for Type A and Type B meters.

A1.3 – Standardization of the Measuring Bowl – Determine the weight of water required to fill the measuring bowl, W , using the scale accurate to 0.1 percent of the weight of the measuring bowl filled with water. Slide a glass plate carefully over the flange of the measuring bowl in a manner to ensure that the measuring bowl is completely filled with water. A thin film of cup grease smeared on the flange of the measuring bowl will make a water tight joint between the glass plate and the top of the measuring bowl. This step shall be performed for Type A and Type B meters.

A1.4 – Effective volume of the Standardization Vessel, R – The constant R represents the effective volume of the standardization vessel expressed as a percentage of the volume of the measuring bowl.

A1.4.1—For A meters, calculate R as follows (Note A1) :

$$R = 0.98 w/W$$

Where:

w = weight of water required to fill the standardization vessel,

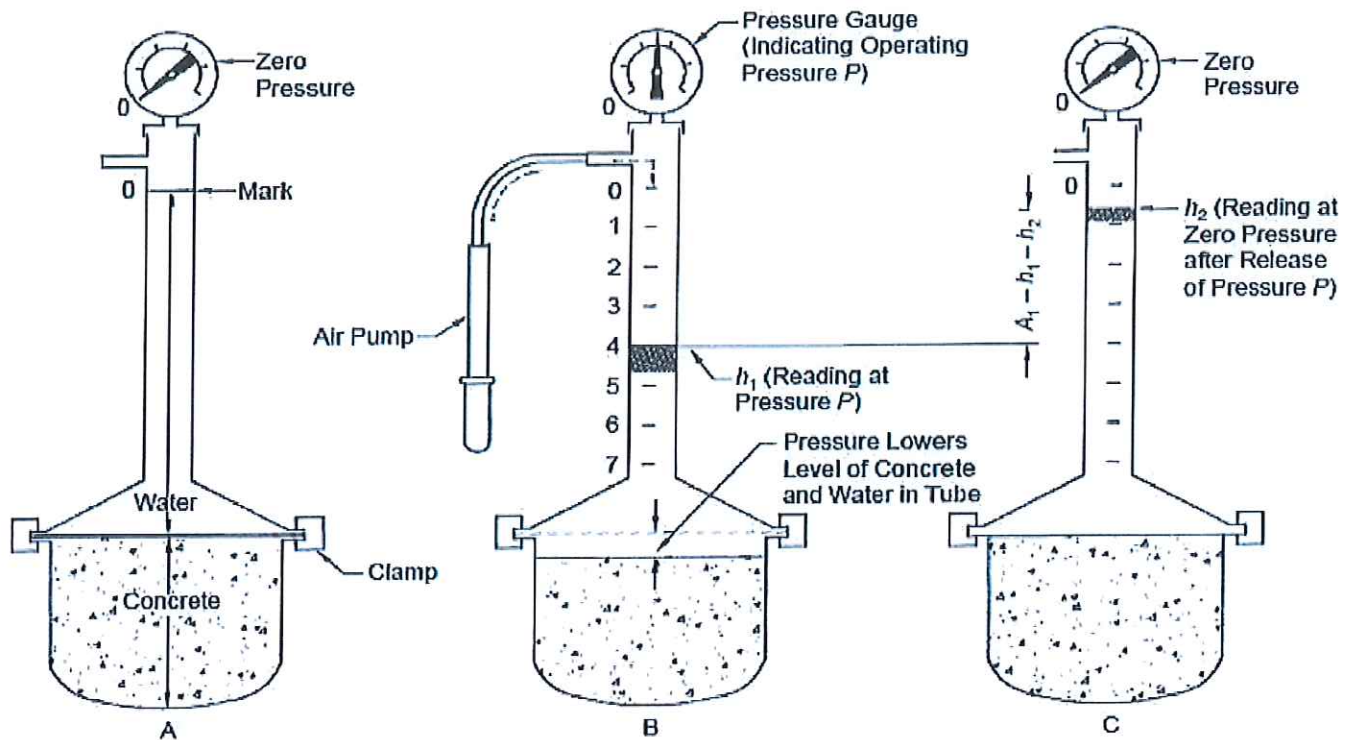
W = weight of water required to fill the measuring bowl.

Note A1: the factor 0.98 is used to correct for the reduction in the volume of air in the standardization vessel when it is compressed by a depth of water equal to the depth of the measuring bowl. The value of this constant will decrease by about 0.01 for each 4 inches increase in measuring bowl depth. The depth of the measuring bowl and atmospheric pressure do not affect the effective volume of the B Type meters.

A1.4.2-- For Type B meters, calculate R as follows: $R = w/W$

A1.5—Determination of, or Check of, Allowance for Expansion Factor, D

A1.5.1 For **Type A meter**, determine the expansion factor, D (note A2) by filling the apparatus with water only (making certain that all entrapped air has been removed and the water level is exactly on the zero mark (Note A3) and applying an air pressure approximately equal to the operating pressure, P , determined by the standardization test described in Section A1.7 the amount the water column lowers will be the equivalent expansion factor, D , for that particular apparatus and pressure (Note A4).



Note: $A_1 = h_1 - h_2$ when measuring bowl contains concrete as shown in this figure; when measuring bowl contains only aggregate and water, $h_1 - h_2 = G$ (aggregate correction factor).
 $A_1 - G = A$ (entrained air content of concrete).

Figure 1—Illustration of the Pressure Method for Air Content: Type A Meter

Note A2 – The application of internal pressure will result in a small increase in volume. This expansion will not affect the test results because, with the procedure described in Section s6 and 8, the amount of expansion is the same for the test and as for the correction factor, and is thereby automatically cancelled. However, it does enter into the standardization test to determine the air pressure to be used in testing fresh concrete.

Note A3—The water columns on some meters of Type a design are marked with an initial water level and a zero mark, the difference between the two marks being the allowance for the expansion factor. This allowance should be checked in the same manner as for meters not so marked and in such a case, the expansion factor should be omitted in computing the standardization readings in section A1.7

Note A4—It will be sufficiently accurate for this purpose to use an approximate value for P determined by making a preliminary standardization test as described in Section A1.7 except that an approximate value for the standardization factor, K, should be used. For this test $K = 0.98R$ which is the same as Equation A1.2 except that the expansion reading, d, as yet unknown, is assumed to be zero.

A1.5.2—For **meters of Type B**, the allowance for the expansion factor, D, is included in the difference between the initial pressure indicated on the pressure gauge and the zero percent mark on the air-content scale on the pressure gauge. This allowance shall be checked by filling the apparatus with water (making certain that all entrapped air has been removed), pumping air into the air chamber until the gauge hand is stabilized at the indicated initial pressure line, and then releasing the air to the measuring bowl (Note A5). If the initial pressure line is correctly positioned, the gauge should read zero percent. The initial pressure line shall be adjusted if two or more determinations show the same variation from zero percent and the test repeated to check the adjusted initial pressure line.

Note A5—this procedure may be accomplished in connection with the standardization test described in Section A1.9.

A1.6-- standardization Reading K – The standardization reading, K, is the final meter reading to be obtained when the meter is operated at the correct standardization pressure.

A1.6.1—for **Type A meters**, the standardization reading, K, is as follows:

$$K = R + D$$

Where:

R = effective volume of the standardization vessel (Section a1.4.1),

D = expansion factor (Section a1.5.1 and Note A6)

A1.7—Standardization Test to Determine Operating Pressure, P, on Pressure Gauge, Type A meter – If the rim of the standardization cylinder contains no recesses or projections, fit it with three or more spacers equally spaced around the circumference. Invert the cylinder and place it at the center of the dry bottom of the measuring bowl. The spacers will provide an opening for flow of water into the standardization cylinder when pressure is applied.

A1.7.1—Secure the inverted cylinder against displacement and carefully lower the cover assembly. After the cover is clamped in place, carefully adjust the apparatus assembly to a vertical position and add water at air temperature, by means of the tube and funnel, until it rises above the zero mark on the standpipe. Close the vent and pump air into the apparatus to the approximate operating pressure.

A1.7.2—Incline the assembly about 30 degrees from vertical and, using the bottom of the measuring bowl as a pivot, describe several complete circles with the upper end of the standpipe, simultaneously tapping the cover and sides of the measuring bowl lightly to remove any entrapped air adhering to the inner surfaces of the apparatus. Return the apparatus to a vertical position, gradually release the pressure (to avoid loss of air from the standardization vessel) and open the vent.

A1.7.3—Bring the water level exactly to the zero mark by bleeding water through the petcock in the top of the conical cover. After closing the vent, apply pressure until the water level has dropped an amount equivalent to about 0.1 to 0.2 percent of air more than the value of the standardization reading, K , determined as described in Section A1.6. to relieve local restraints, lightly tap the sides of the measuring bowl and when the water level is exactly at the value of the standardization reading, K , read the pressure, P , indicated by the gauge and record to the nearest 0.1 psi.

A1.7.4—Gradually release the pressure and open the vent to determine whether the water level returns to the zero mark when the side of the measuring bowl is tapped lightly (failure to do so indicates loss of air from the standardization vessel or loss of water due to a leak in the assembly). If the water level fails to return to within 0.05 percent air of the zero mark and no leakage beyond a few drops of water is found, some air probably was lost from the standardization cylinder. In this case, repeat the standardization procedure step-by-step from the beginning of this paragraph. If the leakage is more than a few drops of water, tighten the leaking joint before repeating the standardization procedure.

A1.7.5—check the indicated pressure reading promptly by bringing the water level exactly to the zero mark, closing the vent, and applying pressure, P , just determined. Tap the gauge lightly with a finger. When the gauge indicates the exact pressure, P , the water column should read the value of the standardization factor, K , used in the first pressure application, within about 0.05% of air.

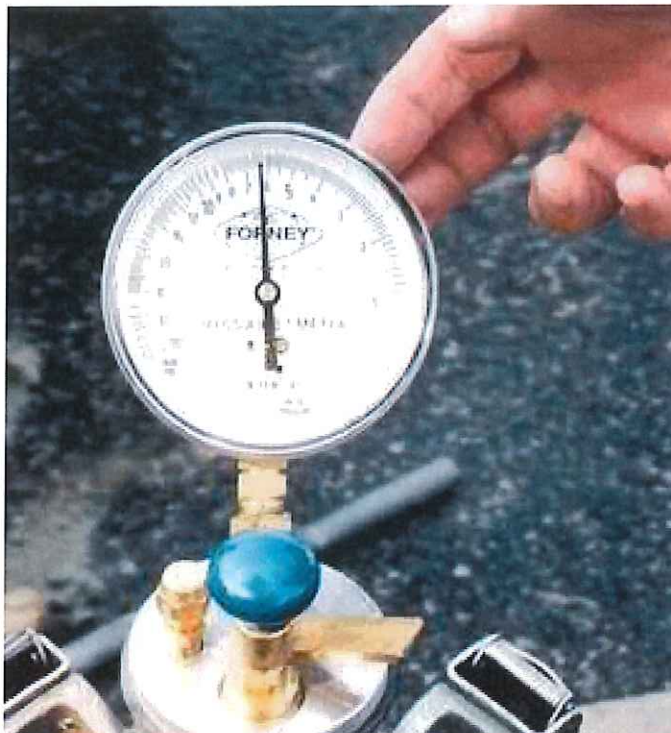
Note A7—CAUTION—The apparatus assembly should not be moved from the vertical position until pressure has been applied that will force water about one third of the way up into the standardization cylinder. Any loss of air from this cylinder will nullify the standardization.

A1.8—Standardization Test to determine alternative Operating Pressure P1 – Type A Meter – the range of air contents that can be measured with a given meter can be doubled by determine an alternative operating pressure P1 such that the meter reads half of the standardization reading, K, (equation A1.3). Exact standardization will require determination of the expansion factor at the reduced pressure in Section A1.5. for most purposes, the change in expansion factor can be disregarded and the alternative operating pressure determined during the determination of the regular operating pressure in section A1.7.



A1.9—Standardization Test to Check the Air Content Graduations of the Pressure Gauge, Type B Meter—Fill the measuring bowl with water as described in Section A1.3. Screw the short piece of tubing or pipe furnished with the apparatus into the threaded petcock hole on the underside of the cover assembly. Assemble the apparatus. Close the air valve between the air chamber and the measuring bowl and open the two petcocks on holes through the cover assembly. Add water through the petcock on the cover assembly, leaving the short piece of tubing of pipe extension in place until all air is expelled from the second petcock.

A1.9.1—Pump air into the air chamber until the pressure reaches the indicated initial pressure line. Allow a few seconds for the compression air to cool to normal temperature. Stabilize the gauge hand at the initial pressure line by pumping or bleeding off air as necessary, tapping the gauge lightly.



Close the petcock not provided with the tube or pipe extension on the underside of the cover. Remove water from the assembly to the calibrating vessel controlling the flow, depending on the particular meter design, by opening the petcock provided with the tube or pipe extension and cracking the air valve between the air chamber and the measuring bowl or by opening the air valve and using the petcock to control flow.

A1.9.2—Perform the standardization at an air content that is within the normal range of use. If the standardization vessel (Section A1.2) has a capacity within the normal range of use, remove exactly that amount of water. With some meters, the calibrating vessel is quite small and it will be necessary to remove several times that volume to obtain an air content within the normal range of use. In this instance, carefully collect the water in an auxiliary container and determine the amount removed by weighing to the nearest 0.1%.

A1.9.3—Calculate the correct air content, R , by using Equation A1.2. Release the air from the apparatus at the petcock not used from filling the standardization vessel and if the apparatus employs an auxiliary tube for filling the standardization container, open the petcock to which the tube is connected to drain the tube back into the measuring bowl (Note A7). At this point of the procedure, the measuring bowl contains the percentage of air determined by the standardization test of the calibrating vessel.

A1.10—Pump air into the air chamber until the pressure reaches the initial pressure line marked on the pressure gauge, close both petcocks in the cover assembly, and then open the valve between the air chamber

and the measuring bowl. The indicated air content on the pressure gauge dial should correspond to the percentage of air determined to be in the measuring bowl. If two or more determinations show the same variation from the correct air content, the dial hand shall be reset to the correct air content and the test repeated until the gauge reading corresponds to the standardized air content within 0.1%. If the dial hand was reset to obtain the correct air content, recheck the initial pressure mark as in Section A1.5.2. If a new initial pressure reading is required, repeat the standardization to check the accuracy of the graduation on the pressure gauge described earlier in this section. If difficulty is encountered in obtaining consistent readings, check for leaks, for the presence of water inside the air chamber (Figure 2), or the presence of air bubbles clinging to the inside surfaces of the meter from the use of cool, aerated water. In this latter instance, use deaerated water, this can be obtained by cooling hot water to room temperature.

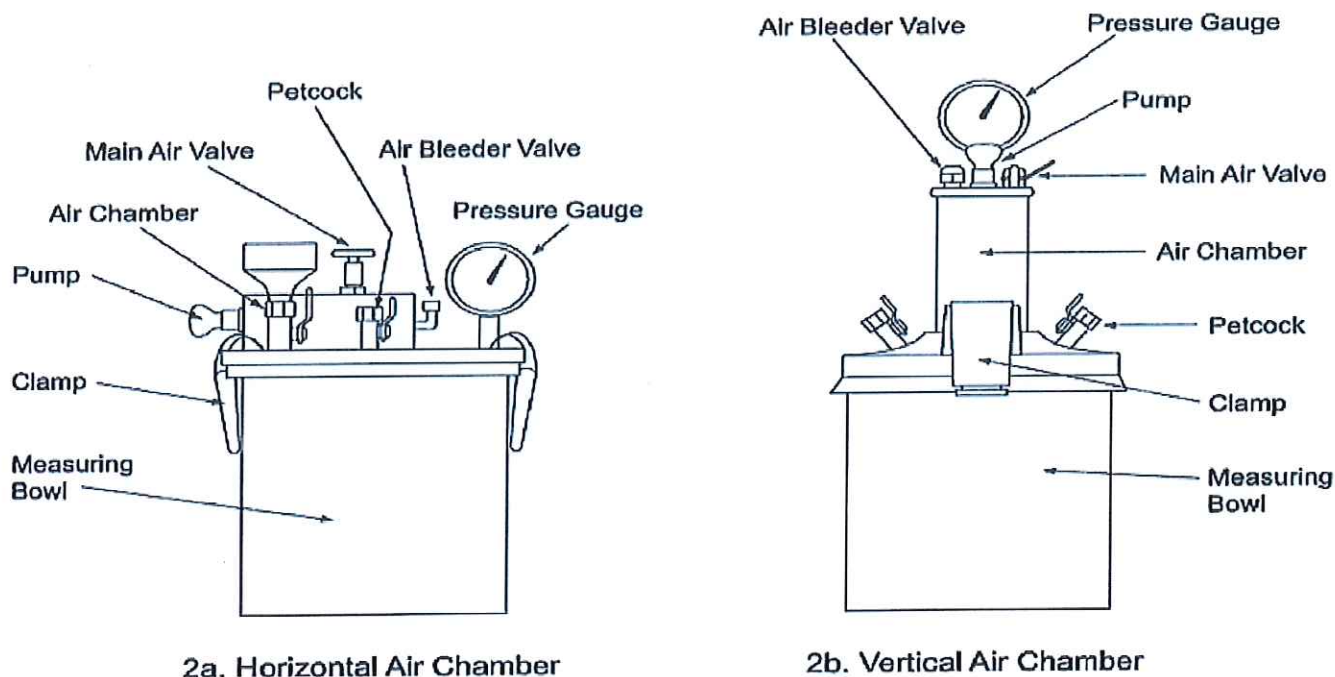


Figure 2—Schematic Diagram: Type B Meter

Note A8—If the calibrating vessel is an integral part of the cover assembly, the petcock used in filling the vessel should be closed immediately after filling the standardization vessel and not opened until the test is complete.

Air entrainment tests by the pressure method

Test methods outlined in the following paragraphs were derived from AASHTO T-152 to provide a basis for determining air content of freshly mixed concrete. Principles involved are based on the fact that air is the only compressible component in freshly mixed concrete. Operation of testing equipment is to be in accordance with the manufacturer's instructions.

The pressure method of determining air entrainment is to be used for concrete intended for both structures and pavement, with the exception of lightweight concrete. Porosity of lightweight aggregates introduces errors into results which make other procedures necessary.

Air test are to be made at the beginning of each pour on structures and for each 100 cubic yards thereafter.

Equipment used to determine the air content of concrete shall meet the requirements of AASHTO T-152. All types of apparatus used for determining air content by the pressure method have several features in common.

- (a) A measuring bowl which is sufficiently rigid to make a pressure tight container of accurate volume and which is suitable to hold a representative sample of the concrete to be tested.
- (b) A cover which is designed to be attached to the measuring bowl in a way which produces a rigid, pressure-tight assembly.
- (c) Means of applying a known pressure to the system, and for observing its effect on the volume of the sample.
- (d) Appropriate tools for placing and consolidating the sample and using the apparatus. A tampering rod 5/8 inch in diameter with a hemispherical tip is furnished for compacting concrete. This rod should be approximately 2 feet in length. A mallet with a rubber or rawhide head weighing approximately ½ lb. is furnished for tapping the measuring bowl during the testing process. Other accessories such as a trowel, strike-off bar, funnel, and water measure are part of the set.

The following procedures for calibration of the apparatus, determination of air content of concrete, and calculations of results will be given in general terms since minor changes are necessary for different types of apparatus. However, the intent will serve as a guide to exact procedures to be used if equipment furnished is slightly different.

Aggregate correction factors shall be made available by the district to the Central Laboratory when coarse aggregate samples are submitted for AASHTO T161 testing.

501.1.8.1 Calibration

Protex Meter. Calibration of pressure-type apparatus is affected by changes in barometric pressure such as those caused by changes of temperature and humidity, and by rough handling. Steps (a) through (e) normally need to be made only at time initial calibration, and occasionally there after to check the stability of volume for the calibration cylinder and measuring bowl. Step (f) must be made as frequent as necessary to insure that proper gauge pressure is being used in tests for air content of concrete.

- (a) Calibration of the calibration cylinder. Accurately determine weight of water, w , in grams required to fill the calibration cylinder, using a scale sensitive to 0.5 gram.
- (b) Calibration of measuring bowl. Determine weight of water, W , (in pounds) required to fill the measuring bowl. Use a scale sensitive to 0.1 percent of the weight of the bowl filled with water. Slide a glass plate carefully over the flange of the bowl in a way to insure that the bowl is completely filled with water. A Thin film of cup grease smeared on the flange of the bowl will make a water tight joint between the glass and the top of the bowl.
- (c) Determination of Constant, R . The Constant, R , represents the volume of the calibration cylinder expressed as a percentage of the volume of the measuring bowl. Calculate R by the following equation:

$$R = \frac{0.2205w(\text{grams})}{W(\text{pounds})}$$

If the scales of adequate capacity are available and the inspector so desires, W may be determined in grams. If that is done the equation reduces to:

$$R = \frac{w(\text{grams})}{W(\text{grams})}$$

- (d) Determination of the expansion factor, D . Determine the expansion factor, D , for any giving apparatus assembly by filling the apparatus with only water. Make certain that all entrapped air has been removed and that the water level is exactly on the zero mark. Apply an air pressure approximately equal to the operating pressure, P , determined by the calibration test described in (f). The amount the water column lowers will be the equivalent expansion factor, D , for that particular apparatus and pressure. For this portion of the calibration, it will be satisfactory to use an approximate value for P . This is determined by making a preliminary test described in (f), except that an approximate value for calibration factor, K , will be used. For this test, K , will be approximate, because the factor, D , as yet unknown, is assumed to be zero. See (e).
- (e) Determination of calibration factor, K . The calibration factor, K , is the amount the water column must be depressed during the calibration procedure to obtain the gauge pressure required, so that graduations on the glass tube correspond directly to the percentage of air introduced into the measuring bowl by the calibration cylinder when the bowl is level full of water. Calculate K as follows:

$$K = 0.98R + D$$

(f) Calibration test to determine operating pressure, P , on pressure gauge. If the rim of the calibration cylinder contains no recesses or projections, fit it with three or more spacers equally spaced around the circumference. Invert cylinder and place it at the center of the dry bottom of the measuring bowl. The spacers provide opening for flow of water into the calibration cylinder when pressure is applied. Secure the inverted cylinder against displacement and carefully lower the conical cover into place and clamp. After cover is clamped in place, carefully adjust the apparatus assembly to a true vertical position. Add water at air temperature by means of the tube and funnel until water rises above the zero mark in the standpipe. Close vent and pump air into the apparatus to the approximate pressure. Incline the assembly about 30 degrees from vertical, and using bottom of the bowl as a pivot, describe several complete circles with the upper end of the standpipe. Simultaneously, tap over and sides of the bowl lightly to remove any entrapped air which might be adhering to inner surfaces of the apparatus. Return the apparatus to a vertical position, gradually release pressure to avoid loss of air (from the calibration cylinder), and open vent. Bring water level exactly to the zero mark by bleeding the petcock in the top of the conical cover. When the zero mark has been reached, close vent and apply pressure until the water level has dropped an amount equivalent to about 0.1 to 0.2 percent of air more than the value of the calibration factor, K , determined as described in (e). To relieve local restraints lightly tap sides of the bowl. When the water level is exactly at the value of calibration factor, K , read the pressure, P , indicated by the gauge and record to the nearest 0.1 psi. Gradually release pressure and open vent to determine whether the water level returns to the zero mark when sides of the bowl are tapped lightly. Failure to do so indicates loss of air from the calibration cylinder or loss of water due to a leak in the assembly. If the water level fails to return to within 0.05% air of the zero mark and no leakage beyond a few drops of water is found, some air probably was lost from the calibration cylinder. In this case, repeat the entire calibration procedure, step by step. If leakage is more than a few drops of water, tighten the leaking joint before repeating the calibration procedure. Check the indicated pressure reading promptly by bringing the water level exactly to the zero mark, closing vent, and applying the pressure, P , just determined. Tap gauge lightly with a finger. When gauge indicates the exact pressure, P , water column should read the value of the calibration factor K , used in the first pressure application. The reading should be within about 0.5 percent of air.

Soiltest Meter The easiest method of calibrating the Soiltest Air Meter is by using the calibration block.

Special Note: Use the 5% block only for checking in-between annual calibrations. The 5% block must be calibrated alongside the yearly calibration of the air-pot to note any offsets. dh - TCP – 11/13/2018

- a. Fill the material container with water
- b. Place the 5 percent calibration block in the material container.
- c. Place and clamp lid onto container, run air test as you normally would for concrete.
- d. If the gauge hand indicates 5 percent air (\pm any calibrated offset), the equipment is properly calibrated.
- e. If the gauge hand indicates air content other than 5 percent, adjust the initial starting point (the yellow needle) and run through the test again. This may be done a few times until the gauge is properly calibrated.

Determination of Aggregate Correction Factor. Determine the aggregate correction factor on a combined sample of fine and coarse aggregate by the methods outlined in the following paragraphs:

Calculate weights of fine and coarse aggregate present in the volume, S, of the sample of fresh concrete whose air content is to be determined as follows:

$$F_8 = \frac{S \times F_b}{B}$$

$$C_8 = \frac{S \times C_b}{B}$$

Where:

F_s = weight of fine aggregate in concrete sample under test, in lbs.

S = volume of concrete sample (Same as volume of measuring bowl of apparatus), in cubic feet.

B = volume of concrete produced per batch, in cubic feet.

F_b = total weight of fine aggregate in batch, in lbs.

C_s = weight of coarse aggregate in concrete sample under test, in lbs., and

C_b = total weight of coarse aggregate in batch, in lbs.

Mix representative samples of fine aggregate of weight, F_s , and coarse aggregate of weight, C, and place in the measuring bowl which has been previously filled 1/3 full of water. Add mixed aggregate a little at a time until all the aggregate is inundated. Add each scoopful in a manner that will entrap as little air as possible. Promptly remove accumulation of foam. Tap sides of the bowl and lightly rod the upper inch of the aggregate about 10 times. Stir after each addition of mixed aggregate to eliminate entrapped air.

While all the aggregate has been placed in the bowl and inundated for at least 5 minutes, strike off all foam and excess water, and thoroughly clean flanges of both the bowl and conical cover so that when the cover is clamped in place, a pressure tight seal will be obtained. Complete test as described below. The aggregate correction factor, G, is equal to $h_1 - h_2$, as determined in the tests on the aggregate. The factor will normally remain fairly constant for any given aggregates but since different aggregated will have different factors, a new factor must be determined for each source.

501.1.8.2 Procedure for Determining Air Content of Concrete

With the Protex Meter, place a representative sample of concrete in the measuring bowl in three equal layers. Consolidate each layer by rodding, and by tapping the bowl. When concrete is placed, consolidate each layer of concrete with 25 strokes of the tamping rod, evenly distributed over the cross section. Follow the rodding of each layer by tapping sides of the bowl with the mallet, until cavities left by rodding are leveled out and no large bubbles of air appear on the surface of the rodded layer. When rodding the first layer, rod should not strike bottom of the bowl. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer. Slightly overfill the bowl with the third layer. After rodding, remove excess concrete by sliding the strike off bar across the top flange with a sawing motion, until the bowl is just level full.

Thoroughly clean flanges of the bowl and conical cover so that when the cover is clamped in place, a pressure-tight seal will be obtained. Assemble the apparatus and add water over the concrete by means of the tube. Water should be added until it rises to about the half way mark in the standpipe. Incline the apparatus assembly about 30 degrees from vertical, using bottom of the bowl as a pivot. Describe several complete circles with the upper end of the column, simultaneously, tapping the conical cover lightly to remove any entrapped air bubbles above the concrete sample. Return the apparatus assembly to its vertical position. Fill the water column lightly above the zero mark, while lightly tapping sides of the bowl. Foam on the surface of the water column may be removed with a syringe or with spray of alcohol to provide a clear meniscus. Bring the water level to the zero mark of the graduated tube before closing vent at top of the water column.

Apply slightly more than the desired test pressure, P (about 0.2 psi more), to the concrete by means of the hand pump. To relieve local restraints, tap sides of the measure. When the pressure gauge indicates exact test pressure, P (as determined in accordance with instructions for the calibration test), read the water level, h_1 , and record to the nearest division or half division (0.10 or 0.05% air content) on the graduated bore tube or gauge glass of the standpipe. For extremely harsh mixes, it may be necessary to tap the bowl vigorously until further tapping produces no change in indicated air content. Gradually release air pressure to vent at the top of the water column, and tap sides of the bowl lightly for about 1 minute. Record the water level, h_2 , to the nearest division or half division. The apparent air content, A_1 is equal to $h_1 - h_2$.

Repeat the steps described in Section 501.16.4.3.3.2 without adding water to reestablish the water level at the zero mark. The two consecutive determinations of apparent air content should check within 0.2% of the air. Use the average to get the value. A_1 , to be used in calculating the air content, A , in accordance with Section 501.16.4.4.

Calculation. Calculate the air content of the concrete as follows:

$$A = A_1 - G$$

Where:

A = Air content percentage, by volume of concrete.

A_1 = Apparent air content percentage, by volume of concrete.

G = Aggregate correction factor percentage, by volume.

Concrete placement shall be halted if results of tests for entrained air indicate non-compliance with specification requirements.

Data for tests for air entrainment should be entered directly in a bound field book by the inspector. The aggregate correction factor should be determined at start of the work for each mix and complete data and calculation entered in the field book. Each test for determination of operating pressure, P , must also be entered.

In the record of test for air entrainment the aggregate correction factor and operating pressure should be identified with the test from which they were determined. This can be done by reference to book and page on which the test is recorded.

AASHTO T 152
Air content of freshly Mixed Concrete By Pressure Method

PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial#	1	2
General		
1. Bowl dampened		
2. Bowl filled in three equal layers		
3. Each layer rodded 25 times		
4. After rodding each layer, bowl tapped 10 to 15 times with a mallet		
5. Excess concrete removed with sawing motion of strike-off bar		
Type "B" Meter		
1. flanges of bowl cleaned and unit assembled		
2. Air valve between air chamber and bowl closed		
3. Using rubber syringe water injected through one petcock until water emerged from opposite petcock		
4. Meter jarred gently until all air was expelled		
5. Air pumped into chamber until gauge hand is on initial pressure line		
6. Waited a few seconds to allow for the gauge to stabilize at the initial pressure line.		
7. Initial pressure stabilized while tapping gauge lightly		
8. Petcocks closed. (Not before filling of air chamber, Step 5)		
9. Air valve between air chamber and measuring bowl opened		
10. Sides of measuring bowl tapped sharply		
11. Pressure gauge tapped lightly and percentage of air read		
12. Air content of sample calculated as follows: Air content (%) = Apparent Air Content – Aggregate Correction Factor		
13. Aggregate correction factor determined for different aggregates		

PASS PASS

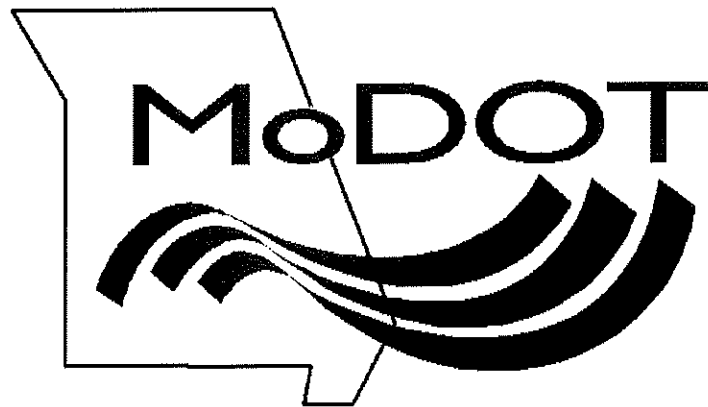
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Examiner: _____ Date: _____

AASHTO T 23

ASTM C31

Making and Curing of Concrete Cylinder Test Specimens in the Field



AASHTO T 23

Making and Curing of Concrete Cylinder Test Specimens in the Field



Rev 01/06/2020

SCOPE

- This method covers procedures for making and curing cylinder specimens from representative samples of fresh concrete for a construction project.
- The concrete used to make the molded specimens shall be sampled after all on-site adjustments have been made to the mixture proportions, including the addition of mix water and admixtures.
- This practice is not satisfactory for making specimens from concrete not having a measurable slump or requiring other sizes or shapes of specimens.

2

SIGNIFICANCE AND USE

- This method provides standardized requirements for making, curing protecting, and transporting concrete test specimens under field conditions.

3

• Strength test data of **STANDARD CURED** specimens that have been made and cured according to AASHTO T23 can be used for the following purposes;

- Acceptance testing for specified strength
- Checking the adequacy of mixture proportions for strength
- Quality control

Significance and Use

4

• Strength test data of **FIELD CURED** specimens that have been made and cured according to AASHTO T23 can be used for the following purposes;

- Determination of whether a structure is capable of being put in service
- Comparison with test results of standard cured specimens or with test results from various in-place test methods
- Adequacy of curing and protection of concrete in the structure or form or shoring removal time requirements

Significance and Use

5

EQUIPMENT

- Cylinder Mold and cap
- Tamping Rod – size determined by the size of specimen being made
- Scoop
- Marker
- Trowel or straight-edge
- Duct tape
- Tachometer
- Vibrator
- PPE (Safety Vest, Gloves, Hard Hat etc. . .)

See **Appendix** for additional information on Equipment

6

TESTING REQUIREMENTS

- **Cylindrical Specimens** – Compressive or splitting tensile strength specimens shall be cylinders cast and allowed to set in an upright position.
- The number and size of cylinders cast for quality assurance shall be as directed by **MoDOT**.
- In addition, the length shall be twice the diameter, and the cylinder diameter shall be at least three times the nominal maximum size of the coarse aggregate.

7

- For acceptance testing for specified compressive strength, cylinders shall be 6"x 12" or 4"x 8".
- For both cylinders specimens, when the nominal maximum size of the coarse aggregate exceeds 2 inches the concrete sample shall be treated by **wet sieved** through a 2 inch sieve as described in AASHTO R60.

Testing Requirements

8

SAMPLING CONCRETE

The samples used to fabricate test specimens under this standard shall be obtained in accordance with AASHTO R 60 unless an alternative procedure has been approved.



9

3 tests to complete before molding begins:

Temperature, Slump and Air Content
(Unit weight and Volume may be requested as well which are covered in Advanced Concrete)

- Within 5 minutes of obtaining the final portion of the composite sample, start tests for :

Section
4.1.2

Temperature



Slump



Air Content



10

- **TEMPERATURE** – Determine and record the temperature in accordance with MoDOT TM20.
- **SLUMP** – Measure and record the slump of each batch of concrete, from which specimens are made, immediately after remixing in the receptacle as required in AASHTO T119M/T119.
- **AIR CONTENT** – Determine and record the air content in accordance with either AASHTO T152 or T196M/T196. the concrete used in performing the air content test shall not be used in fabricating test specimens.

3 Tests to complete

11

PROCEDURE



12

Location:

Mold specimens promptly on a level, rigid, horizontal surface, free from vibration and other disturbances, at a place as near as practicable to the location where they are to be stored.



Procedure

13

Number of Specimens:

- For Strength Acceptance (*Standard Cure*)
 - 2 specimens for 6"x12" cylinders
 - 3 specimens for 4"x8" cylinders
- Tests required to control construction operations (*Field Cure*) such as opening strength, form removal or discontinuance of heating or wet curing on basis of specified strength.
 - 1 per break, as needed.

Procedure

14

- Select the proper tamping rod and scoop.
- Determine the method of consolidation (rodding or vibration) from the slump result.
- While placing the concrete in the mold move the scoop around the perimeter of the mold.
- Consolidate by rodding or vibration accordingly to the size of the sample.
- In placing the final layer or lift, add the amount of concrete that will fill the mold after consolidation.

LAYER = LIFT

Procedure

15

RODDING



16

- The tools needed to complete the molding should be made available prior to sampling.
 - Plastic molds with lids
 - Rod with a hemispherical (round) end
 - $\frac{3}{8} \pm \frac{1}{16}'' \times 12 \pm 4''$ for 4" diameter cylinders
 - $\frac{5}{8} \pm \frac{1}{16}'' \times 20 \pm 4''$ for 6" diameter cylinders
 - Duct tape, marker, scoop or shovel, and any covering similar to the placed concrete

Procedure - Rodding

17

- Select the proper method of consolidation based on the slump (AASHTO T119) of the concrete.

AASHTO Table 3	
Slump	Consolidation Method
≥ 1 inch	Rod or Vibrate
< 1 inch	Vibrate

Molding Requirements
AASHTO Table 4 – Rodding
AASHTO Table 5 - Vibration

Procedure - Rodding

18

Rodding:

LIFT = LAYER

- Place the concrete in the mold, in the required number of layers in approximately equal volume.

The concrete is placed into the mold by use of a scoop, in equal layers.

- 2 layers for 4"x 8" cylinders
- 3 layers for 6"x 12" cylinders

Consolidating:

- Rod each layer **25 times** using the round end of the rod followed by tapping the outside of the mold **10-15** times with an open hand.

Procedure - Rodding

19

- The rodding should be uniformly dispersed across the layer and should extend to the bottom of the mold for the first layer and approximately **1 inch** into the layer below for the second and final layer.



Procedure - Rodding

20

- After each layer is rodded, the mold is tapped lightly **10 – 15** times to release large air bubbles and close holes left by rodding.

NOTE: For light gauge single use molds, use open hand only, as these molds are susceptible to damage if a mallet was used.



Procedure - Rodding

21

- When placing the final layer into the mold, the operator shall attempt to add an amount of concrete that will exactly fill the mold after compaction.
 - Underfilled molds shall be adjusted using representative concrete *during* consolidation.
 - Overfilled molds shall have excess concrete removed.
- After tapping the final layer go to the **Finishing Procedure for Cylinders**.

Procedure - Rodding

22

Filling 1st Layer

1ST LAYER

(6" x 12" Cylinders)



Rodding 25 times
do not forcibly
strike the bottom



Tapping 10-15 times
with palm of hand
for single use molds
susceptible to damage



Procedure - Rodding

23

Filling 2nd Layer

2ND LAYER

(6" x 12" Cylinders)



Measuring 1 inch



Rodding 25 times Tapping 10-15 times



Procedure - Rodding

29

Filling Final 3rd Layer **3RD LAYER** (6"x 12" Cylinders)

Measuring 1 inch
Rodding 25 times
Tapping 10-15

After Tapping the last layer go to the
Procedure - Rodding **Finishing Procedure for Cylinders.** 25

VIBRATING

2 Lifts
6 x 12"
2 Locations

26

PROCEDURE

- The concrete is placed into the mold by use of a scoop or shovel, in 2 equal lifts/layers.
- Place all the concrete for each layer in before commencing vibration of the layer.
- Avoid touching the sides or bottom of the mold.
- When placing the second lift into the mold be sure not to overfill by more than $\frac{1}{4}$ ".
- Extend the vibrator into the *lower* layer approximately 1"

27

- Slowly remove vibrator so that no large air pockets are left in the specimen.
- Number of Insertions per lift:
 - **1 location** for 4" x 8" cylinders.
 - **2 locations** for 6" x 12" cylinders.
- Continue vibration only long enough to achieve proper consolidation.
 - Generally up to 5 seconds with slumps greater than 3" is sufficient, longer times may be necessary with lower slumps, however exceeding 10 seconds is rare.
 - After vibrating the lift, tap the sides with an open hand 10-15 times for light gauge molds other wise you may use a mallet.

Procedure for Vibrating

28

- **NOTE:** For single use molds (plastic) susceptible to damage, use an **open hand** to tap the outside 10-15 times to avoid damaging the mold.



- After tapping the last layer go to the Finishing Procedure for Cylinders.

Procedure for Vibrating

29

6 by 12 inch Cylinders	
Rodding - Use a $\frac{5}{8}$ inch Rod	Vibration
3 Lifts	2 Lifts
25 Roddings per lift Penetrate previous layer by 1 inch	2 insertion per lift Typically ≤ 5 seconds is required
Tap 10-15 times with a mallet per lift Use open hand on molds easily damaged by a mallet	Tap 10-15 times with a mallet per lift Use open hand on molds easily damaged by a mallet

30

4 by 8 inch Cylinders	
Rodding - Use a $\frac{3}{8}$ inch Rod	Vibration
2 Lifts	2 Lifts
25 Roddings per lift Penetrate previous layer by 1 inch	1 insertion per lift Typically ≤ 5 seconds is required
Tap 10-15 times with a mallet per lift Use open hand on molds easily damaged by a mallet	Tap 10-15 times with a mallet per lift Use open hand on molds easily damaged by a mallet

31

FINISHING PROCEDURE FOR CYLINDERS



32

- Perform all finishing with minimum manipulation necessary to produce a flat even surface that is level with the rim or edge of the mold and that has no depressions or projections larger than $\frac{1}{8}$ inch.
- Finishing tools: handheld float, trowel, or tamping rod
- Wipe off the excess concrete and put the cap on.

Finishing Procedure

33

Use the Tamping Rod to level the top



Put the cap on
and ID the container

Finishing Procedure

34

- Mark the specimens using a method that will not alter the top surface of the concrete.
 - Do not mark the removable caps.

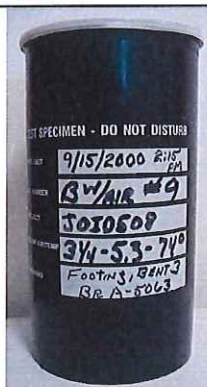


Finishing Procedure

35

Written Identification:

- Cylinder number
- ID number
- Date of pour
- Project information
- Cement factor
- Class of concrete



Identification

36

- Secure the cap to the mold.
(use Duct tape)
- Move cylinders to their
initial curing position
dependent on their ultimate
use.



Finishing Procedure

37

- After molding, the specimens are immediately
moved to a safe location for curing and are not
moved again until hardened to prevent damage.
- When moved they are placed into the proper
curing environment, dependent on their intended
use.
- Upon removal of the
molds, mark the test
specimens to retain
their identities.



Finishing Procedure

38

CURING

- **Curing** is the maintaining of moisture and
temperature conditions for proper hydration of the
concrete mixture.



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• **Standard Curing**

- Acceptance testing for specified strength
- Checking adequacy of mixture proportions
- Quality control

• **Field Curing**

- Determining when a structure may be put into service
- Form removal time
- Checking adequacy of curing and protection of structure
- Comparison tests

Curing
50

Standard Curing

- Includes two parts:

- 1. Initial Curing:** Is the time period in which the fresh concrete “sets” and becomes rigid.
- 2. Final Curing:** Is the time period in which the fresh concrete begins to harden and gain strength.

41

Standard Curing - Initial


- **Initial Curing Conditions:**
 - **Time Period**
 - Up to 48 hours after molding
 - **Temperature** (Record temp. using a Max-Min Thermometer)
 - For specimens < 6000 psi
 - 60 to 80 °F
 - For specimens ≥ 6000 psi
 - 68 to 75 °F
 - **Moisture Environment**
 - Store in properly constructed boxes
 - Damp sand pits
 - Cover with removable plastic lids
 - Place inside plastic bags (MoDOT Preferred)
 - Immediately immerse with plastic lids in water saturated with calcium hydroxide

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Standard Curing - Initial

- **Shield specimens from direct sunlight or heat or loss of moisture.**
- **Controlling Temperature Environment**
 - Thermostatically controlled heating and cooling devices
 - Light bulbs or stoves
 - Fans
 - Water baths
 - Ice
 - Ventilation



43



Standard Curing - Final

- **Final Curing Conditions**
 - **Remove Molds**
 - Copy identification markings on to specimen
 - Final curing must begin within 30 minutes of mold removal
 - **Final Curing**
 - Maintain free water on surfaces at all times using;
 - Moist rooms
 - Storage tanks
 - Temperature $73.5 \pm 3.5^{\circ}\text{F}$

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Standard Curing - Final

MODOT EPG: Use water storage tanks or moisture rooms per AASHTO M201 (ASTM C511).

NOTE: Additional information on curing can be found in MODOT's EPG section 501

45

Standard Curing - Field

- **Field Curing**

- Approximates what is happening to the structure itself, so specimens are treated as closely as possible to the structure.

- **Cylinders**

- Shall be stored and cured on or near the structure, and in the same environment as the formed work.

- » Provide like temperature and moisture environment as the formed work

- » Remove cylinders from molds when formwork is removed

46

Standard Curing - Field

- **Testing**

- Remove from the field

- » Maintain moisture and test in “as is” condition

47

TRANSPORTATION

- Prior to transporting, cure and protect specimens as required.
- Specimens shall not be transported until at least 8 hours after initial set.
- Specimens may be transported to the central Laboratory for final curing. (MoDOT)
- To transport, after the initial cure period, the specimen shall be removed from the mold and placed in a plastic bag to maintain free moisture during shipping. (MoDOT)

48

- During transporting, protect the specimen with suitable cushioning material to prevent damage from jarring.
- During cold weather, protect the specimens from freezing with suitable insulated material.
- Prevent moisture loss during transportation by wrapping the specimens in plastic, wet burlap, surrounding them with wet sand, or tight-fitting plastic caps on plastic molds.
- Transportation time shall not exceed 4 hours.

Transportation

49

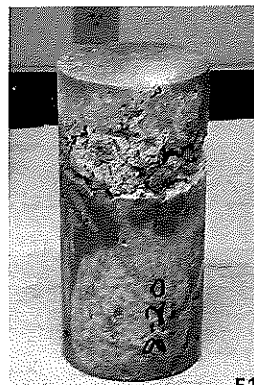
REPORT

- **Identification number**
- **Location** of concrete represented by the samples
- **Date, Time, and Name** of individual molding specimens
- **Slump, air content, and concrete temperature, test results** and results of any other tests on the fresh concrete, and any **deviations** from the standard test methods.
- **Curing Method –**
 - **For Standard Curing:** Report the initial with Max and Min Temperatures and final curing method.
 - **For Field Curing:** Report the location where stored, manner of protection from the elements, temperature, and moisture environment, and time of removal from molds.

50

Common Errors:

- Not enough or too many strokes of rod per layer
- Uneven distribution of strokes around layer
- Mold not lightly tapped after rodding each layer
- Shipped without maintaining proper moisture



51

TABLES

52

AASHTO Table 1

Tamping Rod Requirements

Diameter of cylinder or Width of Beam mm (inch)	Rod Dimensions ^a	
	Diameter mm (inch)	Length of rod mm (inch)
< 150 (4)	10 (3/8)	300 (12)
150 (6)	16 (5/8)	500 (20)
225 (9)	16 (5/8)	650 (26)

^aRod tolerances length ± 100 mm (4 inches) and diameter ± 2 mm ($1/16$ inch).

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AASHTO Table 3

Method of Consolidation Requirements

Slump, mm (in)	Method of Consolidation
≥ 25 mm (≥ 1 inch)	Rodding or Vibration
≤ 25 mm (≤ 1 inch)	Vibration

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AASHTO Table 4 - Cylinders		
Molding Requirements by Rodding		
Specimen Type and Size	Number of Layers of Approximately Equal Depth	Number of Roddings per Layer
Cylinders:		
Diameter, mm (inch)		
100 (4 inch)	2	25
150 (6 inch)	3	25
225 (9 inch)	4	50

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AASHTO Table 5

Table 5 – Molding Requirements by Vibration			
Specimen Type and Size	Number of Layers	Number of Vibrator Insertions per Layer	Approximate Depth of Layer
Cylinder Diameter**			
4 in.	2	1	1/2 depth of specimen
6 in.	2	2	1/2 depth of specimen
9 in.	2	4	1/2 depth of specimen
Beam Width			
6 to 8 in.	1	*	depth of specimen as near as practicable
>8 in.	2 or more	*	depth of specimen as near as practicable

* Vibrator inserted at intervals not exceeding 6 in. along center of line of long dimension of specimen. For specimens wider than 6 in., use alternating insertions along two lines.

** Cylinders at least three times the nominal maximum size of the coarse aggregate

501.1.3.4 Protection of sample

After the sample has been obtained, it must be protected from direct sunlight and wind until it is used, which must not be more than 15 minutes after sampling. When the sample has been moved to the place where the test is to be made or specimens are to be molded it should be mixed with a shovel if necessary to assure uniformity of the mixed sample.

501.1.3.5 Compressive Strength

Compressive tests are performed both in the field and in the laboratory on cylindrical specimens of concrete, 6 in. diameter and 12 in. tall (6x12) or 4 in. diameter and 8 in. tall (4x8). The Standard Specifications require use of compressive specimens for job control of concrete production.

All concrete for air and slump tests as well as preparation of the specimens should be secured from a single batch of concrete. Air and slump tests should always be made on samples of concrete used for preparation of compressive specimens.

Cylinder forms shall be filled with fresh concrete in accordance with the instructions provided by AASHTO T 23 (ASTM C 31). Care should be taken when placing the caps on the molds to avoid damage to the surface of the concrete. The lids should be kept on tight to prevent moisture loss.

501.1.3.5.1 Curing

Curing of compressive specimens will depend on whether they are for standard cure or field cure.

Standard Cure is defined as 1) specified strength for 28-day testing; 2) Check of mixture proportions or design strength; 3) Quality control (i.e. monitoring mix variability) or 4) Maturity meter curve.

Standard curing involves two phases of curing: initial and final.

Each set of compressive test specimens for standard cure consists of two 6x12 cylinders or three 4x8 cylinders. Standard Cure specimens shall be cured in accordance with AASHTO T23 (ASTM C31) for initial and final curing.

Standard Cure – Initial

If specimens cannot be molded at the place where they will receive initial curing, immediately after finishing move the specimens to an initial curing place for storage. Recommended method for initial curing is keeping the specimen in the plastic mold covered with a plastic lid or place in a damp sand pit for a maximum of 48 hours in a temperature range from 60° F to 80° F and an environment preventing moisture loss.

Standard Cure - Final

Upon completion of initial curing and within 30 minutes of removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of 70° F to 77° F using water storage tanks or moisture room per AASHTO M201 (ASTM C511).

Storage Tanks When water tanks are used for final curing the temperature shall be maintained at 70° F to 77° F. Method of recording temperature is required. **Transportation of Specimens** Specimens may be transported to the Central Laboratory for final curing. To transport, after the initial cure period, the specimen shall be removed from the mold and placed in a plastic bag to maintain free moisture during shipping. Specimens should not be transported to begin final cure until at least 8 hours after final set. During transporting, use suitable material to prevent damage from jarring and use suitable insulation material during cold weather. Show shipper's name and address on the outside of the box. The box comes with the address of Central Laboratory printed on the side and a preprinted form that provides basic information about the cylinders. If the box does not have the form preprinted, contact the Central Laboratory for copies of the self stick form. SiteManager Sample ID number should be written on the side of cylinders or cylinder molds. Necessary boxes, cardboard liners, polyethylene bags, wire ties and rolls of strapping tape are stock items available by requisition.

Field Curing

Field cure is defined as 1) Opening to traffic strength or staged construction; 2) Comparison with test results of standard cure to in place methods, such as maturity method verification; 3) Adequacy of curing and protection of concrete in the structure, such as cold weather placement or 4) Form removal.

Field curing shall be in accordance with AASHTO T23 (ASTM C 31). Store cylinders in or on the structure as near as practical to the represented concrete. Protect all surfaces of the cylinders from the elements, and ensure a temperature and moisture environment similar to the formed work. To meet these conditions specimens made for the purpose of determining when a structure is capable of being put in service shall be removed from the molds at the time of removal of form work.

Compressive test specimens for field cures may consist of one or more for either 6x12 cylinders 4x8 cylinders. Specimens prepared to determine when forms may be removed will be cured as described in above except for bridge decks or heated concrete. Specimens representing bridge decks are to be cured on the deck under wet mats until the cylinders are to be broken or wet curing is discontinued. If cylinders remain after wet curing has ended, they shall be cured in plastic molds under field conditions until they are to be broken.

Specimens representing heated concrete are to be left in the enclosure subject to the same protection as concrete they represent until they are to be broken. Cylinders should be left in molds and covered with wet burlap for 48 hours. If cylinders remain after the heating period has ended they shall be cured in plastic molds under field conditions until they are to be broken.

Curing of bridge decks shall be in accordance with Standard Specification 704, wet curing shall be maintained for 7 days and until the concrete has reached a minimum of 3000 psi.

AASHTO T 23 Making and Curing of Concrete Cylinder Specimens in the Field PROFICIENCY CHECKLIST

Applicant: _____

Employer: _____

Trial#	1	2
Sampled concrete per AASHTO R60		
Conducted Slump, Air Content, and Temperature Tests a. Reported results.		
Molding Cylinders		
1. Each layer properly consolidated per results of Slump, AASHTO T119		
2. 4" x 8" Mold filled in 2 approx. equal layers (Vibrated = 2 layers)		
6" x 12" Mold filled in 3 approx. equal layers (Vibrated = 2 layers)		
3. Rod each layer 25 times a. 4" x 8", vibrator, one location per layer b. 6" x 12", vibrator, two locations per layer		
4. Mold tapped lightly 10 to 15 times after each layer		
5. Mold tapped with open hand for light gauge single use molds		
6. Cylinder finished using either a tamping rod, handheld float, or a trowel so that the specimen is level with the rim of the mold.		
7. Mold properly cleaned and sealed with cap		
8. Identification information written on the container		
9. Set up initial cure per AASHTO T23 at 60-80°F		
10. Reported all core information, temperatures, and curing information		

PASS PASS

FAIL FAIL

Examiner: _____ Date: _____

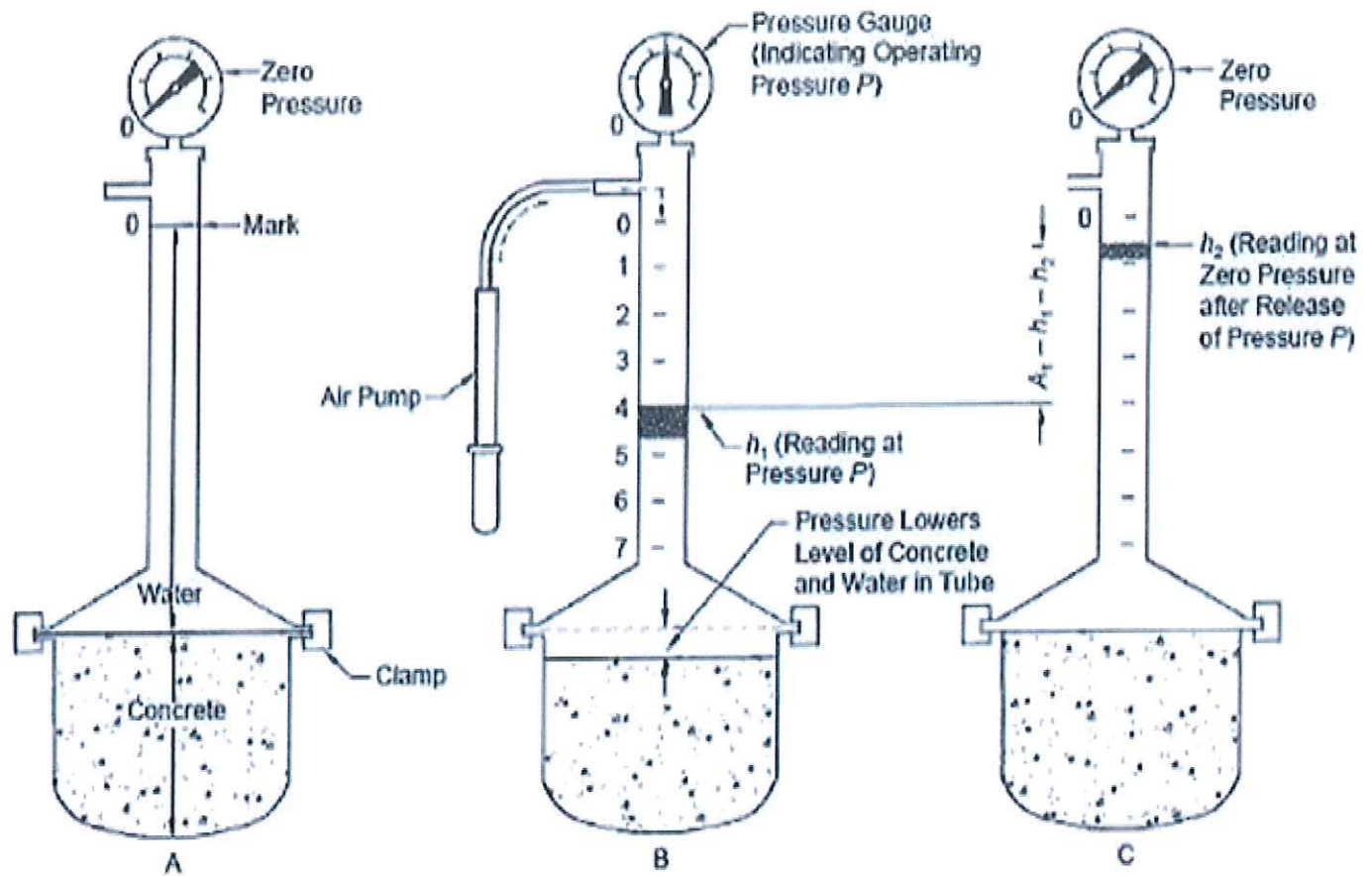
4.-- APPARATUS

4.1-- Air Meters – There are two basic designs Meter Type A and Meter Type B.

4.1.1-- Meter Type A – an air meter consisting of a measuring bowl and cover assembly, see image below:



Meter Type A



Note: $A_1 = h_1 - h_2$ when measuring bowl contains concrete as shown in this figure; when measuring bowl contains only aggregate and water, $h_1 - h_2 = C$ (aggregate correction factor).
 $A_1 - C = A$ (entrained air content of concrete).

Figure 1—Illustration of the Pressure Method for Air Content: Type A Meter

The operational principle of this meter consists of introducing water to a predetermined height above a sample of concrete of known volume and the application of a predetermined air pressure over the water. The determination consists of the reduction in volume of the air in the concrete sample by observing the amount the water level is lowered under the applied pressure, the latter amount being standardized in terms of percent of air in the concrete sample.

4.1.2-- Meter Type B — An air meter consisting of a measuring bowl and cover assembly, see image below:

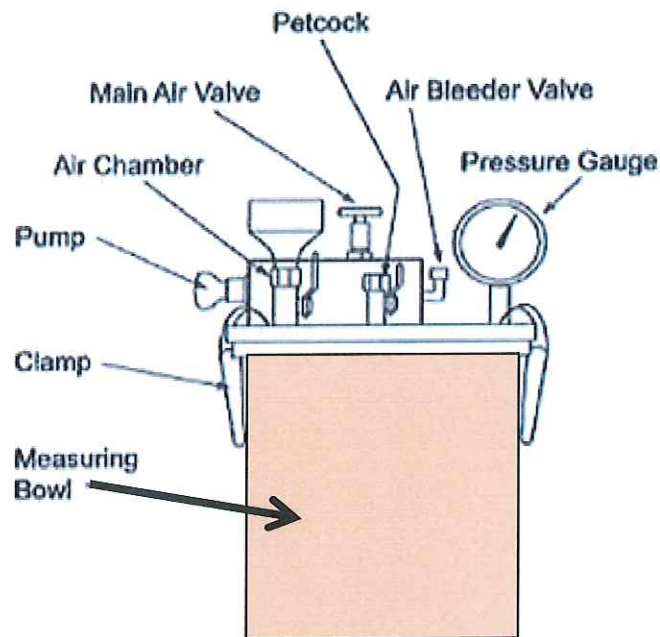


Meter Type B

The operational principle of this meter consists of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample, the dial on the pressure gauge being standardized in terms of percent air for the observed pressure in which equalization takes place. Working pressures of 7.5 to 300 psi have been used satisfactorily.

4.2-- Measuring Bowl — Must be cylindrical in shape, made of steel, hard metal, or other hard material not readily attacked by the cement paste, having a minimum diameter equal to 0.75 to 1.25 times the height, and a capacity of at

least 0.20 ft³. It shall be flanged or otherwise constructed to provide for a pressure-tight fit between the measuring bowl and the cover assembly. The interior surfaces of the measuring bowl and surfaces of rims, flanges, and other component fitted parts shall be machined smooth. The measuring bowl and cover assembly shall be sufficiently rigid to limit the expansion factor, D , of the apparatus assembly (**Annex A1.5**) to not more than 0.1% of air content on the indicator scale when under normal operating pressure.



2a. Horizontal Air Chamber

4.3-- Cover Assembly:

4.3.1-- The cover assembly shall be made of steel, hard metal, or other hard material not readily attacked by the cement paste. It shall be flanged or otherwise constructed to provide for a pressure-tight fit between measuring bowl and cover assembly and shall have machined smooth interior surfaces contoured to provide an air space above the level of the top of the measuring bowl. The cover shall be rigid to limit the expansion factor of the apparatus assembly as prescribed in Section 4.2.

4.3.2 --The cover assembly shall be fitted with a means of direct reading of the air content. The cover for the **Type A meter** shall be fitted with a standpipe, which may be a transparent graduated tube or may be a metal tube of uniform bore with a glass water gauge attached. In the **Type B meter**, the dial of the pressure gauge shall be standardized to indicate the percent of air. Graduations shall be provided for a range in air content of at least 8%, easily readable to 0.1%, as determined by the proper air pressure standardization test.

4.3.3-- The cover assembly shall be fitted with air valves, air bleeder valves, for bleeding off air, and petcocks through which water may be introduced as necessary. The cover shall have a way to clamp or tighten down to the measuring bowl and provide a pressure-tight seal without entrapping air at the joint between the flanges of the cover and the measuring bowl. A suitable hand pump shall be provided with the cover, either as an attachment or as an accessory.

4.4-- Standardization Vessel – A measure having an internal volume equal to a percent of the volume of the measuring bowl corresponding to the approximate percent of air in the concrete to be tested; or, if smaller, it shall be possible to check standardization of the meter indicator at the approximate percent of air in the concrete to be tested by repeated filling of the measure. When the design of the meter requires placing the standardization vessel within the measuring bowl to check standardization, the measure shall be cylindrical in shape and of an inside depth $\frac{1}{2}$ inch less than that of the measuring bowl.

NOTE: When design of the meter requires withdrawing of water from the water-filled measuring bowl and cover assembly to check standardization, the measure may be an integral part of the cover assembly or maybe a separate cylindrical measure.



4.5-- The designs of various available types of air meters are such that they differ in operating techniques and, therefore, all of the items described in sections 4.6 through 4.16 may not be required.

4.6-- Coil Spring or Other Device – for Holding Standardization Cylinder in Place

4.7-- Spray Tube – a brass tube of appropriate diameter, which may be an integral part of the cover assembly or which may be provided separately. It shall be so constructed that when water is added to the container, it is sprayed to the walls of the cover in such a manner as to flow down the sides causing a minimum of disturbance to the concrete.

4.8 --Trowel – A standard brick mason's trowel

4.9-- Tamping Rod – A round, straight steel rod, with a $\frac{5}{8}$ inch \pm $\frac{1}{16}$ inch diameter, the length shall be at least 4 inches greater than the depth of the measure in which rodding is being performed but not greater than 24 inches in overall length. The length tolerance for the tamping rod is $\pm \frac{1}{8}$ inch. The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.

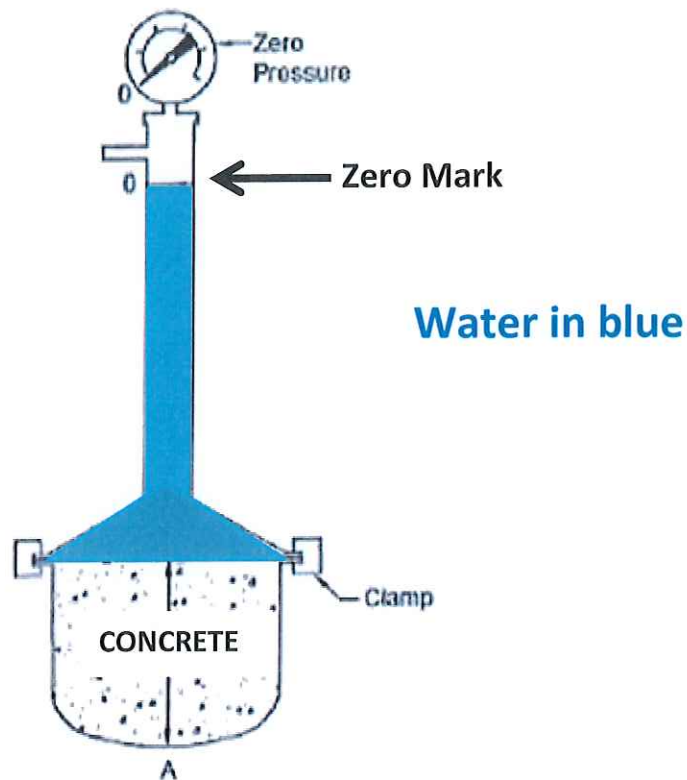
4.10-- Mallet – a mallet (with a rubber or rawhide head) weighing approximately 1.25 ± 0.50 pounds for use with measures of 0.5 ft^3 or smaller and a mallet weighing approximately 2.25 ± 0.50 pounds for use with measures larger than 0.5 ft^3 .

4.11-- Strike-Off Bar – a flat straight bar of steel or other suitable metal at least $\frac{1}{8}$ inch thick and $\frac{1}{4}$ inch wide by 12 inches long.

4.12-- Strike-Off Plate – A flat rectangular metal plate at least $\frac{3}{4}$ inch thick or a glass or acrylic plate at least $\frac{1}{2}$ inch thick with a length and width at least 2 inches greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of $\frac{1}{16}$ inch.

4.13-- Funnel – With the spout fitting into a spray tube.

4.14-- Measure for Water – Having the necessary capacity to fill the indicator with water from the top of the concrete to the zero mark.



4.15 -- Vibrator – as described in R39.

» *Internal Vibrator*

- ≥ 9000 vpm
- Element $\frac{3}{4}$ " - $1\frac{1}{2}$ " dia.
- Length of shaft and element must exceed depth of section by ≥ 3 "



4.16 – Sieves - $1\frac{1}{2}$ inch with not less than 2 ft^2 of sieving area.

4.17 – Scoop – Of a size large enough so each amount of concrete obtained from the sampling receptacle is representative and small enough so it is not spilled during placement in the measuring bowl.

6-- Standardization of a Type A Meter

6.1 Make standardization tests in accordance with procedures prescribed in the annex. Rough handling will affect the standardization of Type A meters. Changes in barometric pressure will also affect the standardizations of Type A meters.

The steps described in **Sections A1.2 to A1.6**, as applicable to the meter type under consideration, are prerequisites for the final standardization test to determine the operating pressure, P , on the pressure gauge of the Type ammeter as described in **Section A1.7**. Normally the steps in **Sections A1.2 to A1.6** need be made only once (at the time of initial standardization) or only occasionally to check volume constancy of the standardization cylinder and measuring bowl. On the other hand the standardization test described in **Sections A1.8 and A1.9**, as applicable to the meter type being standardized, must be made as frequently as necessary to ensure that the proper gauge pressure, P is being used for the Type A meter. A change in elevation of more than 600 feet from location at which a Type A meter was last standardized will require re-standardization in accordance with **Section A1.8**.

7.4-- Aggregate Correction Factor Determination for Type A meters

7.4.1 – Initial Procedure for Type A Meter – When all of the aggregate has been placed in the measuring bowl (see slide show for 7.3 for placement of Aggregate in the Measuring Bowl), remove excess foam and keep the aggregate inundated for a period of time approximately equal to the time between introduction of the water into the mixer and the time of performing the test for air content before proceeding with the determination as directed in section 7.4.2 or 7.4.3

7.4.2 – Type A Meter – Complete the test as described in section 8.1 through 9.3.2. The aggregate correction factor, G , is equal to $h_1 - h_2$. (See figure 1) The aggregate correction factor will vary with different aggregates. It can be determined only by test, because apparently is not directly related to absorption of the particles. The test can be easily made and should not be ignored. Ordinarily the factor will remain reasonable constant for given aggregates, but an occasional check test is recommended.

9.3 – Procedure for Determining Air Content of Concrete– Type A Meter

Preparation for Test – NOTE: See section 9 on the slide show for placement of, and consolidation by Rodding or Vibrating the concrete sample.

Thoroughly clean the flanges or rims of the measuring bowl and of the cover assembly so that when the cover is clamped in place a pressure-tight seal will be obtained. Assemble the apparatus and add water over the concrete by means of the tube until it rises to about the halfway mark in the standpipe. Incline the apparatus assembly about 30 degrees from vertical and, using the bottom of the measuring bowl as a pivot, describe several complete circles with the upper end of the column, simultaneously tapping the cover lightly to remove any entrapped air bubbles above the concrete sample. Return the apparatus assembly to a vertical position and fill the water column slightly above the zero mark, while lightly tapping the side of the measuring bowl. Bring the water level to the zero mark of the graduated tube before closing the vent at the top of the water column.

9.3.3—Test Procedure – Apply slightly more than the desired test pressure, P (about 0.2psi), to the concrete by means of the small hand pump. To relieve local restraints, tap the sides of the measure sharply and, when the pressure gauge indicates the exact test pressure, P , as determined in accordance with Section A1.7, read the water level, h_1 , and record to the nearest division or half-division on the graduated precision-bore tube or gauge glass of the standpipe. See figure 1B, for extremely harsh mixes, it may be necessary to tap the measuring bowl vigorously until further tapping procedures no change in the indicated air content. Gradually release the air pressure through the vent at the top of the water column and tap the sides of the measuring bowl lightly for about 1 minute record the water level, h_2 , to the nearest division or half-division.

See figure 1C, calculate the apparent air content as follows:

$$A1 = h1 - h2$$

Where:

A1 = apparent air content

h1 = water level reading at pressure, P

h2 = water level reading at zero pressure after release of pressure, P

9.3.4-- Check Test – Repeat the steps described in section 9.3.3 without adding water to reestablish the water level at the zero mark. The two consecutive determinations of apparent air content should check within 0.2 percent of air and shall be averaged to give the value A1 to be used in calculating the air content, As, in accordance with Section 10.

9.3.5—In the event the air content exceeds the range of the meter when it is operated at the normal test pressure P, reduce the test pressure to the alternative test pressure P1 and repeat the steps outlined in sections 9.3.3 and 9.3.4.

$$P1 = Pa \cdot p / (2Pa - P)$$

Where:

P1 = alternative test pressure, psi

Pa = atmospheric pressure, psi (approximately 14.7psi but will vary with altitude and weather conditions);

P = normal test or operating gauge pressure, psi

5.2 Apparatus: Reference Temperature Measuring Device,

Will be readable and accurate to $\pm 0.2^{\circ}\text{C}$ (0.5°F) at the verification points as stated in 6.1 below. A certificate or report that verifies the accuracy shall be available in the laboratory for review. Accuracy of liquid-in glass reference temperature measuring devices shall be verified once. Verification of direct-reading resistance reference temperature measuring devices shall be performed at least every twelve months. The certificate or report shall provide documentation that the reference standard used in the verification is traceable to the National Institute of Standards and Technology (NIST)

6. Verification of the Accuracy of Temperature Measuring Devices

6.1 The accuracy of each temperature measuring device used for determining the temperature of freshly mixed concrete shall be verified at least annually, or whenever there is a question of accuracy. Verify the accuracy of the temperature measuring device by comparing the readings of the reference temperature measuring device to the temperature measuring device at two temperatures at least 15°C (30°F) apart.

6.2 Verification of the accuracy of the temperature measuring devices may be made in oil or other suitable bath liquids having uniform density if provision is made to:

6.2.1 maintain the bath temperature constant within 0.2°C (0.5°F) during the verification process.

6.2.2 Continuously circulate the bath liquid to provide a uniform temperature throughout the bath.

6.2.3 Suspend the temperature measuring devices in such a manner that the devices are not contacting the sides or bottom of the bath container during verification.

6.3 Place both the temperature and reference temperature measuring devices in the bath for at least 5 min before reading temperatures at the test points specified in 6.1.

6.4 Prior to reading the temperature measuring devices, if the temperature in the bath has been reduced, slightly tap thermometers containing liquid to avoid adhesion of the liquid to the glass.

6.5 Read and record the temperature of both the reference temperature measuring device and the temperature measuring device. Reject the temperature measuring device if the difference in readings exceeds 0.5°C (1°F) at either test point. If the indicator of the rejected temperature measuring device is adjustable, reverification is permitted after adjustment. In addition to the temperature readings, record the identification numbers of both devices used, the date verified, and the name of the individual performing the verification.

Apparatus

Molds, General – Molds for specimens or fastenings in contact with the concrete shall be made of steel, cast iron, or other nonabsorbent material, nonreactive with concrete containing portland or other hydraulic cements. Molds shall hold their dimensions and shape under conditions of use. Provisions for tests of watertightness are given in M205M/M205. A suitable sealant, such as heavy greases, modeling clay or microcrystalline wax shall be used where necessary to prevent leakage through the joints. Positive means shall be provided to hold base plates firmly to the molds. Reusable molds shall be lightly coated with mineral oil or a suitable nonreactive form release material before use.

Cylinder – Molds for casting concrete test specimens shall conform to the requirements of M205M/M 205.



Beam Molds – beam molds shall be of the shape and dimensions required to produce the specimens stipulated in section in T23. The inside surfaces of the molds shall be smooth. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warpage. Maximum variation from the nominal cross section shall not exceed 3.2mm (1/8 inch) shorter than the required length in accordance with section 6.2 in AASHTO T23.



Tamping Rods – A round, smooth, straight, steel rod with a diameter conforming to the requirements in Table 1. The length of the tamping rod shall be at least 100mm (4inch) greater than the depth of the mold in which rodding is being performed, but not greater than 600mm (24inch) in overall length. The rod shall have the tamping end or both ends rounded to a hemispherical tip of the same diameter as the rod.



Table 1—Tamping Rod Requirements

Diameter of Cylinder or Width of Beam, mm (in.)	Rod Dimensions ^a	
	Diameter, mm (in.)	Length of Rod, mm (in.)
<150 (6)	10 (³ / ₈)	300 (12)
150 (6)	16 (⁵ / ₈)	500 (20)
225 (9)	16 (⁵ / ₈)	650 (26)

^a Rod tolerances length ± 100 mm (4 in.) and diameter ± 2 mm (¹/₁₆ in.).

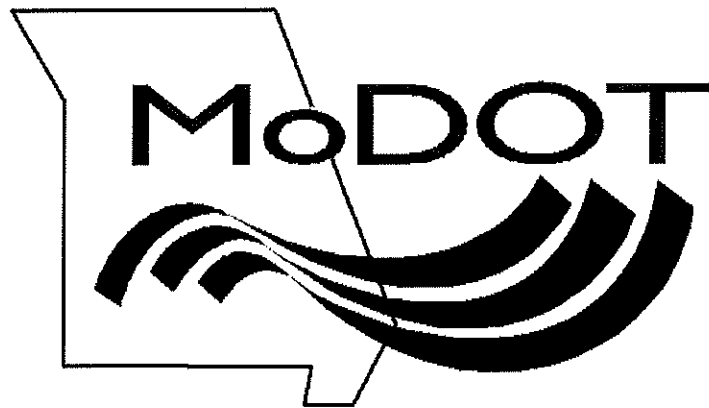


Vibrators – An Internal vibrator shall be used. The vibrator frequency shall be at least 9000 vibrations per minute (150Hz) while the vibrator is operating in the concrete. The diameter of a round vibrator shall be no more than $\frac{1}{4}$ of the diameter of the cylinder mold or $\frac{1}{4}$ the width of the beam mold. Other shaped vibrators shall have a perimeter equivalent to the circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 75mm (3inches). The vibrator frequency shall be checked periodically.

Air content apparatus – The apparatus for measuring air content shall conform to the requirements of T196M/T196 or T152

Temperature Measuring Devices – the temperature measuring devices shall conform to the applicable requirements of MT 20.

Glossary



Glossary of Terms

AASHTO

American Association of State Highway and Transportation Officials

Absolute Volume (V)

The absolute volume of each ingredient in cubic yards is equal to the quotient of the mass of the ingredient divided by the product of its specific gravity times 62.4. The absolute volume of each ingredient in cubic meters is equal to the mass of the ingredient in kilograms divided by 1000 times its specific gravity.

Aggregate Correction Factor

An easily run test that accounts for air in the aggregate structure which fills with water under pressure. It is determined on inundated fine and coarse aggregate in approximately the same moisture condition, amount and proportions occurring in the concrete sample under test.

Air Content

The amount of air in mortar or concrete, exclusive of pore space in the aggregate particles, usually expressed as a percentage of total volume of mortar or concrete.

Air Void

A space in cement paste, mortar, or concrete filled with air, and entrapped air void is characteristically 1mm (0.04 in.) or more in size and irregular in shape; an air entrained air void is typically between 10µm and 1mm in diameter and spherical (or nearly so).

Batch Weights

Quantity of concrete or mortar mixed at one time.

Bulk Specific Gravity and Mass

For the aggregate components, the bulk specific gravity and mass should be based on the saturated surface-dry condition. For cement, the actual specific gravity should be determined by T133. A value of 3.15 may be used for cements manufactured to meet the requirements of M85.

Central Mixed Concrete

A stationary concrete mixer from which the fresh concrete is transported to the work.

Compression Test

Test made on a specimen of mortar or concrete to determine the compressive strength; unless otherwise specified, compression tests of mortars are made on 50mm (2 in.) cubes, and compression tests of concrete are made on cylinders either 4 inches in diameter and 8 inches in height or 6 inches in diameter and 12 inches in height.

Compressive Strength

The measure resistance of a concrete or mortar specimen to axial loading; expressed as pounds per square inch (psi) of cross-sectional area.

Concrete

A composite material that consists essentially of a binding medium in which is embedded particles or fragments of relatively inert material filler. In Portland cement concrete, the binder is a mixture of Portland cement and water; the filler may be any of a wide variety of natural or artificial aggregates.

Consistency

The relative mobility or ability of fresh concrete or mortar to flow. The usual measures of consistency are slump or ball penetration for concrete and flow for mortar.

Consolidation

The process of inducing a closer arrangement of the solid particles in freshly mixed concrete or mortar during placement by the reduction of voids, usually by vibration, centrifugation, tamping, or some combination of these actions; also applicable to similar manipulation of other cementitious mixtures, soils, aggregates, or the like.

Core

A cylindrical specimen of standard diameter drilled from a structure or rock foundation to be tested in compression or examined petrographically.

Entrained Air

Round, uniformly distributed, microscopic, non-coalescing air bubbles entrained by the use of air-entraining agents; usually less than 1mm (.04 in.) in size.

Entrapped Air

Air in concrete that is not purposely entrained. Entrapped air is generally considered to be large voids (larger than 1mm [.04 in.]).

Field Cured Cylinders

Test cylinders cured as nearly as practicable in the same manner as the concrete in the structure to indicate when supporting forms may be removed, additional loads may be imposed, or the structure may be placed in service.

Finishing

Leveling, smoothing, compacting, and otherwise treating surfaces of fresh or recently placed concrete or mortar to produce desired appearance and service.

Gradation

The distribution of particles of granular material among various sizes, usually expressed in terms of cumulative percentages larger or smaller than each of a series of sizes (sieve openings) or the percentages between certain ranges of sizes (sieve openings).

Length Measurement

The longitudinal measurement taken along the specimen axis

Plasticity

The property of fresh concrete or mortar which determines its resistance to deformation or its ease of molding.

PSI

Pounds per square inch; a measurement of the compressive, tensile or flexural strength of concrete as determined by appropriate test.

Pumping

The forceful displacement of a mixture of soil and water that occurs under slab joints, cracks, cracks and pavement edges which are depressed and released quickly by high-speed heavy vehicle loads; occurs when concrete pavements are placed directly on fine-grained, plastic soils or erodible sub base materials.

Quality Assurance

Planned and systematic actions by an owner or his representative to provide confidence that a product or facility meet applicable standards of good practice. This involves continued evaluation of design, plan specification development, contract advertisement and award, construction, and maintenance, and the interactions of these activities.

Quality Control

Actions taken by a producer or contractor to provide control over what is being done and what is being provided so that the applicable standards of good practice for the work are followed.

Rebar

Abbreviation for "Reinforcing Bar." Bars, wires, strands, and other slender members embedded in concrete in such a manner that the reinforcement and the concrete act together in resisting forces.

Rod, Tamping

A straight steel rod of circular cross section having one or both ends rounded to a hemispherical tip.

Rodding

Compaction of concrete by means of a tamping rod

Sample

A group of units, or portion of material, taken from a larger collection of units or quantity of material, which serves to provide information that can be used as a basis for action on the larger quantity or the production process; the term is also used in the sense of a sample of observations.

Slump

A measure of consistency of freshly mixed concrete, equal to the subsidence measured to the nearest 6mm ($\frac{1}{4}$ in.) of the molded specimen immediately after removal of the slump cone.

Standard Cure

The curing method used when specimens are intended for acceptance testing for specified strength, checking the adequacy of mixture proportions for strength, quality control.

Strike off

To remove concrete in excess of that required to fill the form evenly or bring the surface to grade; performed with a straight edged piece of wood or metal by means of forward sawing movement or by a power operated tool appropriate for this purpose; also the name applied to the tool.

Tamping

The operation of compacting freshly placed concrete by repeated blows or penetrations with a tamping device.

Thickness Measurement

The length measurement of a core taken perpendicular to the driving surface of a pavement.

Three Point Caliper

A device used to determine the length of a cylindrical shaped specimen consisting of three resting points and a means of evenly measuring nine different points on the opposite end.

Total Mass (M)

The total mass of all materials batched is the sum of the masses of the cement, the fine aggregate in the condition used, the coarse aggregate in the condition used, the mixing water added to the batch, and any other solid or liquid materials used.

Truck-Mixed Concrete

Concrete, the mixing of which is accomplished in a truck mixer

Volumetric Method

Air is removed from a known volume of concrete by agitation in an excess of water. It may be used with any type of aggregate including light weight and porous material. The test is not affected by atmospheric pressure and the specific gravity of the material need not be known.