Superpave Training

MAPA Black To Basics
February 23, 2023
Columbia, MO

Presentation Slides

- Created by David Richardson
- Revisions by Mike Lusher

QC/QA

- **Quality Control** – Contractor
- **Quality Assurance** – Specifying Agency
  - MoDOT Asphalt Plant Inspector
  - MoDOT Construction Inspector

Presentation Topics

- **Superpave QCQA Course Prerequisites**
  - Aggregate Technician
  - Bituminous Technician
- Superpave QCQA Course
  - Gyratory Compactor
  - Maximum Specific Gravity (Rice)
  - Ignition Oven
- Asphalt Aggregate (Consensus) Tests Course (Agg Tech prerequisite)
  - Fractured Face Count
  - Uncompacted Voids
  - Sand Equivalent
- Tensile Strength Ratio (TSR) Course

Superpave QC/QA Prerequisites

- **Aggregate Technician**
  - Aggregate Sampling
  - Sample Size Reduction
  - Gradation
  - Moisture Content
  - Deleterious Material
  - Specific Gravity & Absorption of Fine (FA) & Coarse Aggregate (CA)
  - Flat & Elongated (Thin & Elongated in MoDOT spec Section 403; a Superpave aggregate consensus test)

NOTE: Recent updates are mostly about required types and usage of thermometers.

Superpave QC/QA Prerequisites

- **Bituminous Technician**
  - Sampling Asphalt Binder
  - Sampling Asphalt Mix
  - Mix Sample Size Reduction
  - Mix (Puck/Cores) Specific Gravity
  - Mix Moisture Content (oven)
  - Mix Binder Content (nuclear)
  - Air Voids
  - Temperature

NOTE: Recent updates are mostly about required types and usage of thermometers.

Presentation Topics

- Superpave QCQA Course Prerequisites
  - Aggregate Technician
  - Bituminous Technician
- **Superpave QCQA Course**
  - Gyratory Compactor
  - Maximum Specific Gravity (Rice)
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  - Uncompacted Voids
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GYRATORY COMPACTOR OPERATIONS

AASHTO T 312-[22]

11-24-06 Revision
11-9-07 Revision
1-2-09 Revision
4-22-09 Revision
11-18-09 Revision
11-17-10 Revision
1-19-11 Revision
3-2-12 Revision
2-5-15 Revision
12-28-16 Revision
12-12-18 Revision
1-11-19 Revision
1-14-19 Revision
2-8-19 Revision
2-25-19 Revision
12-17-19 Revision
2-19-23 (ML Revision)

OUTLINE

- ***Introduction***
- Compaction method
- Bulk specific gravity of gyro pucks
- Calculations
- Verification & Calibration

Gyratory Puck


PINE
CAUTION!
106

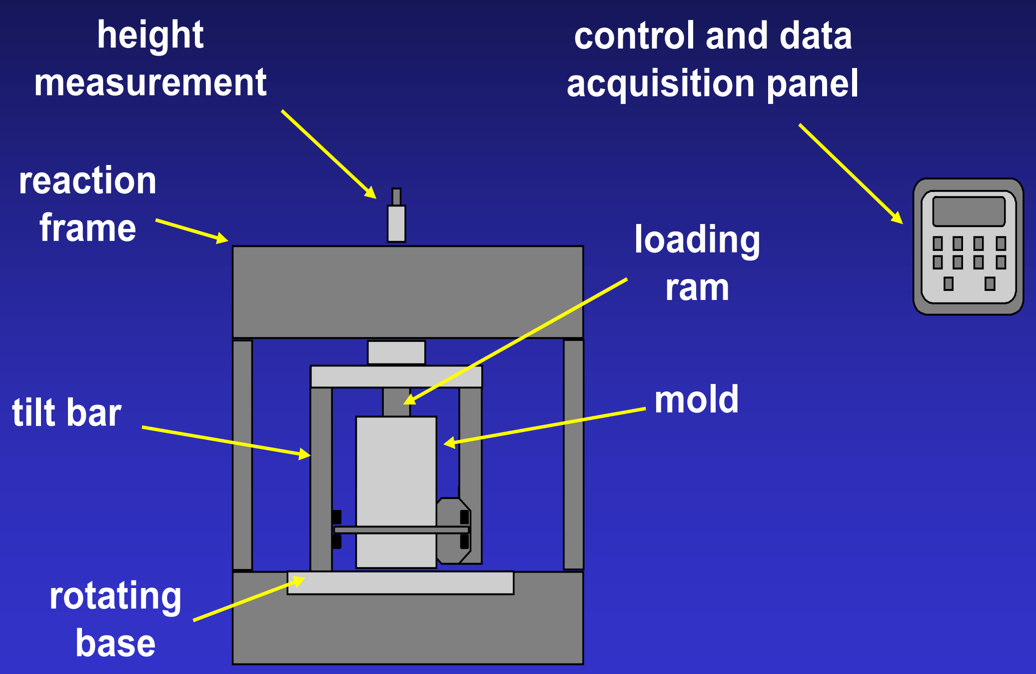
GYRATORY COMPACTOR

- Uses a gyratory motion which compacts by shearing action
- Simulates compacting action achieved under a roller
- The resulting specimen's density, particle orientation and structural characteristics are similar to a pavement

"GYRO"

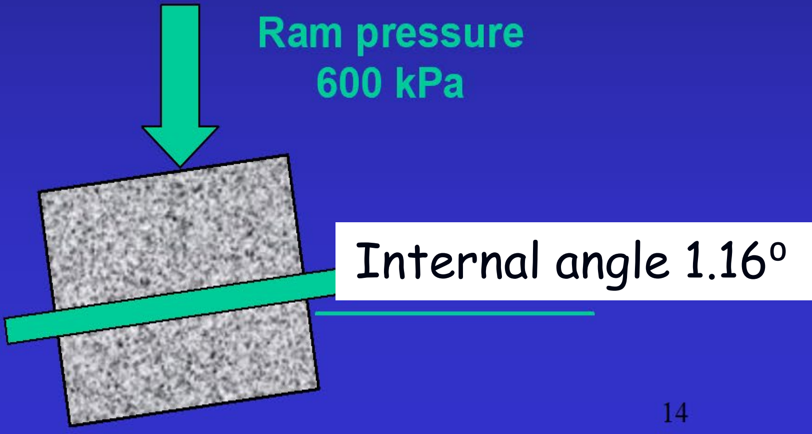
Compaction

Key Components of Gyratory Compactor



Compaction

- Gyratory compactor
  - Axial and shearing action
  - 150 mm diameter molds
    - Aggregate size up to 37.5 mm
    - Height measurement during compaction
      - Allows densification during compaction to be evaluated



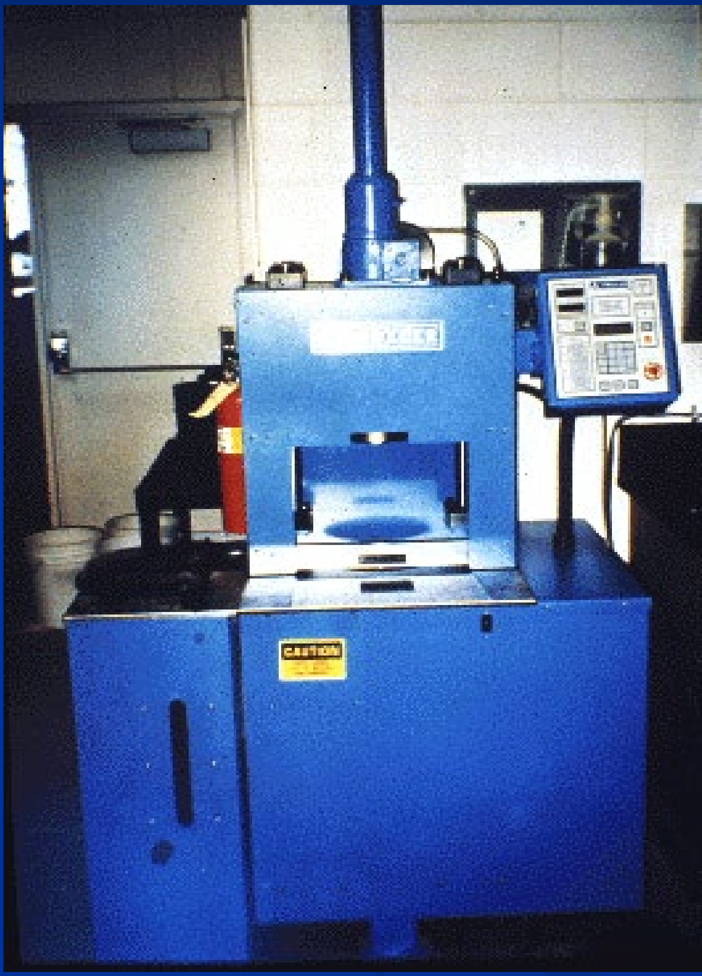
USES of the GYRO

- 1. During ***mix design*** (lab fabricated sample)
- 2. During ***construction*** for field verification (plant-mixed material)

USES, cont'd.

- To evaluate:
  - volumetric properties e.g. ***air voids*** and ***VMA***
  - densification properties e.g. ***tenderness potential***
  - moisture sensitivity (***TSR***)

GYRATORY COMPACTOR




Gyratory Compactor
PINE
PINE Instrument Company
Grove City, Pennsylvania 16127
STAPLES

GYROS
In Missouri

In descending order of usage:

- Big Pine
- Baby Pine
- Troxler 4141
- Troxler 4140
- Brovold

OUTLINE

- Introduction
- ***Compaction method***
- Bulk specific gravity of gyro pucks
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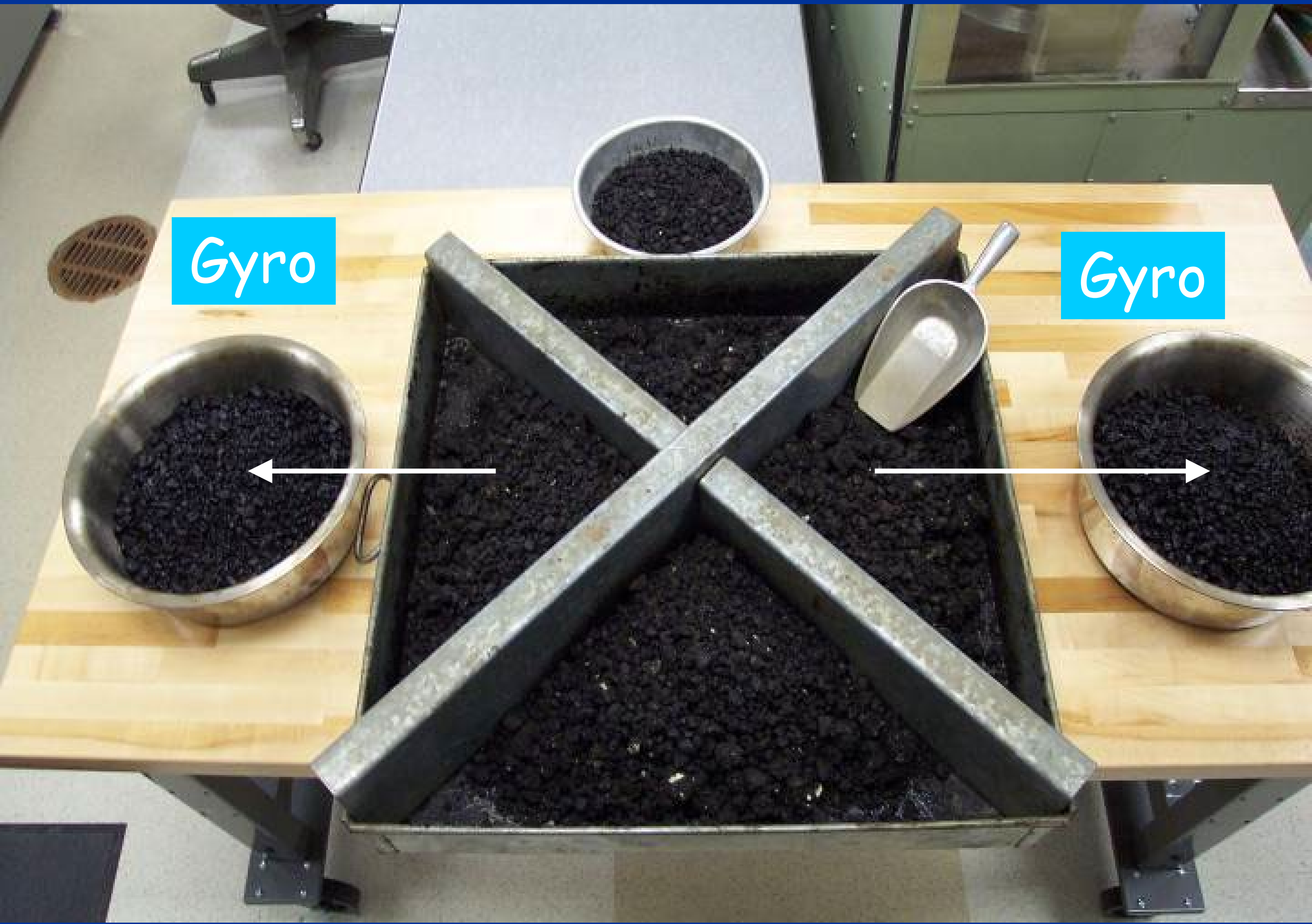
AASHTO TEST METHODS & SPECIFICATIONS

- R35 Volumetric Design Practice
- M323 Volumetric Design Specs
- R30 Mix Conditioning (recently updated)
- ***T 312 Gyro operation***
- ***T 166 Bulk Specific Gravity of gyro pucks***
- T 209 Max Specific Gravity of Voidless Mix (Rice)
- T 283 Moisture Sensitivity
- M 339 Thermometers Used in the Testing of Construction Materials (New)

Volumetrics/Binder Content Sample

- 50 lb. sample –get 2 portions for the 2 volumetric pucks



Location of Gyro Puck Weight on JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03 | **CONTRACTOR = MY BUSINESS** | **SP125 03-16**

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
35JSJ001	100207..LD1	/ Hard Rock Stone, Dig Deep, MO	2.515	2.713	2.9	Jet City Dolo.	5-8	25
35JSJ002	100204..LD1	/ Hard Rock Stone, Dig Deep, MO	2.476	2.725	3.7	Jet City Dolo.	5-8	25
35JSJ003	1002MS..MSLD	/ Hard Rock Stone, Dig Deep, MO	2.480	2.761		Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/ Missy Lime Co. #2, Ste. General, MO	2.303	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ Black Asphalt Products, Decoy, MO	1.023	[illegible]				

MATERIAL IDENT #	35JSJ001	35JSJ002	35JSJ003	30CAJ016	35JSJ0[illegible]	[illegible]	[illegible]	[illegible]	COMB.
03016	3/4"	3/8"	MAN SAND	Hyd. Lime	6[illegible]	[illegible]	[illegible]	[illegible]	GRAD
1 1/2"	100.0	100.0	100.0	100.0	6[illegible]	[illegible]	[illegible]	[illegible]	100.0
1"	100.0	100.0	100.0	100.0	6[illegible]	[illegible]	[illegible]	[illegible]	100.0
3/4"	100.0	100.0	100.0	100.0	6[illegible]	[illegible]	[illegible]	[illegible]	100.0
1/2"	97.6	100.0	100.0	100.0	5[illegible]	[illegible]	[illegible]	[illegible]	98.6
3/8"	83.8	96.1	100.0	100.0	5[illegible]	[illegible]	[illegible]	[illegible]	89.8
#4	31.8	35.0	99.9	100.0	19.1	4.2	26.0	2.0	51.3
#8	7.0	8.0	82.0	100.0	4.2	1.0	21.3	2.0	28.5
#16	2.6	3.5	40.7	100.0	1.6	0.4	10.[illegible]	2.0	14.6
#30	1.6	2.6	26.6	100.0	1.0	0.3	6.9	2.0	10.2
#50	1.6	2.1	13.5	100.0	1.0	0.[illegible]	3.5	2.0	6.7
#100	1.5	1.9	5.4	100.0	0.9	0.2	1.4	2.0	4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2	1.1	2.0	4.2

LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	38[illegible].0	Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax =	205	ASPHALT CONTENT	6.2%
CALIBRATION NUMBER		90004	MASTER GAUGE BACK CNT. =			219[illegible]		A1 =	-5.234741		
MASTER GAUGE SER. NO. =		770	SAMPLE WEIGHT =			7200		A2 =	3.436895		

Aggregate & Mixture Properties Based on Contractors Mix Design

	0.9
TSR =	95
-200/AC =	1.1
Gyro Wt. =	4610
BACK CNT. =	2196

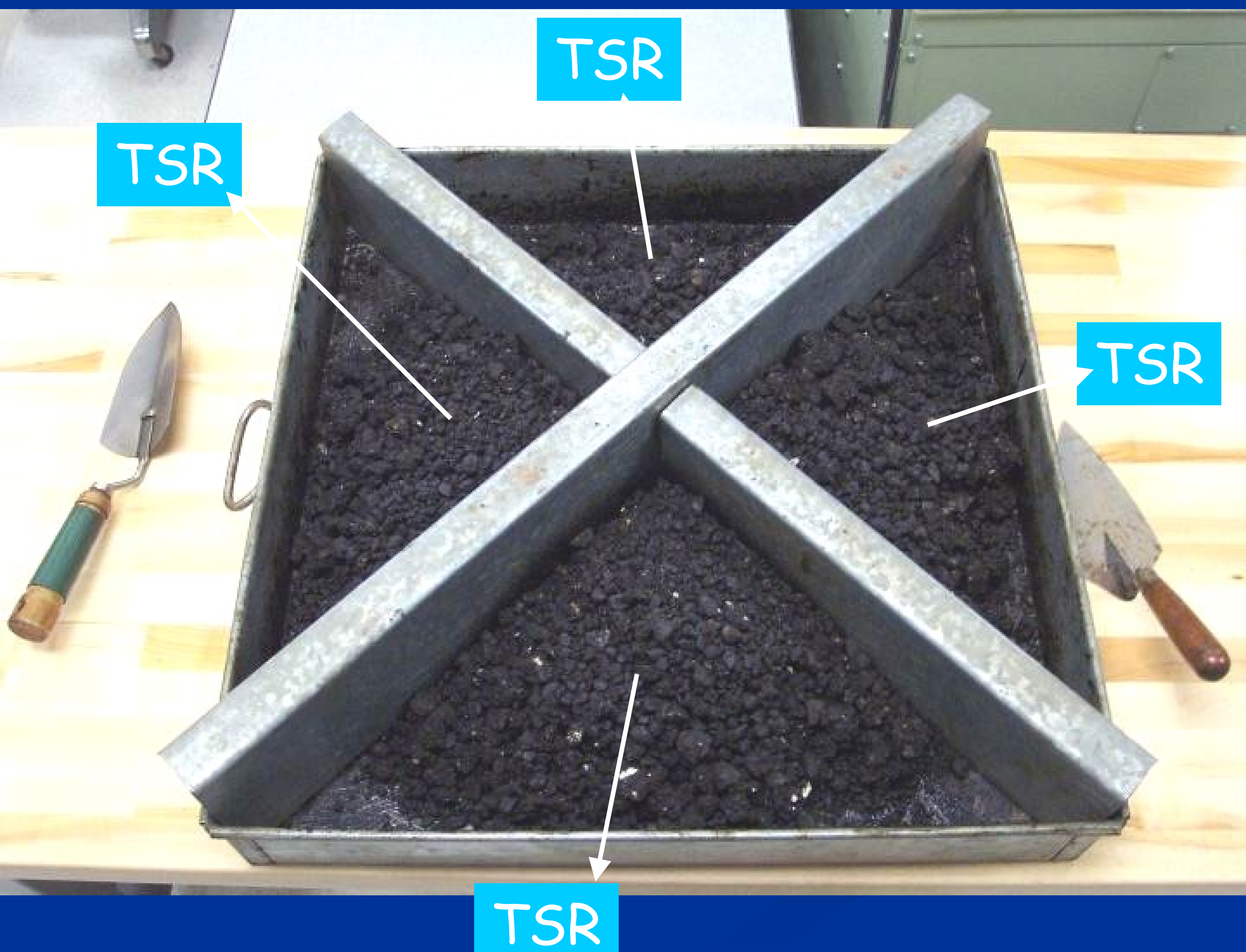
OPERATIONAL MODES

- 1. Normally, compact to a ***fixed number of gyrations***; resulting height must be =115 ± 5 mm
- 2. For TSR, compact to a ***fixed height*** = 95 ± 5 mm

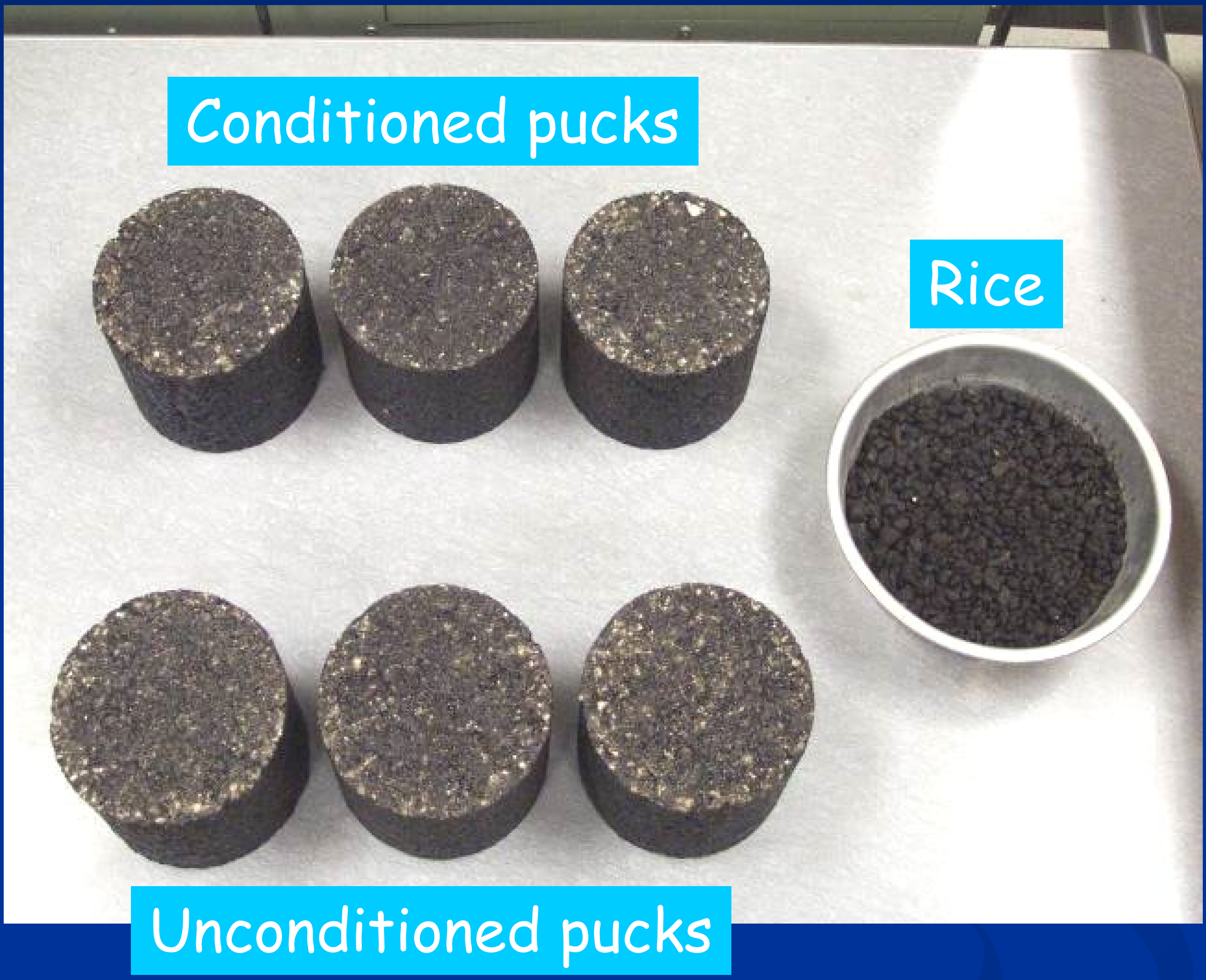

Volumetrics puck
TSR puck
NOV 19 2004

TSR SAMPLE

- 60-75 lb. sample for six TSR pucks



TSR



SAMPLE PREP

- Mix design ***lab-produced sample***: prior to compaction, condition sample in oven for 2 hours at compaction temperature.
- Absorption is occurring during this step.
- ***Field verification sample***: no special conditioning step; conditioning occurs in silo, truck, and MTV.
- Recommended that reheating of field sample should not exceed 30 min.

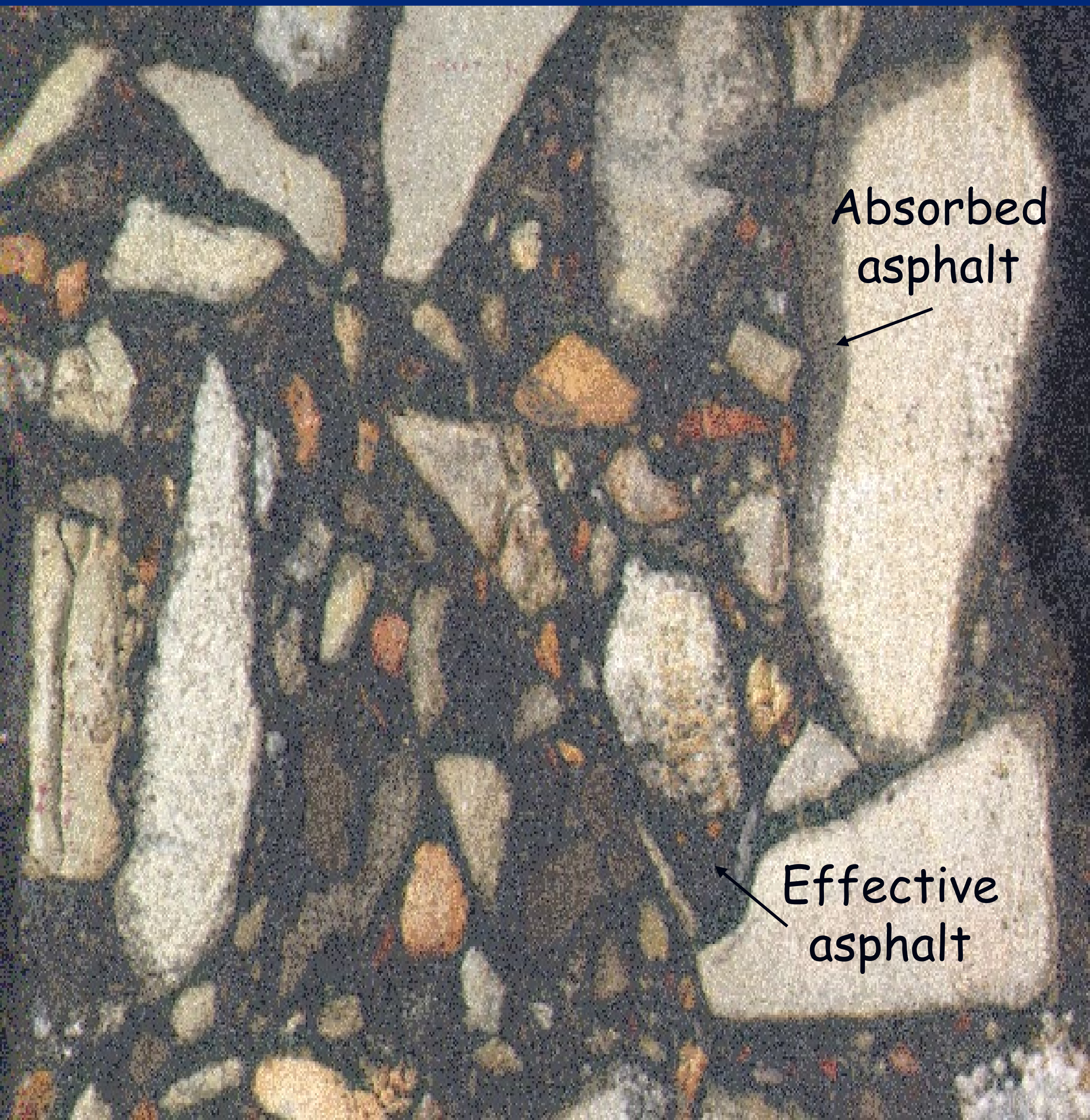
TIME AT HIGH TEMPERATURE

- Continued absorption of asphalt
- Age-hardening of asphalt

TIME AT HIGH TEMPERATURE

SURGE SILO

ABSORPTIVENESS OF AGGREGATE



Location of Gyro Molding Temperature on JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03 **CONTRACTOR = MY BUSINESS** **SP125 03-16**

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
35JSJ001	100207..LD1	/ Hard Rock Stone, Dig Deep, MO	2.515	2.713	2.9	Jet City Dolo.	5-8	25
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35JSJ003	1002MS..MSLD	/ Hard Rock Stone, Dig Deep, MO	2.480	2.761		Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/ Missy Lime Co. #2, Ste. General, MO	2.303	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ Black Asphalt Products, Decoy, MO	1.023		PG70-22	Gyro Mold Temp. 300-310°F		

MATERIAL IDENT #	35JSJ001	35JSJ002	35JSJ003	30CAJ016	35JSJ001	35JSJ002	35JSJ003	30CAJ016	COMB.
03016	3/4"	3/8"	MAN SAND	Hyd. Lime	60.0	12.0	26.0	2.0	GRAD
1 1/2"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
3/4"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1/2"	[illegible]	[illegible]	[illegible]	[illegible]	58.6	12.0	26.0	2.0	98.6
3/8"	[illegible]	[illegible]	[illegible]	[illegible]	50.3	11.5	26.0	2.0	89.8
#4	[illegible]	[illegible]	[illegible]	[illegible]	19.1	4.2	26.0	2.0	51.3
#8	[illegible]	[illegible]	[illegible]	[illegible]	4.2	1.0	21.3	2.0	28.5
#16	[illegible]	[illegible]	[illegible]	[illegible]	1.6	0.4	10.6	2.0	14.6
#30	[illegible]	[illegible]	[illegible]	[illegible]	1.0	0.3	6.9	2.0	10.2
#50	[illegible]	[illegible]	[illegible]	[illegible]	1.0	0.3	3.5	2.0	6.7
#100	[illegible]	[illegible]	[illegible]	[illegible]	0.9	0.2	1.4	2.0	4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2	1.1	2.0	4.2

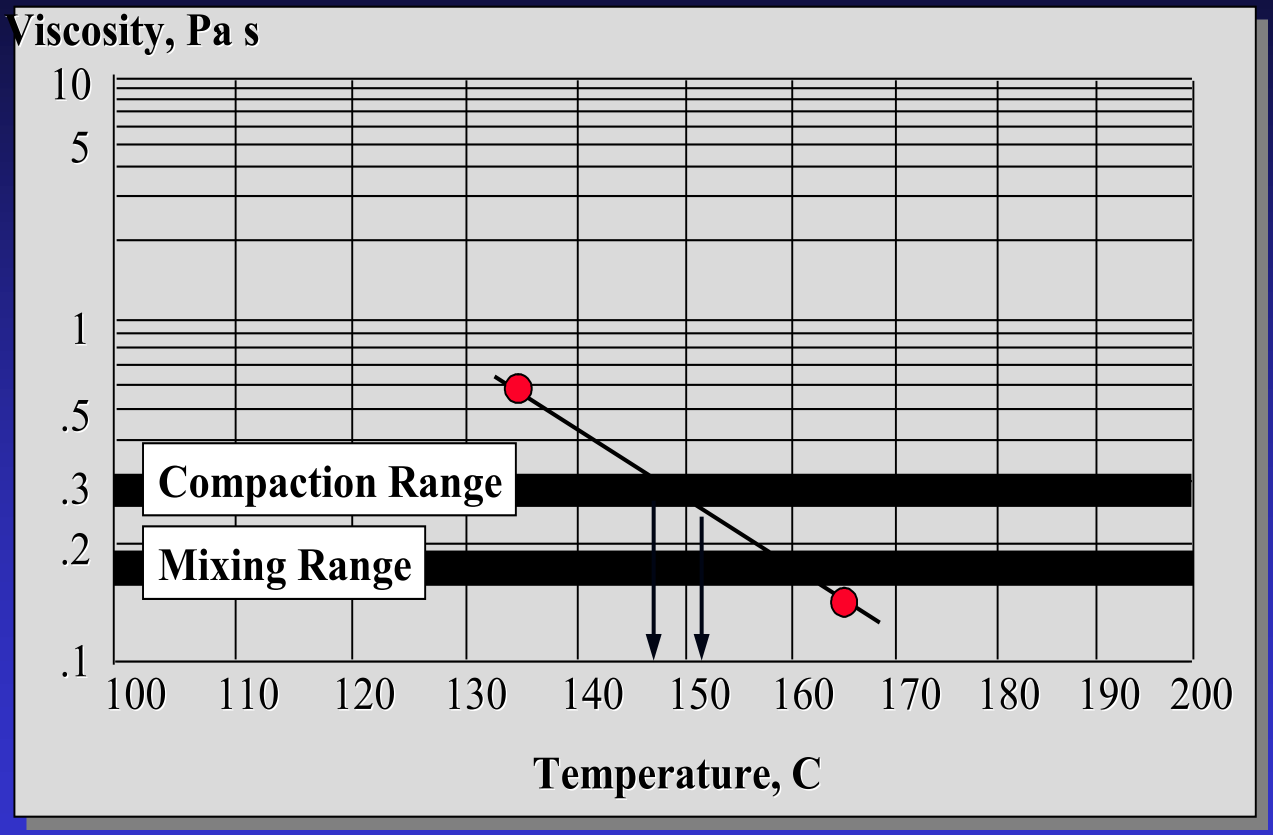
PG70-22 Gyro Mold Temp. 300-310°F

LABORATORY	Gmm = 2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini = 9	MIX COMPOSITION	
CHARACTERISTICS	Gmb = 2.308	V.M.A. =	14.4	-200/AC =	1.1	3855.0	Ndes = 125	MIN. AGG.	93.8%
AASHTO T312	Gsb = 2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax = 205	ASPHALT CONTENT	6.2%
CALIBRATION NUMBER	90004	MASTER GAUGE BACK CNT. =	2196				A1 = -5.234741		
MASTER GAUGE SER. NO. =	770	SAMPLE WEIGHT =	7200				A2 = 3.436895		

Aggregate & Mixture Properties Based on Contractors Mix Design

MIXTURE MOLDING TEMPERATURE

Mixing/Compaction Temps



Compaction

After re-heating, take mix and preheated mold from oven. Place paper in bottom of mold.

Place Mix in Mold

Place Mold in Gyro Compactor

GYRO SETTINGS

- Pressure= 600 ± 18 kPa
- Number of gyrations is a function of design traffic

GYRATION LEVELS

Design	$N_{initial}$	N_{design}	$N_{maximum}$
F	--	50	--
E	7	75	115
C	8	80 or 100	160
B	9	125	205

- C mixes at 80 gyrations: no $N_{initial}$ or N_{max} requirements
- SMA:
  - N_{design}= 100
  - No N_{max} requirement

NUMBER OF GYRATIONS

- N_{ini}= initial number of gyrations: at a low number, the ease of mix densification is analyzed to spot tenderness potential .
- N_{des}= the number of gyrations corresponding to the design traffic; want 4% air voids at this point (96% density)
- N_{max}= maximum number applied to the specimen to assess densification after many years; want > 2% V_a (<98% density)

NUMBER OF GYRATIONS

- N_{ini}, N_{des}, and N_{max} are shown on the JMF.
- ***Samples for field verification of volumetrics should be compacted to N_{des} gyrations.***

Location of Gyration Info on JMF

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30CAJ016	1002HL..HL	/ [illegible]	[illegible]	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ [illegible]			PG70-22	Gyro Mold Temp. 300-310°F		

MATERIAL IDENT #	35JSJ001	35JSJ002	[illegible]	[illegible]	[illegible]01	35JSJ002	35JSJ003	30CAJ016	COMB. GRAD
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1 1/2"	100.0	100.0	[illegible]	[illegible]	[illegible].0	12.0	26.0	2.0	100.0
1"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
3/4"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1/2"	97.6	100.0	100.0	100.0	58.6	12.0	26.0	2.0	98.6
3/8"	83.8	96.1	100.0	100.0	50.3	11.5	26.0	2.0	89.8
#4	31.8	35.0	99.9	100.0	19.1	4.2	26.0	2.0	51.3
#8	7.0	8.0	82.0	100.0	4.2	[illegible]	21.3	2.0	28.5
#16	2.6	3.5	40.7	100.0	1.6	0.4	10.6	2.0	14.6
#30	1.6	2.6	26.6	100.0	1.0	0.3	6.9	2.0	10.2
#50	1.6	2.1	13.5	100.0	1.0	0.3	3.5	2.0	6.7
#100	1.5	1.9	5.4	100.0	0.9	0.2	[illegible]	[illegible]	4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2	[illegible]	2.0	4.2

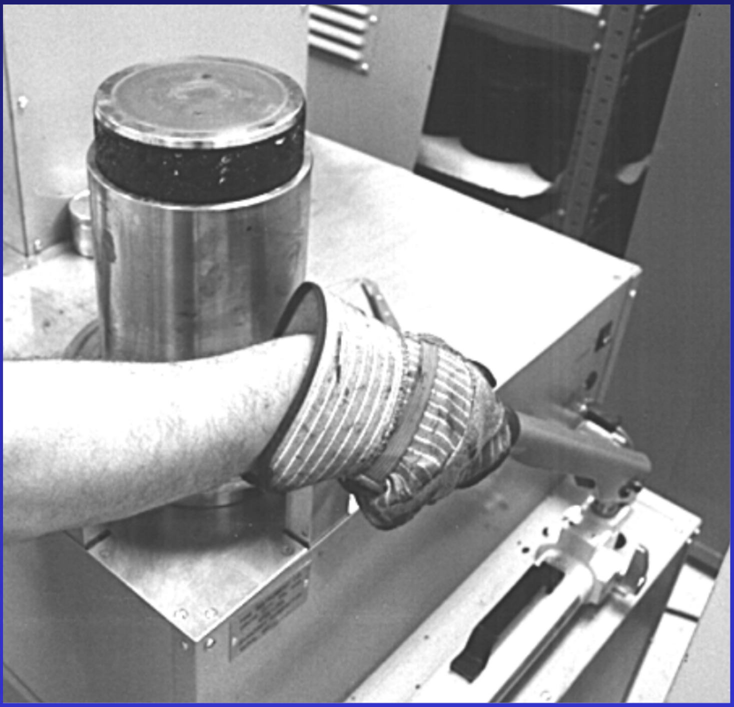
LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	3855.0	Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax =	205	ASPHALT CONTENT	6.2%
CALIBRATION NUMBER		90004	MASTER GAUGE BACK CNT. =			2196		A1 =	-5.234741		
MASTER GAUGE SER. NO. =		770	SAMPLE WEIGHT =			7200		A2 =	3.436895		

Aggregate & Mixture Properties Based on Contractors Mix Design

2.0
Nini = 9
Ndes = 125
Nmax = 205

Compaction

Once compaction is finished, extrude sample from mold.



Compaction

Remove the paper and label samples.

- Label on sides

COOLING

NOTES

- OPERATION
  - Clean rollers with solvent
  - Keep rotation ring cleaned and oiled
  - Periodically, check oil level
  - Make sure anti-rotational cogs are tight. Keep some spares on hand.

RECORD KEEPING

- Must have a unique ID on each piece of equipment
- Must keep a list of equipmment for IAS inspection

COMMON GYRO ERRORS

- Not placing a paper disk on bottom or top of specimen
- Not removing paper disks while puck is still warm
- Not using top or bottom plates
- Not compacting mix at proper temperature
- Not properly verifying the calibration of the compactor prior to use
- Not pre-heating the mold and plates
- Not charging the mold with mix quickly in one lift without spading or rodding

COMMON GYRO ERRORS, cont'd.

- Avoid allowing built-up asphalt in gyro mold to smear the sides of the puck as it is extruded, closing off voids. As a minimum, wipe off top and bottom lids after every puck.
- Don't let paper disks become brittle by keeping them in in bottom of mold in oven overnight

OUTLINE

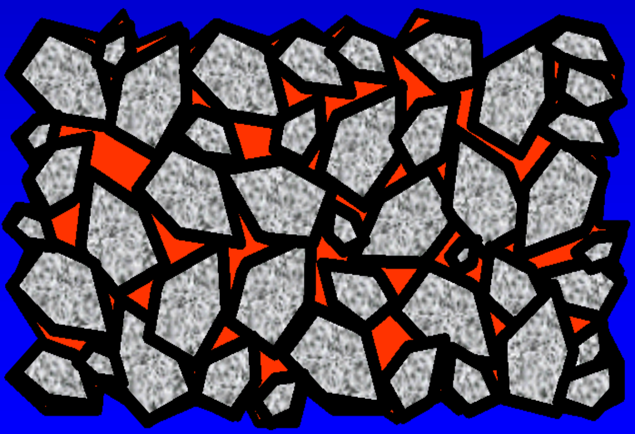
- Introduction
- Compaction method
- ***Bulk specific gravity of gyro pucks***
- Calculations
- Verification & Calibration

MIXTURE BULK SPECIFIC GRAVITY (G_{mb})

BSG of Compacted HMA

- AC mixed with agg. and compacted into sample

$$G_{mb} = \frac{\text{Mass agg. and AC}}{\text{Vol. agg., AC, air voids}}$$

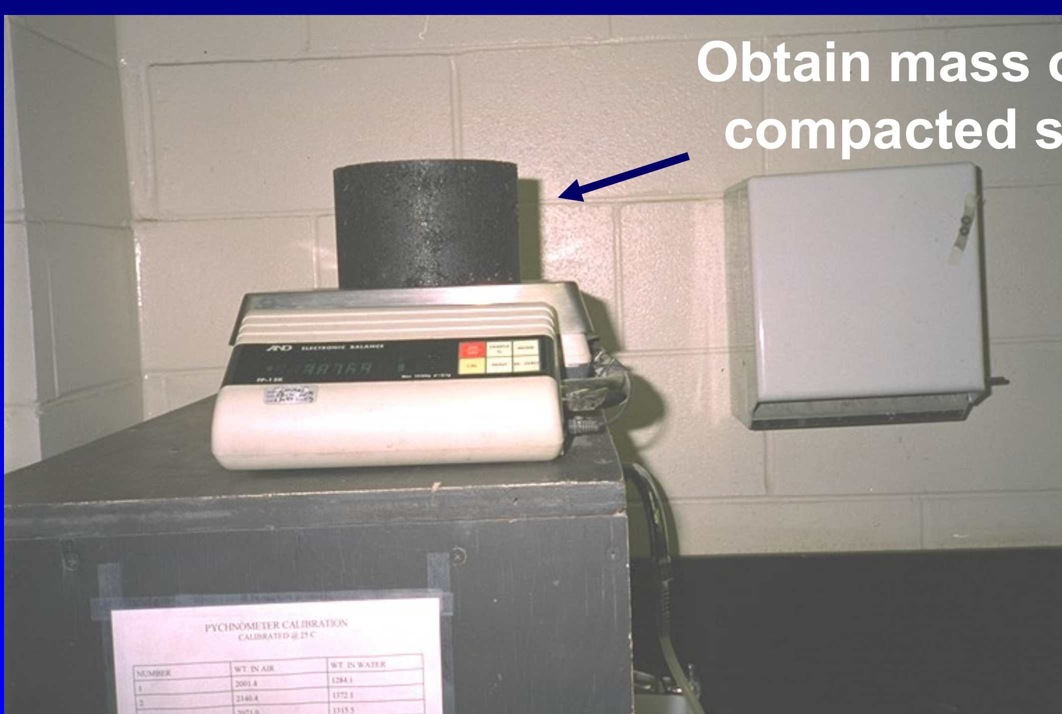


TESTING G_{mb}

- Puck should be at room temperature (25±5 C)

Testing

Obtain mass of dry compacted sample



Testing

COMMON G_{mb} TESTING ERRORS

- Submerged specimens touch side of water container
- Water temperature not 25 ± 1 C (77 ± 1.8 F)
- Specimen temperature not 25 ± 5 C (77 ± 9 F)
- Dirty water in water container
- Air bubbles clinging to the basket
- Blotting with a dry towel
- Blotting more than 15 seconds
- Water level not maintained

Consequences of Mistakes Examples

$$G_{mb} = \frac{W_{dry}}{(W_{ssd} - W_{submerged})}$$

$$V_a = \frac{G_{mm} - \mathbf{G_{mb}}}{G_{mm}} \times 100$$

Low W_{dry} → Low G_{mb} → High V_a

High W_{ssd} → Low G_{mb} → High V_a

Low W_{ssd} → High G_{mb} → Low V_a

OUTLINE

- Introduction
- Compaction method
- Bulk specific gravity of gyro pucks
- ***Calculations***
- Verification & Calibration

Calculations

- $G_{mb} = A / (B - C)$

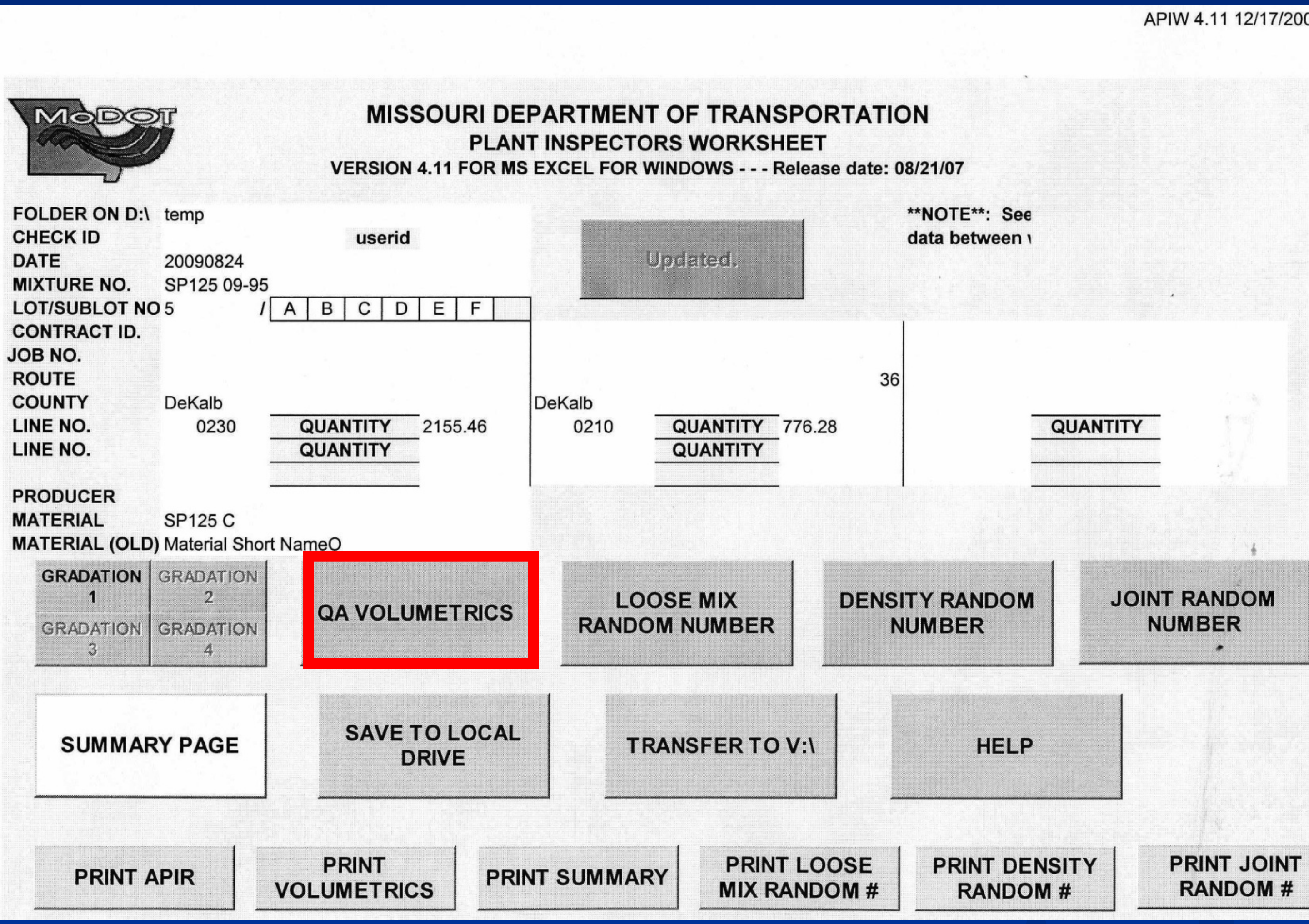
  Where:

  A = mass of dry sample

  B = mass of SSD sample

  C = mass of sample under water

MoDOT SPREADSHEET



SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. SP125 09-95 LOT NO. 5

SUBLOT	A	B	C	D	E	F	
DATE		08/24/09					

AASHTO T 209 — A2 required when T85 absorption >2.0% on any aggregate fraction.

TECHNICIAN		phillc1					
A = Wt. of sample:		2076.6					
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:		1392.3					
X = A + D (A2 used in lieu of A for dry-back)	0.0	3468.9	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:		2628.1					
Y = X - E	0.0	840.8	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	0.000	2.470	2.470	2.470	2.470	2.470	2.470

AASHTO T 166

TECHNICIAN		phillc1					
MOLDING TEMPERATURE		152					
A = Weight of sample in air:		4748.0					
B = Weight of sample in water: SPEC. 1		2758.3					
C = Weight of surface dry sample:		4752.2					
Gmb = BULK SP. G. = A / (C-B)	0.000	2.381	0.000	0.000	0.000	0.000	0.000
A = Weight of sample in air:		4748.0					
B = Weight of sample in water: SPEC. 2		2758.8					
C = Weight of surface dry sample:		4753.2					
Gmb = BULK SP. G. = A / (C-B)	0.000	2.381	0.000	0.000	0.000	0.000	0.000
AVG. Gmb	0.000	2.381	0.000	0.000	0.000	0.000	0.000

TECHNICIAN		phillc1					
MoDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							
AASHTO T 308 (IGNITION)							
GAUGE %AC		5.71					
NUCLEAR OR IGNITION							
% MOISTURE		0.12					
% AC BY IGNITION OR NUCLEAR		5.6					

AASHTO R 35

A = Gmm (FIELD)	0.000	2.470	2.470	2.470	2.470	2.470	2.470
B = Gmb (FIELD) (Avg.)	0.000	2.381	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)		2.642	0.000	0.000	0.000	0.000	0.000
D = Ps = Percent Agg. in mix	100.0	94.4	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	0.0	14.9	0.0	0.0	0.0	0.0	0.0
Va = 100 X ((A - B) / A)	0.0	3.6	100.0	100.0	100.0	100.0	100.0
VFA = (VMA-Va) / VMA	0	76	0	0	0	0	0

See Updated worksheet

Veight of sample in air:							
Veight in water:							
Veight of surface dry sample:							
= CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0
= MAX. SPECIFIC GRAVITY (T209)	0.000	2.470	2.470	2.470	2.470	2.470	2
OMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	
KNESS							
LOT	A	B	C	D	E	F	

2ND CORE SUBLOT WHEN DENOTED IN QC PLAN

NICIAN							
Veight of sample in air:							
Veight in water:							
Veight of surface dry sample:							
= CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0
= MAX. SPECIFIC GRAVITY (T209)	0.000	2.470	2.470	2.470	2.470	2.470	2
OMPACTION OF CORE = 100 x (Gmc / Gmm)							

Puck Bulk Specific Gravity Portion

AASHTO T 166

TECHNICIAN			phillc1					
MOLDING TEMPERATURE			152					
A = Weight of sample in air:			4748.0					
B = Weight of sample in water:	SPEC. 1		2758.3					
C = Weight of surface dry sample:			4752.2					
Gmb = BULK SP. G. = A / (C-B)		0.000	2.381	0.000	0.000	0.000	0.000	0.000
A = Weight of sample in air:			4748.0					
B = Weight of sample in water:	SPEC. 2		2758.8					
C = Weight of surface dry sample:			4753.2					
Gmb = BULK SP. G. = A / (C-B)		0.000	2.381	0.000	0.000	0.000	0.000	0.000
AVG. Gmb		0.000	2.381	0.000	0.000	0.000	0.000	0.000

Excessive Water Absorption

- MoDOT now enforcing the water absorption check: at the end of the test, water absorption is calculated:

- Abs= [(B – A) / (B – C)] x 100
- A= mass dry specimen in air
- B = mass SSD specimen in air
- C = mass specimen in water

- If greater than 2%, must re-run using CoreLok (T331) or paraffin coated (wrapped) ["Parafilm"] specimen (D1188)

Check for Excessive Water Absorption

Up to 2 Cores at Same Location

AASHTO T 166 **T 166**

MENU

TECHNICIAN							
A = Mass of sample in air:							
B = Mass in water:							
C = Mass of surface dry sample:							
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WATER ABS. = 100 x ((B-A)/(B-C))	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

FOR 2ND CORE SUBLOT WHEN DENOTED IN QC PLAN

TECHNICIAN							
A = Weight of sample in air:							
B = Weight in water:							
C = Weight of surface dry sample:							
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WATER ABS. = 100 x ((B-A)/(B-C))	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

AASHTO T 331 **Corelok**

TECHNICIAN							
A = Mass of sample in air:							
Bag Mass							
B = Mass sealed sample:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C = Mass sample removed from bag:							
E = Mass of sealed sample in water:							
F = Bag specific gravity: (0.932 green InstroTek bag)							
Gmc = A / ((C + (B - A)) - E - ((B - A) / F))	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHECK (%)							
THICKNESS							
SUBLOT							

FOR 2ND CORE SUBLOT WHEN DENOTED IN QC PLAN

TECHNICIAN							
A = Mass of sample in air:							
Bag Mass							
B = Mass sealed sample:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C = Mass sample removed from bag:							
E = Mass of sealed sample in water:							
F = Bag specific gravity: (0.932 green InstroTek bag)	0.932	0.932	0.932	0.932	0.932	0.932	0.932
Gmc = A / ((C + (B - A)) - E - ((B - A) / F))	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHECK (%)							
THICKNESS							
SUBLOT							

VOLUMETRICS

- Air Voids
- VMA
- VFA

AIR VOIDS

- $$V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$$

VMA

Voids in Mineral Aggregate

$$VMA = 100 - \frac{G_{mb}\, P_s}{G_{sb}}$$

VMA is an indication of film thickness on the surface of the aggregate

VFA

- $$VFA = \frac{VMA - V_a}{VMA} \times 100$$

OUTLINE

- Introduction
- Compaction method
- Bulk specific gravity of gyro pucks
- Calculations
- ***Verification & Calibration***

VERIFICATION & CALIBRATION

- *Gyratory compactor*
- Molds

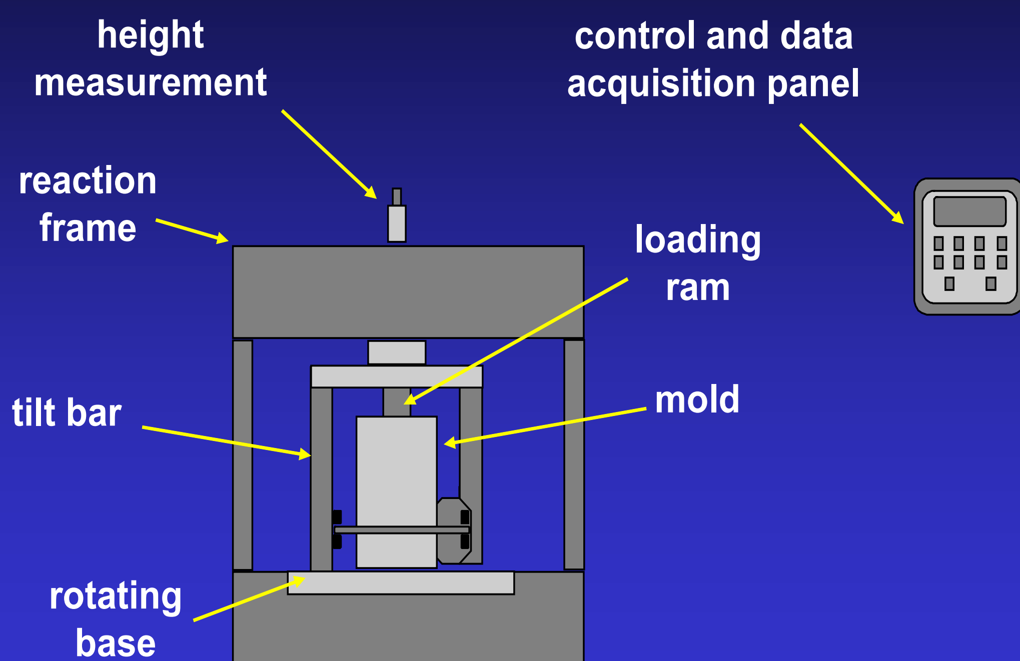
CALIBRATION AND VERIFICATION

- Must check:
  - rate of gyration (rotational speed)
  - roller clearance & zero position
  - height measurement
  - ram force (load)
  - angle of gyration:
    - Internal angle (calibration)
    - External angle (verification)

"GYRO"

Compaction

Key Components of Gyratory Compactor



Actions

- Calibration:
  - Measure
  - Adjust
  - Re-measure

- Verification:
  - Measurement

CALIBRATION

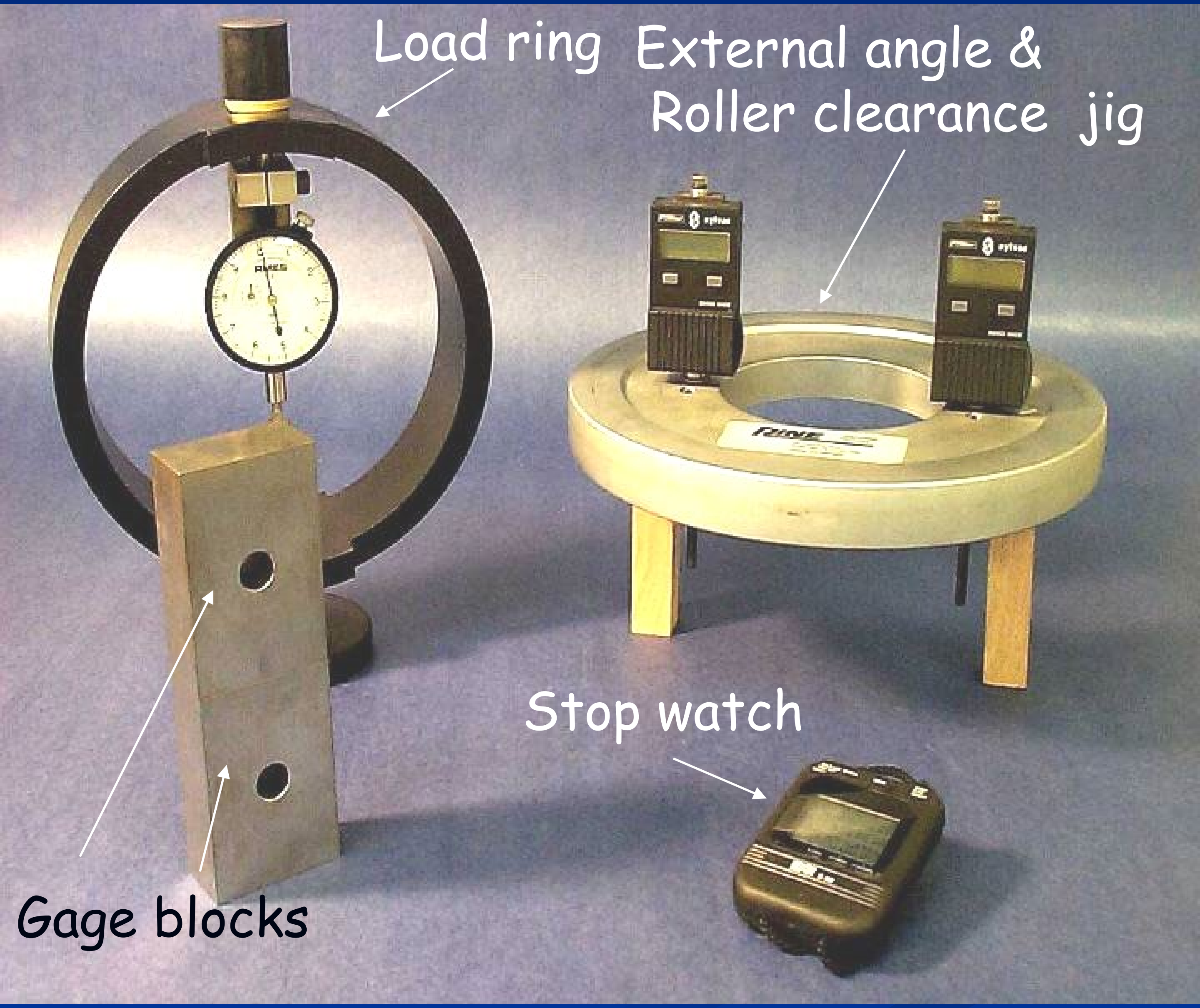
CALIBRATION FREQUENCY

- Calibration should be performed:
  - At least once per year
  - When verification fails

Calibration Actions

- Rate of gyration (speed)
- Roller clearance & zero position
- Ram force:
  - 18 loads
  - 1500 to 18,000 N
- Specimen Height
  - 8 positions (blocks)
  - 3 to 10 in.
- Angle of gyration (*internal* angle)

CALIBRATION & VERIFICATION INSTRUMENTS



CALIBRATION

- Internal angle: 1.16 ± 0.02°

CALIBRATION

- Rate of gyration (rotational speed): 30.0 ± 0.5 rotations per minute (10 rotations in 20 ± 0.33 sec)
- Ram Force: Target ± 1%
- Ram Position (height):±0.002"
- Internal angle: 1.16 ± 0.02°
- Roller clearances and zero position - done on some machines

Pine AFGC125X Gyratory Compactor Calibration Change Record

☐ Pine AFGC125X (115 V 60 Hz)
☑ Pine AFGC125XA (220 V 60 Hz)
☐ Pine AFGC125XE (220 V 50 Hz)
Model

035
Serial Number

David [illegible] 5-20-08
Technician (sign and date)

Missouri D.O.T.
SGC Owner (Company Name)

Rolla, Mo.
SGC Location (City and State)

Status of Compactor Prior to Calibration Change

37.22	8-21-07	3-27-08	Pine Certified Service
Machine Hours	Previous SGC Calibration Date	Previous SGC Verification Date	Previous Calibration Service Provider (if known)

External Angle of Gyration

Pine ACGCA001
Angle Sensor Apparatus

☐ Owned by Customer
☐ Owned by Calibrator

After adjustment

Parameter	"As Found"	"As Left"	
Unloaded Angle	1120"	.1110	
Loaded Angle			
Adjustable Link Gap (0.002" to 0.004")	.0025	.0025	in
Intermediate Link Gap (0.002" to 0.004")	.0025	.0025	in
Fixed Link Gap (0.0015" to 0.002")	.003	.0015	in
Zero Plane (0.001" tolerance)	.0 - .0	.0 - .0	in
Dial Difference	.1120"	.1110	

1.27°

Internal Angle of Gyration

☐ TestQuip (DAV1)
☑ Pine AFLS1 (RAM)
Internal Angle Device

017
Serial Number

☐ Owned by Customer
☑ Owned by Calibrator

11-20-07
Device Calibration Date

Parameter	"As Found"	"As Left"
Internal Angle	1.19 out	1.173° in

Consolidation Pressure (Force Measurement)

Pine AFGCLR05C
Load Ring Model

2321
Serial Number

☐ Owned by Customer
☑ Owned by Calibrator

11-21-07
Ring Calibration Date

measured

Force (newtons)	Dial (actual)	"As Found"	"As Left"
1500	33.2	33.1	33.1
2500	[illegible]	[illegible]	[illegible]
3500	78.6	78.8	78.8
4500	[illegible]	[illegible]	[illegible]
5500	124.8	124.9	125.0
6500	147.8	147.7	147.8
7500	170.5	170.5	170.7
8500	193.1	192.8	193.0
9500	215.7	215.9	216.1
10500	238.[illegible]	238.3	238.6
11500	260.9	261.7	261.9
12500	283.6	283.9	284.0
13500	306.3	307.0	307.1
14500	329.2	329.2	329.5
15500	352.5	352.8	353.0
16500	375.8	376.0	376.4
17500	398.9	399.1	399.5
18000	410.5	411.1	411.5

Specimen Height (Position Measurement)

Pine AFG123C
Gage Block Model

2926-2927-2928-2929
Serial Number

☐ Owned by Customer
☑ Owned by Calibrator

11-20-07
Block Calibration Date

Height (inches)	"As Found"	"As Left"
10	10.000	10.000
9	9.000	9.000
8	8.000	8.000
7	[illegible]	[illegible]
6	6.000	6.000
5	5.000	5.000
4	4.000	4.000
3	3.000	3.000

Notes:

1% of 78.6=0.8
78.6-0.8= 77.8=lower limit-ok
78.6+0.8= 79.4=upper limit-ok

PROVING RING SERIAL NUMBER: 1440 CALIBRATION DATE: 8/1/2006

Different than previous example

GYRATORY COMPACTOR CALIBRATION DATA POINTS

This sheet is specific to a certain proving ring

Newtons	lbf	Dial (actual)	Dial - 1%	Dial + 1%	Dial - 3%	Dial + 3%
0	0.0	0.0	0.0	0.0	0.0	0.0
500	112.4	11.0	10.9	11.1	10.7	11.3
1000	224.8	22.0	21.8	22.2	21.3	22.7
1500	337.2	33.0	32.7	33.3	32.0	34.0
2000	449.6	44.4	43.9	44.8	43.1	45.7
2500	562.0	55.8	55.2	56.3	54.1	57.5
3000	674.4	67.2	66.5	67.8	65.2	69.2
3500	786.8	78.9	78.1	79.6	76.5	81.2
4000	899.2	90.6	89.6	91.5	87.8	93.3
4500	1011.6	102.2	101.2	103.3	99.2	105.3
5000	1124.1	113.9	112.8	115.1	110.5	117.4
5500	1236.5	125.1	123.8	126.3	121.3	128.8
6000	1348.9	136.2	134.8	137.5	132.1	140.3
6500	1461.3	147.7	146.2	149.2	143.3	152.1
7000	1573.7	159.3	157.7	160.8	154.5	164.0
7500	1686.1	170.8	169.1	172.5	165.7	175.9
8000	1798.5	182.5	180.7	184.3	177.0	188.0
8500	1910.9	194.2	192.2	196.1	188.3	200.0
9000	2023.3	205.8	203.8	207.9	199.7	212.0
9500	2135.7	217.2	215.0	219.3	210.7	223.7
10000	2248.1	228.5	226.2	230.8	221.7	235.4
10500	2360.5	239.9	237.5	242.3	232.7	247.1
11000	2472.9	251.3	248.8	253.8	243.7	258.8
11500	2585.3	262.7	260.1	265.3	254.8	270.6
12000	2697.7	274.1	271.4	276.8	265.9	282.3
12500	2810.1	286.0	283.2	288.9	277.5	294.6
13000	2922.5	298.0	295.0	301.0	289.0	306.9
13500	3034.9	309.9	306.8	313.0	300.6	319.2
14000	3147.3	320.9	317.7	324.1	311.3	330.6
14500	3259.7	331.9	328.6	335.3	322.0	341.9
15000	3372.2	343.5	340.0	346.9	333.2	353.8
15500	3484.6	355.0	351.5	358.6	344.4	365.7
16000	3597.0	366.6	362.9	370.2	355.6	377.6
16500	3709.4	378.1	374.4	381.9	366.8	389.5
17000	3821.8	389.7	385.8	393.6	378.1	401.4
17500	3934.2	401.4	397.3	405.4	389.3	413.4
18000	4046.6	413.0	408.8	417.1	400.6	425.4

Roller Clearance & Zero Position

- Make sure external angle jig and rollers are clean
- Make sure dial gages are in snug and gage tips are tightened
- Want some play in rollers:
  - 0.0015 to 0.0020 (fixed post)
  - 0.0020 to 0.0040 (other 2 posts)
- Zero Degree Position Check: at 180° rotation dial readings remain within ± 0.0010”

GYRATORY COMPACTOR PROFICIENCY EXAM
LIST OF SPECIFICATIONS

<u>Verification of Calibration</u>

- Speed of gyrations: 10 rotations in 20 ± 0.33 seconds
- Ram Force: Must look at proving ring calibration chart.
    - If Reading = Target ± 1%: OK
    - If Reading is greater than Target ± 1%, but less than or equal to Target ± 3%: Calibration recommended
    - If Reading is greater than Target ± 3%: Calibration required
- Height (Ram Position):
    - If Measured Height = 6.000 ± 0.002": OK
    - If Measured is greater than 6.000 ± 0.002", but less than 6.000 ± 0.004": Calibration recommended
    - If Measured is greater than or equal to 6.000 ± 0.004": Calibration required (Machine may indicate this condition)

=========MACHINE ASSISTANCE STOPS AT THIS POINT=========

- Roller Clearances:
    - 0.0015 to 0.0020" for fixed post (3 o'clock): OK
    - 0.0020 to 0.0040" for other two posts (9 and 12 o'clock): OK
- Zero Degree Position:
    - Dial indicator readings do not change by more than ± 0.0010" when angle verification device is rotated 180°: OK
- External Angle:
    - Calculate the difference between the left and the right dial indicator readings (difference = left – right)
    - Compare difference:
      For example, 0.1083" ≤ difference ≤ 0.1126": OK
    - NOTE: Actual "difference limits" for a compactor will be determined during calibration using the internal angle device.
- Internal Angle:
    - Verify the internal angle measurement instrument (e.g. Pine RAM) using the static angle gauge (e.g. Pine calibration tube)
    - Determine the internal angle: Average of 4 measurements (2 of top angle, and 2 of bottom angle) shall be 1.16 ± 0.02 degrees.

VERIFICATION

Verification Actions

- Rate of gyration (speed)
- Roller clearance & zero position
- Ram force:
  - 2 loads
  - 3500; 14,500 N
- Specimen Height
  - 1 position (blocks)
  - 6 in.
- Angle of gyration (***external*** angle)

VERIFICATION FREQUENCY

- ***Verification*** is a shortened version of ***calibration***
- Frequency of verification:
  - ***Daily (Sec 403) [but Weekly During Use (2023 Prof Test)?]***
  - ***When moved***
  - ***After any maintenance or adjustments***
  - ***After questionable results***
- Condition:
  - *Clean, cold machine*
  - "Cold" = warmed up to operating temperature, but mix has *not* been run through the machine

Standard Specification Sec 403.17.3.1 (2022; 4th Edition April 2023)

Equipment - Test Method (AASHTO)	Requirement	Interval (Month)
Gyratory Compactor - T 312	Calibrate – 1.16 ± .02° internal angle	12[a]
Gyratory Compactor - T 312	Verify	Daily
Gyratory Molds - T 312	Check Critical Dimensions	12
Thermometers - T 209, T 166, T 312	Calibrate	6
Vacuum System - T 209	Check Pressure	12
Pycnometer (Flask) - T 209	Calibrate	Daily
Binder Ignition Oven - T 308	Verify	12[b]
Nuclear Content Gauge – T 287 or MoDOT TM 54	Drift & Stability – Manuf. Recommendation	1

Ex.: Verification Work Sheet Using Internal Instead of External Angle

…ratory Calibration/Verification Data Sheet 969

	5-10-09						
VERIFIED/BY	JG+AE	ae+JG	ae	ale	JG	JG	JG
CAL/VER DATE	~~[illegible]~~	…-7-09	4-8-09	4/13/09	4-27-09	4/28/09	4/29/09
ROTATION SPEED 30.0 ± 0.5	19.98	…1990	1999	1994	1999	2015	1996
LOAD	~~79.0~~						
3500	79.0	…9.5	79.3	79.0	79.2	79.0	79.2
14500	331.0	…32.2	331.8	330.8	332.2	331.9	332.2
OK?	OK	OK	ok	OK	OK	OK	ok
HEIGHT 6 ± 0.002	5.999	…5.999	5.999	5.999 ~~6.000~~	5.999	5.999	6.000
Roller Clearence 0.0015 - 0.0020 3	.0020	…020	.0020	.0020	.0015	0.0015 0.0035	0.0015 0.0035
0.0020 - 0.0040 9,12	.0035 .0035	…030 .0035	.0040 .0035	.0040 .0035	.0035 - .0035	0.0040	0.0040
0° POSITION ± 0.0010	0.0005	…005 .0000	0.000 .0005	.0005 .0005	.0005 .0000	0.0005 0.0000	0.0000 0.0010
Internal Angle Top 1	1.20 1.17	1.17	1.18	1.18	1.18	1.18	1.18
2	1.19 1.17	1.17	1.18	1.18	1.18	1.17	1.18
Inter Angle Bottom 1	1.19 1.17	1.19	1.19	1.19	1.19	1.19	1.19
2	1.19 1.19	1.19	1.19	1.19	1.19	1.19	1.19
1.16 ± 0.02° AVG	1.19 1.18	1.18	1.19	1.19	1.19	1.18	1.19
Angle OK?	[illegible]	OK	?	?	?	OK	

VERIFIED/BY	ae	JG	JG	ae	ae	JG	JG
CAL/VER DATE	5-4-09	5-5-09	5-6-09	5-13-09	5-19-09	5-26-09	5-27-09
ROTATION SPEED 30.0 ± 0.5	20.04	20.10	20.02	20.11	20.10	20.02	20.06
LOAD							
3500	79.1	79.0	79.1	79.3	79.3	76.0	76.0
14500	331.8	332.0	332.0	332.5	332.4	329.0	324.0
OK?	✓	✓	OK	OK	OK	OK	
HEIGHT 6 ± 0.002	6.000	6.001	6.000	5.999	6.000	5.999	6.000
Roller Clearence 0.0015 - 0.0020 3	.0015	.0020	.0020	.0020	.0020 .0035 .0040	.0015	.0015
0.0020 - 0.0040 9,12	.0040 .0035	.0040 .0035	.0040 .0035	.0040 .0040		.0045 / .0035	.0040 / .0030
0° POSITION ± 0.0010	.0005 .0005	.0005 .0000	.0005 - .0005	.0000 .0000	.0005 .0000	.0010 .0010	.0005 .0005
Internal Angle Top 1	1.17	1.17	1.18	1.18	1.18	1.18	1.18
2	1.18	1.16	1.17	1.18	1.18	1.16	1.16
Inter Angle Bottom 1	1.19	1.19	1.19	1.19	1.19	1.19	1.19
2	1.19	1.19	1.19	1.19	1.19	1.19	1.19
1.16 ± 0.02° AVG	1.18	1.18	1.18	1.19	1.19	1.18	1.18
Angle OK?	OK	OK	OK	OK	OK	OK	OK

VERIFICATION:

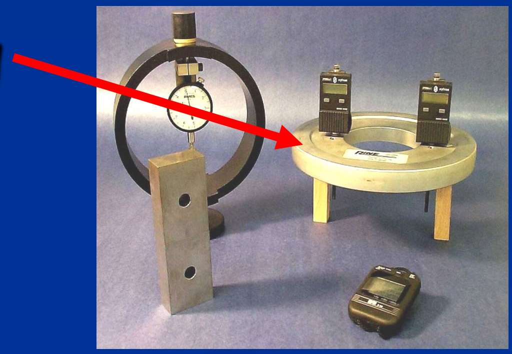
- ***External angle verification can be substituted for internal angle verification***; The external angle must correspond to be within the proper internal angle range as established during ***calibration***, e.g., during calibration of the internal angle, the corresponding external angle will be noted. This can be used for external angle verification

VERIFICATION

- Rate of gyration (rotational speed): 30.0 ± 0.5 rotations per minute (10 rotations in 20 ± 0.33 sec)
- Ram Force: Target ± 1%
- Ram Position (height):±0.002"
- External angle: Whatever corresponds to internal angle as set during calibration: 1.16 ± 0.02°
- Roller clearances and zero position - done on some machines

External Angle Methods

- Depending on the gyro make/model:
  - External angle jig



  - Internal check provided by the gyro (not "internal angle")

Example

- During calibration, the internal angle was set to 1.173 º which met 1.16 ± 0.02º
- At the same time, the external angle difference was 0.1110 in. which, using trigonometry, corresponds to 1.27 º (tan Θ = Difference/ L) where L = 5.000 in.

- For the next year, during daily verification, the external angle must be 1.27 ± 0.02º

Pine AFGC125X Gyratory Compactor Calibration Change Record

- ☐ Pine AFGC125X (115 V 60 Hz)
- ☑ Pine AFGC125XA (220 V 60 Hz)
- ☐ Pine AFGC125XE (220 V 50 Hz)

Model

035 — Serial Number

[signature] 5-20-08 — Technician (sign and date)

Missouri D.O.T. — SGC Owner (Company Name)

Rolla, Mo. — SGC Location (City and State)

Status of Compactor Prior to Calibration Change

37.22	8-21-07	3-27-08	Pine Certified Service
Machine Hours	Previous SGC Calibration Date	Previous SGC Verification Date	Previous Calibration Service Provider (if known)

External Angle of Gyration

Pine ACGCA001 — Angle Sensor Apparatus

- ☐ Owned by Customer
- ☐ Owned by Calibrator

Parameter	"As Found"	"As Left"
Unloaded Angle	1.120°	1.110
Loaded Angle		
Adjustable Link Gap (0.002" to 0.004")	.0025	.0025
Intermediate Link Gap (0.002" to 0.004")	.0025	.0025
Fixed Link Gap (0.0015" to 0.002")	.003	.0015
Zero Plane (0.001" tolerance)	.0 - .0	.0 - .0
Dial Difference	1.120°	1.110

Internal Angle of Gyration

- ☐ TestQuip (DAV1)
- ☑ Pine AFLS1 (RAM)

Internal Angle Device

017 — Serial Number

- ☐ Owned by Customer
- ☑ Owned by Calibrator

11-20-07 — Device Calibration Date

Parameter	"As Found"	"As Left"
Internal Angle	1.19	1.173°

Specimen Height (Position Measurement)

1.27°

Pine AFG123C — Gage Block Model

2926-2927-2928-2929 — Serial Number

- ☐ Owned by Customer
- ☑ Owned by Calibrator

11-20-07 — Block Calibration Date

Height (inches)	"As Found"	"As Left"
10	10.000	10.000
9	9.000	9.000
8	8.000	8.000
7	7.000	7.000
6	6.000	6.000
5	5.000	5.000
4	4.000	4.000
3	3.000	3.000

Consolidation Pressure (Force Measurement)

Pine AFGCLR05C — Load Ring Model

2321 — Serial Number

- ☐ Owned by Customer
- ☑ Owned by Calibrator

11-21-07 — Ring Calibration Date

Force (newtons)	Dial (actual)	"As Found"	"As Left"
1500	33.2	33.1	33.1
2500	[illegible]	[illegible]	[illegible]
3500	78.6	78.8	78.8
4500	101.7	101.8	101.9
5500	124.8	124.9	125.0
6500	147.8	147.7	147.8
7500	170.5	170.5	170.7
8500	193.1	192.8	193.0
9500	215.7	215.9	216.1
10500	238.3	238.3	238.6
11500	260.9	261.7	261.9
12500	283.6	283.9	284.0
13500	306.3	307.0	307.1
14500	329.2	329.2	329.5
15500	352.5	352.8	353.0
16500	375.8	376.0	376.4
17500	398.9	399.1	399.5
18000	410.5	411.1	411.5

Notes:

VERIFICATION & CALIBRATION

- Gyratory compactor
- ***Molds***

GYRO MOLD EVALUATION

- Frequency: min. 12 months
  - External calibration service (usually in conjunction with gyro calibration)
  - In-house

- Critical dimensions:
  - Mold inside diameter
  - End plate diameter
  - Mold length

Internal Diameter

- Methods:
  - ***Three-point internal bore gauge***
  - Coordinate Measuring Machine (CMM)

Mold Diameter
3-Point Bore Gauge

- Set the zero with a "master ring"

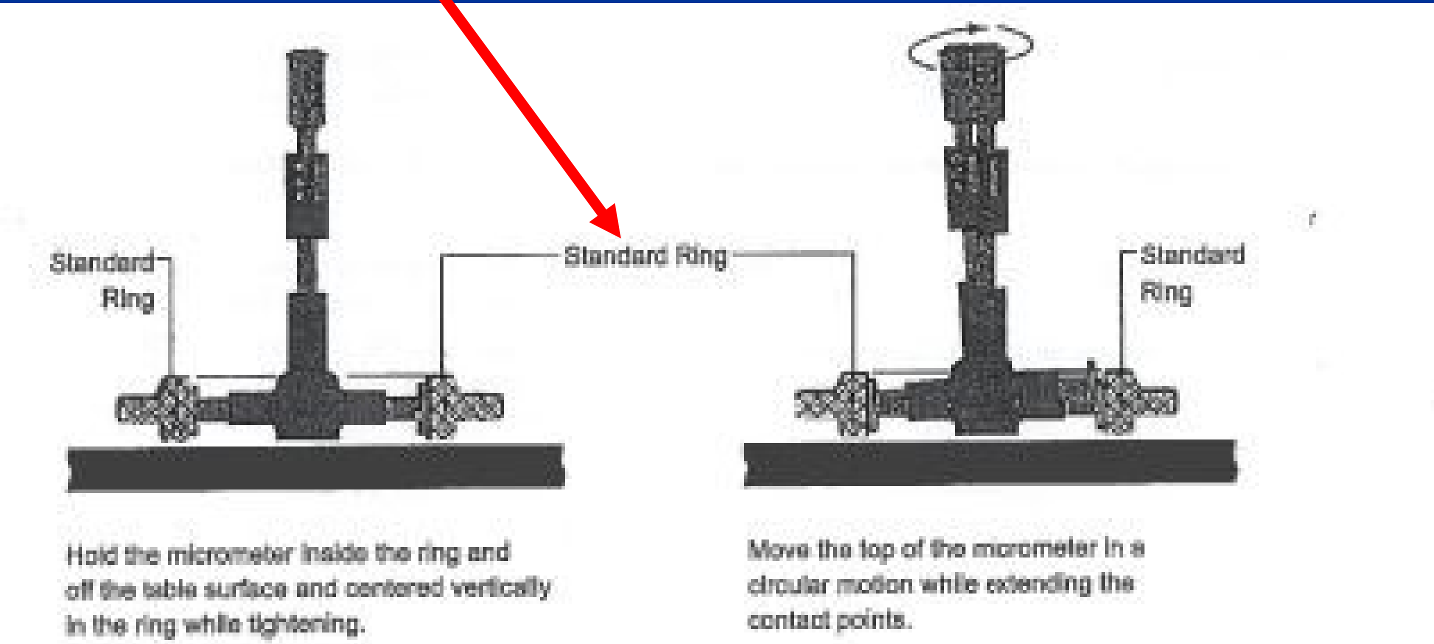


Figure A4.1—Techniques for Using the Three-Point Bore Gauge with the Calibrated Master Ring

Mold Diameter
3-Point Bore Gauge

- Measure mold internal diameter at 3 elevations, with 3 different measurements (nearest 0.001 mm preferred) at each elevation: total of 9 measurements

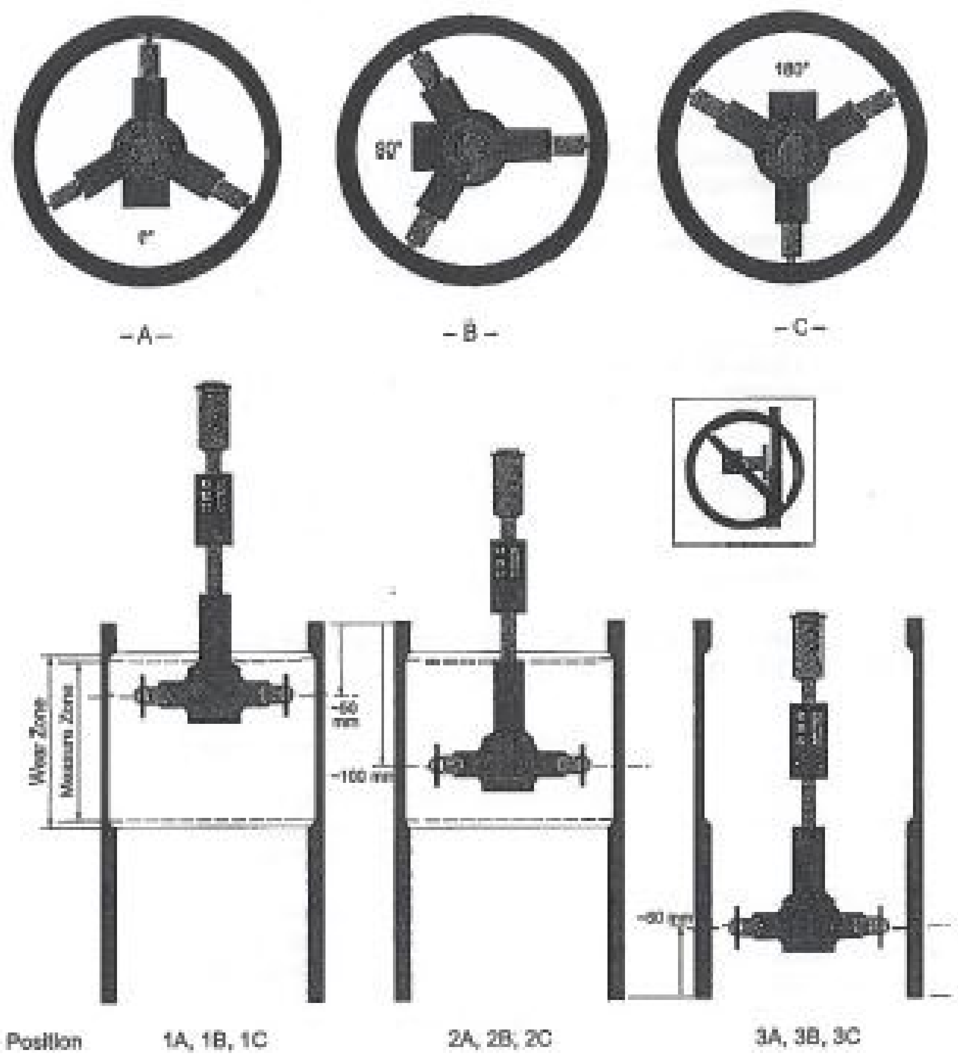


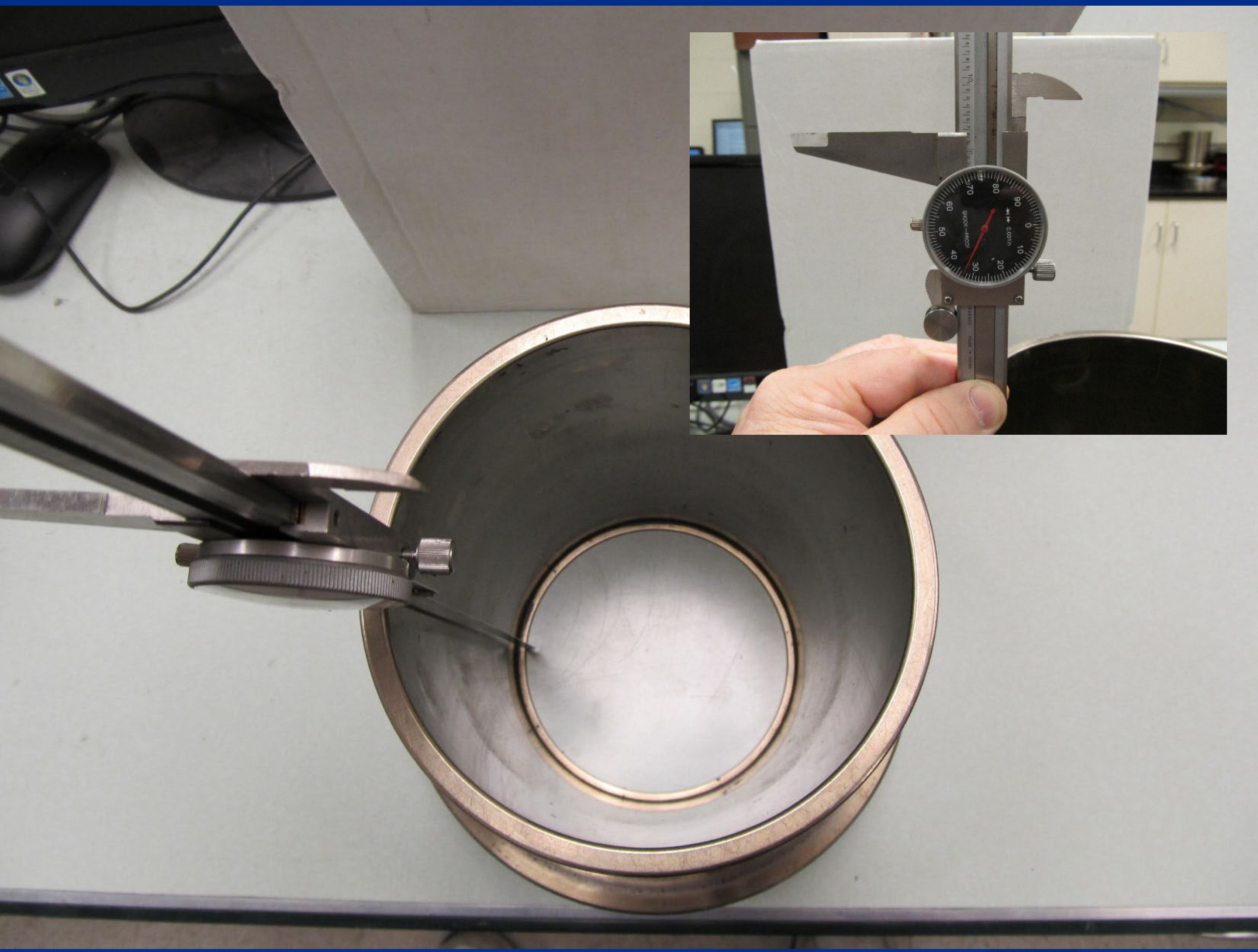
Figure A4.2—Bore Gauge Measurement Positions within the Mold Bore

Mold Diameter 3-Point Bore Gauge

- For in-service molds, each diameter bore measurement recommended to be 149.9-150.0 mm.
- Maximum clearance should be $\leq$ 150.2 mm
- If any diameter fails maximum, mold should not be used (too much play, compaction tends to decrease, which would affect volumetrics)

Mold Length

- Caliper or micrometer
- Measure to nearest 0.025 mm
- Length should be at least 250 mm

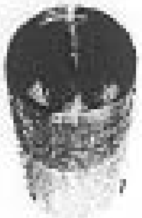


End Plate Diameter

- Measure with a caliper or micrometer
- Find maximum plate diameter (A) by measuring several points
- Measure a "B" diameter at a point 90º from A
- Diameters at each point should be 149.50 to 149.75 mm
- If end plate has excessive clearance, it should not be used: too much play, decrease in compaction

Calibration Data Sheet- Mold

Gyratory Compactor Mold Inspection Report



Mo. D.O.T. / Rolla, Mo.
Mold Owner and Location

David Lee 8-20-08
Technician (sign and date here)

Mitutoyo 511-166 Bore Gage
with 150 mm setting ring
Device(s) Used to Measure Mold

7-25-08
150 mm Ring Calibration Date

Mold Dimensions as per the AASHTO T-312 Standard

parameter	minimum	maximum	A	B	C	D
Mold Identification Number			1	2	3	
Inner Diameter (top)	5.9016" (149.90 mm)	5.9055" (150.00 mm)	5.9045	5.904	5.9035	
Inner Diameter (middle)	5.9016" (149.90 mm)	5.9055" (150.00 mm)	5.9055	5.9045	5.904	
Inner Diameter (bottom)	5.9016" (149.90 mm)	5.9055" (150.00 mm)	5.912	5.9055	5.905	
Top Plate Identification Number						
Top Plate Diameter	5.8858" (149.50 mm)	5.8957" (149.75 mm)	5.894	5.895	5.893	
Bottom Plate Identification Number						
Bottom Plate Diameter	5.8858" (149.50 mm)	5.8957" (149.75 mm)	5.893	5.895	5.894	

Critical Mold Dimensions specific to the Pine AFGC125X

parameter	minimum	maximum	A	B	C	D
Mold Flange Thickness (1)	.998"	1.002"	1.000	.9998	1.000	

Notes Regarding Mold Wear:

- Excessive mold wear can influence the volumetric properties of compacted specimens. As the clearance between the inner diameter of the mold and the outer diameter of the plates (top or bottom) increases, the amount of compaction tends to decrease. If this clearance is less than 0.5 mm, then the impact on compaction is insignificant.
- The AASHTO T-312 specifications for mold inner diameter and end plate outer diameter is worded in such a way that the clearance should indeed always be lower than 0.5 mm. (Because of the precise wording used in the specification, however, it is possible for a mold to have wear which exceeds that permitted by AASHTO T-312 yet still has a clearance which is less than 0.5 mm.)
- Pine recommends that any mold with an inner diameter worn beyond 5.9134" (150.20 mm) should be replaced.

VISUAL INSPECTION

- Free of residue and deep gouges
- Identify visible wear areas
- End plates should be free of raised burrs

MAXIMUM SPECIFIC GRAVITY OF VOIDLESS LOOSE MIX (RICE)

G_{mm}

AASHTO T 209-[22]

11-24-06 Revision
11-9-07 Revision
4-22-09 Revision
11-18-09 Revision
11-17-10 Revision
12-29-14 Revision
12-9-15 Revision
3-2-16 Revision
12-12-18 Revision
2-8-19 Revision
12-17-19 Revision
2-19-23 (ML Revision)

AASHTO TEST METHODS & SPECIFICATIONS

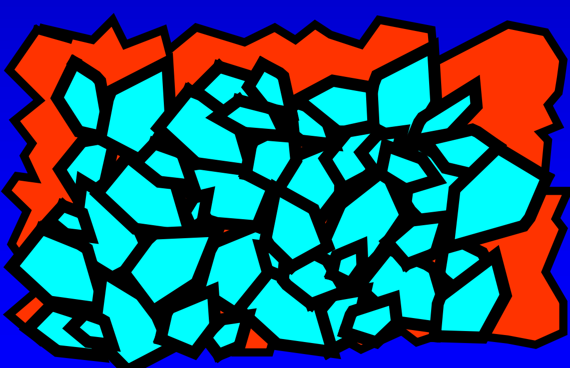
- R35 Volumetric Design Practice
- M323 Volumetric Design Specs
- R30 Mix Conditioning (recently updated)
- T 312 Gyro operation
- T 166 Bulk Specific Gravity of gyro pucks
- ***T 209 Max Specific Gravity of Voidless Mix (Rice)***
- T 283 Moisture Sensitivity
- M 339 Thermometers Used in the Testing of Construction Materials (New)

"RICE" GRAVITY

Maximum Specific Gravity

- Loose (uncompacted) mixture

$$G_{mm} = \frac{\text{Mass agg. and AC}}{\text{Vol. agg. and AC}}$$



MAXIMUM SPECIFIC GRAVITY OF VOIDLESS MIX

- Specific gravity is the ratio of the mass in air of a volume of material to the mass in air of an equal volume of water
- “Rice” test
- “G_{mm}”:
  - G=specific gravity
  - m=mix
  - m=maximum

SAMPLE LOCATION

- Volumetric sample: behind the paver
- TSR sample:
  - Behind paver
  - Truck
  - Plant discharge

USES

- 1. Computing % air voids (a pay factor):
- $V_a = [(\boldsymbol{G_{mm}} - G_{mb}) \div \boldsymbol{G_{mm}}] \times 100$

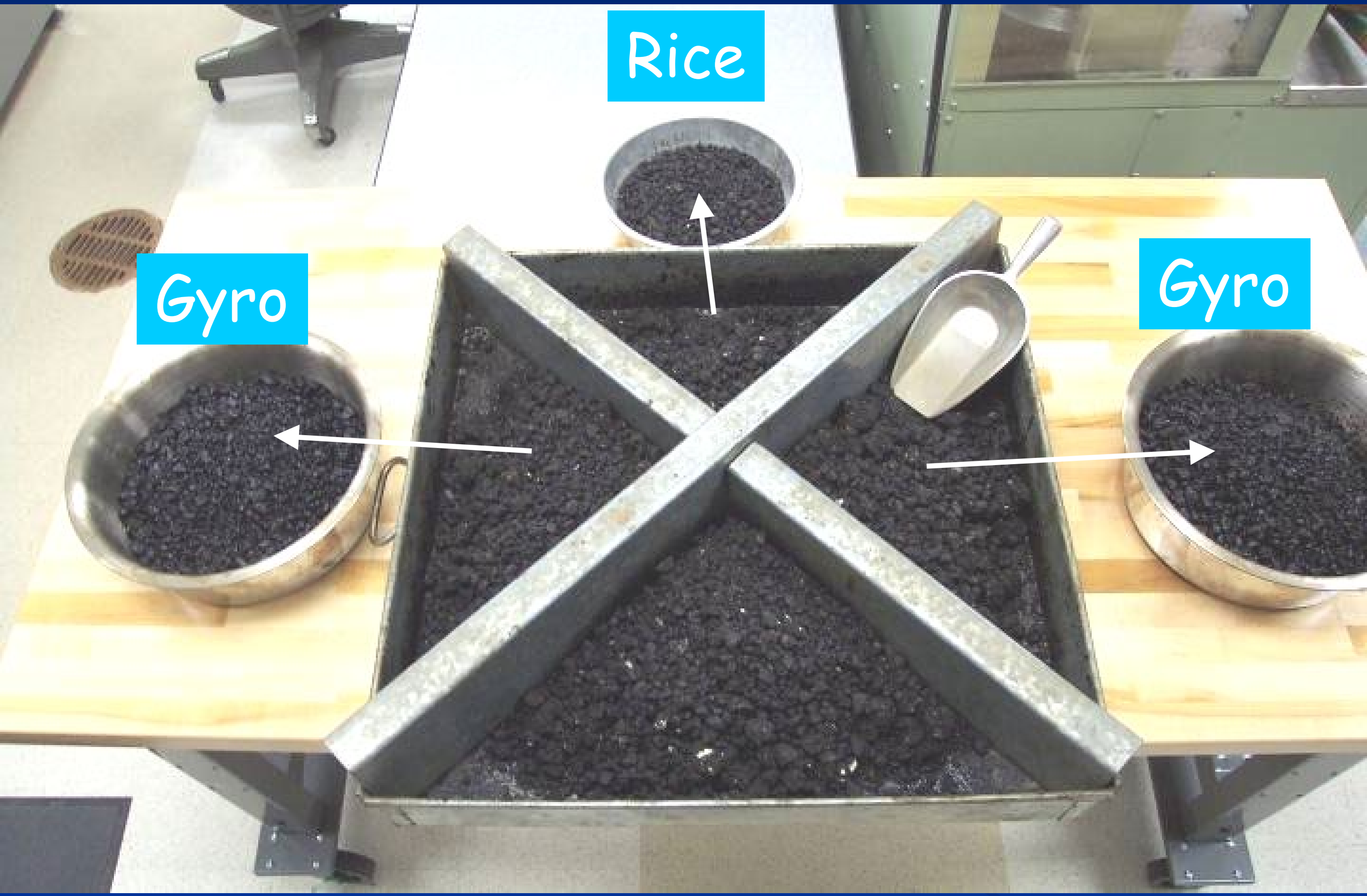
- 2. Computing pavement density (a pay factor):
- $Density = (G_{mc} \div \boldsymbol{G_{mm}}) \times 100$

- G_{mc}=core specific gravity

CALIBRATION

- Pycnometer: daily
- Vacuum: every 12 months

SAMPLE SPLIT



ALTERNATE METHODS

- ***Weigh-in-Air***
- Weigh-in-Water

SUMMARY OF STEPS: Weigh-in-Air Method

- 1. Dry specimen to constant weight at 105 ± 5 °C (mass repeats within 0.1%) *-see cookbook on "mass repeats"*

Or

Run AASHTO T 329 Moisture content of mix to be assured that the specimen is dry (< 0.1%).

- 2. Separate loose mix into small pieces. Be sure not to over-manipulate the sample and cause aggregate to be broken into pieces smaller than original size. Bring specimen to room temperature.

Testing

3. Weigh the dry specimen
Total- tare = "A"

Weigh-in-Air Method

- 4. Add sufficient water to the pycnometer containing the specimen to cover it (~25 ºC)

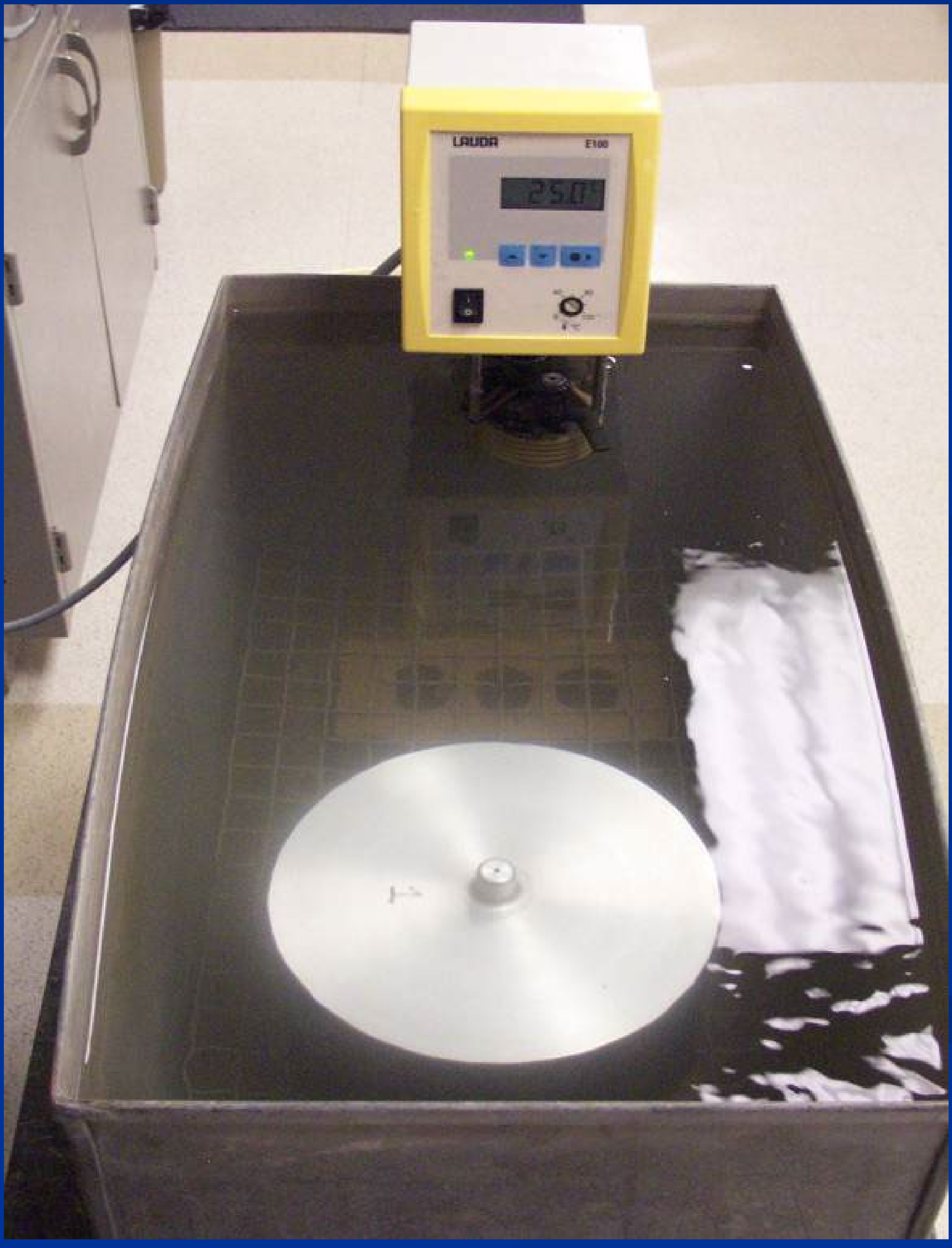
5. De-air the specimen (shake under vacuum). The vacuum is required to be 27.5 ± 2.5 mm Hg absolute vacuum. A manometer is to be connected to the system during testing.

AGITATION

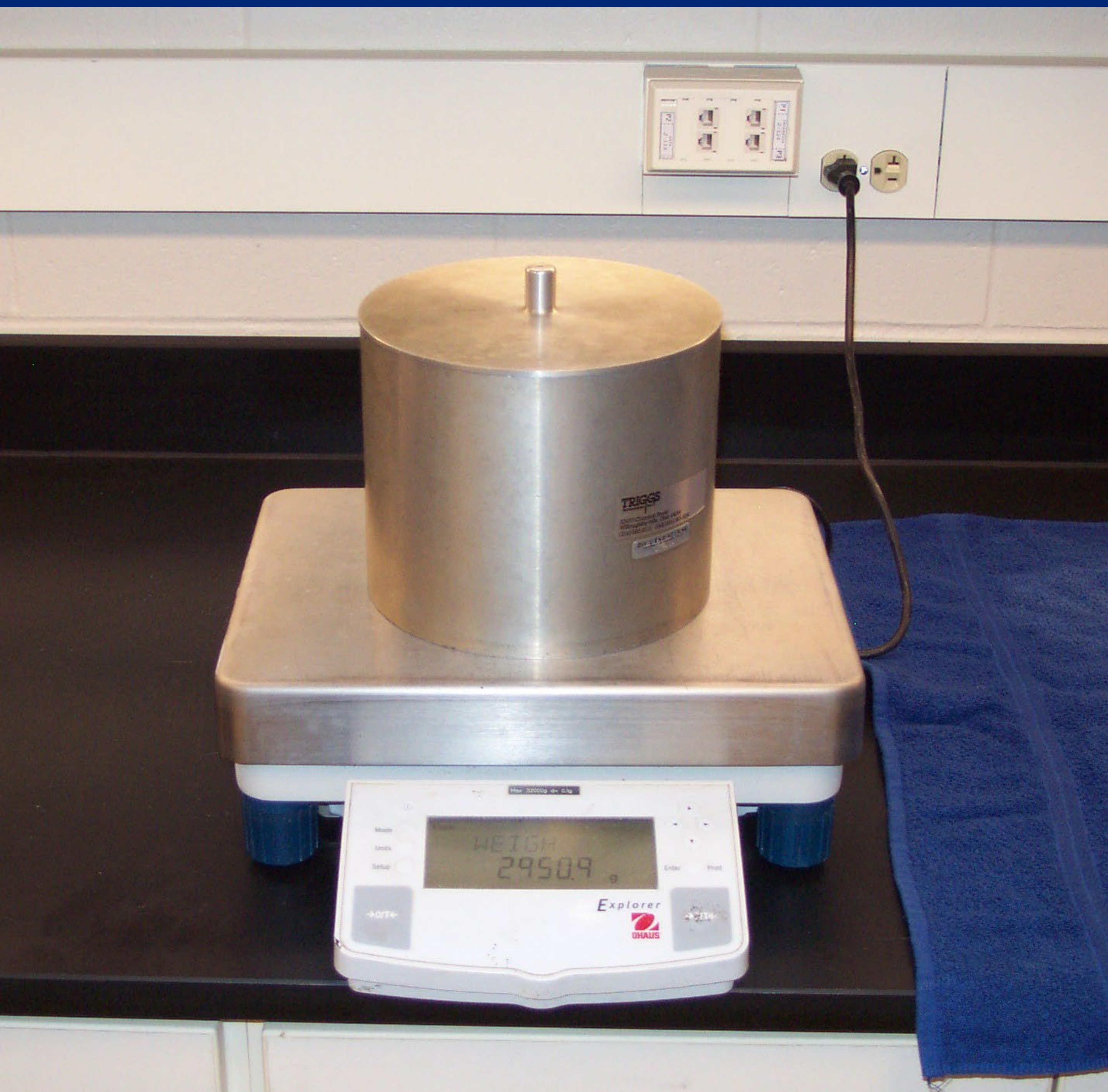
- Mechanical
- Manual

- Manual method has come and gone and come again in the specs as an allowable method

6. Fill the pycnometer with water and bring the specimen to test temperature (25 ± 1°C)



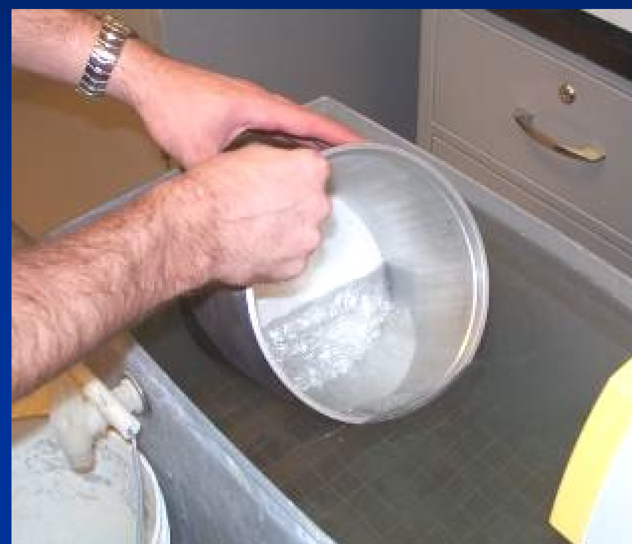
7. Determine weight of [specimen + pycnometer + water] = "E"

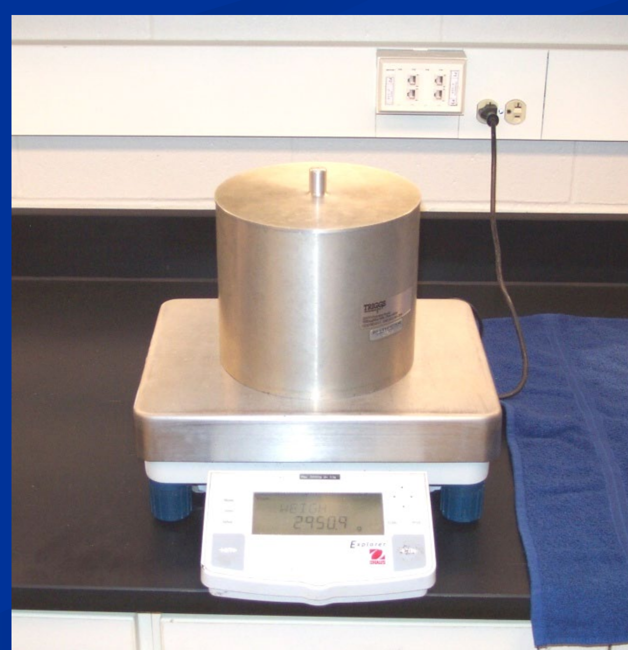


Weigh-in-Air Method: Pycnometer Standardization

- 8. Determine weight of pycnometer full of water to determine its volume. The water is required to be at 25 ± 0.5 °C

  "D"





"D" will be too high with cold temperature & cloudiness

"D" will be too low with high temperature

CALCULATION

- Results of steps 3,4, 8 determine the volume of specimen.
- 9. Knowing mass of specimen and mass of water displaced (volume of specimen), calculate G_{mm}

$$G_{mm} = \frac{A}{A + D - E}$$

DRY-BACK STEP

- 10. If absorption of ***any*** coarse aggregate fraction is greater than 2.0%, dry back the specimen to a surface dry condition and weigh. Use this weight ***"A2" in the denominator in place of "A"***.
- Absorption data is on the JMF.

DRY-BACK

- Purpose- to see if water has penetrated the binder coating
- So--dry the sample back to a surface-dry condition --don't oven dry all the way to ~ zero moisture

When to Implement Dry-Back

- If coarse aggregate absorptions are excessive, perform on first lot (all sublots)
- If initial G_{mm} and the dry-back G_{mm} are within 0.002 of each other in each of the first 4 sublots, the dry-back procedure may be reduced to once per 4 sublots (FAQ).

CALCULATION (Dry-Back Procedure)

- 11. Knowing mass of specimen and mass of water displaced (volume of specimen), calculate G_{mm}.

$$G_{mm} = \frac{A}{A2 + D - E}$$

ALTERNATE METHODS

- Weigh-in-Air
- ***Weigh-in-Water***

SUMMARY OF STEPS: Weigh-in-Water Method

- 1. Dry specimen to constant weight at 105 ± 5 ºC (mass repeats within 0.1%)-*see cookbook on "mass repeats"*

Or

Run *AASHTO* T 329 Moisture content of mix to be assured that the specimen is dry (< 0.1%).

- 2. Separate loose mix into small pieces. Be sure not to over-manipulate the sample and cause aggregate to be broken into pieces smaller than original size. Bring specimen to room temperature.

Testing

3. Weigh the dry specimen Total-tare = "A"

4. De-air the specimen (shake under vacuum). The vacuum is required to be 27.5 ± 2.5 mm Hg absolute vacuum. A manometer is to be connected to the system during testing.

Shaker

ALTERNATE METHOD: Weigh-in-Water

- 5. Instead of weighing on top of the scale (in air), suspend the pycnometer below the scale in water (25 ± 1°C) without lid:

[pycnometer +specimen] under water= **C**

Weigh in Water

- 6. Remove specimen from pycnometer. Immediately determine weight under water of pycnometer.
- [pycnometer] under water= **B**

- 7. Calculate G_{mm}:

$$G_{mm} = \frac{A}{A + B - C}$$

DRY-BACK STEP

- 8. If absorption of *any* coarse aggregate fraction is greater than 2.0%, dry back the specimen to a surface dry condition and weigh. Use this weight "A2" in the denominator.
- Absorption data is on the JMF.

CALCULATION (Dry-Back Procedure)

- 9. Knowing mass of specimen and mass of water displaced (volume of specimen), calculate G_{mm}

$$G_{mm} = \frac{A}{A2 + B - C}$$

"C" will be incorrect if water temperature is not standard

RICE GRAVITY Methods in Missouri

- Weigh-in-air
- Weigh-in-water: majority?

RICE GRAVITY Methods in Missouri

- Mechanical agitation- vast majority
- Manual – very few
- Combination - a few

- A few tailor the method to the circumstance

CALCULATIONS OF VOLUMETRICS

AIR VOIDS

- $$V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$$

AIR VOIDS

- $$V_a = \frac{2.557 - 2.455}{2.557} \times 100$$

$V_a = 4.0\%$

VMA

Voids in Mineral Aggregate

$$VMA = 100 - \frac{G_{mb} P_s}{G_{sb}}$$

VMA is an indication of film thickness on the surface of the aggregate

Location of Specific Gravities on JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03 **CONTRACTOR = MY BUSINESS** **SP125 03-16**

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
35JSJ001	100207..LD1	/ Hard Rock Stone, Dig Deep, MO	2.515	2.713	2.9	Jet City Dolo.	5-8	25
35JSJ002	100204..LD1	/ Hard Rock Stone, Dig Deep, MO	2.476	2.725	3.7	Jet City Dolo.	5-8	25
35JSJ003	1002MS..MSLD	/ Hard Rock Stone, Dig Deep, MO	2.480	2.761		Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/ Missy Lime Co. #2, Ste. General, MO	2.303	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ Black Asphalt Products, Decoy, MO						

MATERIAL IDENT #	35JSJ001	35JSJ002	35JSJ003	30CAJ016					COMB.
03016	3/4"	3/8"	MAN SAND	Hyd. Lime					GRAD
1 1/2"	100.0	100.0	100.0	100.0					100.0
1"	100.0	100.0	100.0	100.0					100.0
3/4"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1/2"	97.6	100.0	100.0	100.0	58.6	12.0	26.0	2.0	98.6
3/8"	83.8	96.1	100.0	100.0	50.3	11.5	26.0	2.0	89.8
#4	31.8	35.0	99.9	100.0	19.1	4.2	26.0	2.0	51.3
#8	7.0	8.0	82.0	100.0	4.2	1.0	21.3	2.0	28.5
#16	2.6	3.5	40.7	100.0	1.6	0.4	10.6	2.0	14.6
#30	1.6	2.6	26.6	100.0	1.0	0.3	6.9	2.0	10.2
#50	1.6	2.1	13.5	100.0	1.0	0.3	3.5	2.0	6.7
#100	1.5	1.9	5.4	100.0	0.9	0.2	1.4	2.0	4.5
#200	1.5	[illegible]	4.2	[illegible]	0.9	0.2	1.1	2.0	4.2

LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	3855.0	Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax =	205	ASPHALT CONTENT	6.2%
CALIBRATION NUMBER		90004	MASTER GAUGE BACK CNT. =	2196				A1 =	-5.234741		
MASTER GAUGE SER. NO. =		770	SAMPLE WEIGHT =	7200				A2 =	3.436895		

Aggregate & Mixture Properties Based on Contractors Mix Design

Gmm =	2.405
Gmb =	2.308
Gsb =	2.629

VMA

Example Calculations

- **Given that G_{mb} = 2.455, P_s = 95%, and G_{sb} = 2.703**

$$VMA = 100 - \frac{(2.455)(95)}{2.703} = 13.7$$

G_{sb} CHANGES

- If the blend has changed say, due to a Field Adjustment of fraction %'s, then Gsb should be re-calculated.

VFA

Voids Filled with Asphalt

$$VFA = 100 \times \frac{VMA - V_a}{VMA}$$

VFA is the percent of VMA that is filled with asphalt cement

VFA

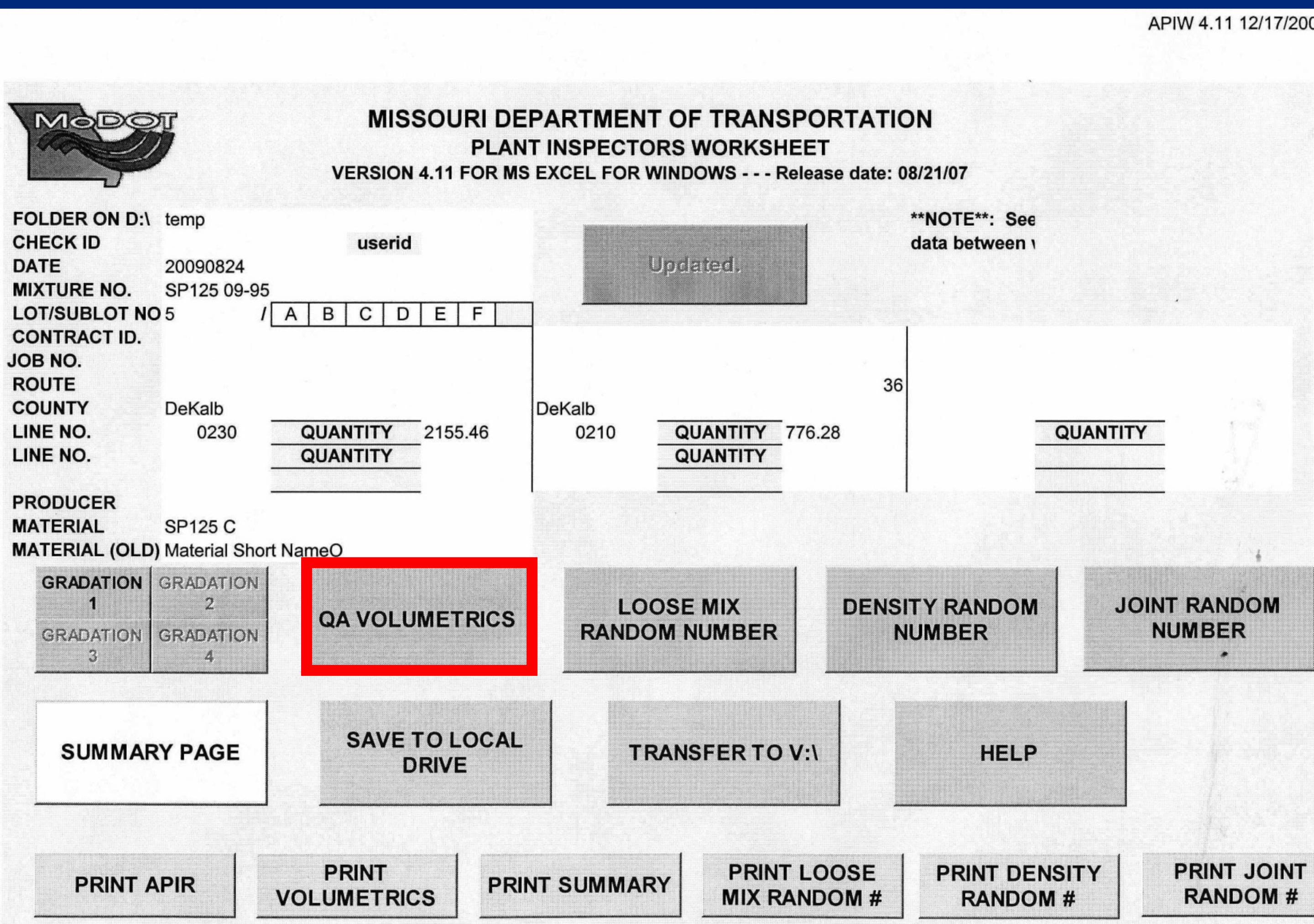
- $$VFA = \frac{13.7 - 4.0}{13.7} \times 100$$

VFA= 71%

CALCULATIONS

- QC calculates air voids, VMA, and VFA 1 per ***sublot***
- QA calculates air voids, VMA, and VFA 1 per ***4 sublots***
- ***Only air voids and VMA are pay factors***

MoDOT SPREADSHEET



SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. #VALUE! LOT NO. 0

SUBLOT							
DATE							

AASHTO T 209

A2 required when T85 absorption >2.0% on any aggregate fraction.

TECHNICIAN							
A = Wt. of sample:	1594.4						
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:	7472.2						
X = A + D (A2 used in lieu of A for dry-back)	9066.6	0.0	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:	8421.5						
Y = X - E	645.1	0.0	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	2.472	2.472	2.472	2.472	2.472	2.472	2.472

AASHTO T 166

TECHNICIAN								
MOLDING TEMPERATURE								
A = Weight of sample in air:		4867.8						
B = Weight of sample in water:	SPEC. 1	2801.9						
C = Weight of surface dry sample:		4880.4						
Gmb = BULK SP. G. = A / (C-B)		2.342	0.000	0.000	0.000	0.000	0.000	0.000
A = Weight of sample in air:		4899.1						
B = Weight of sample in water:	SPEC. 2	2814.5						
C = Weight of surface dry sample:		4911.9						
Gmb = BULK SP. G. = A / (C-B)		2.336	0.000	0.000	0.000	0.000	0.000	0.000
AVG. Gmb		2.339	0.000	0.000	0.000	0.000	0.000	0.000

TECHNICIAN							
MoDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							
AASHTO T 308 (IGNITION)							
GAUGE %AC	5.35						
NUCLEAR OR IGNITION							
% MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						

AASHTO R 35

A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg.)	2.339	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.8	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = [(VMA-Va) / VMA] X 100	59	0	0	0	0	0	0

AASHTO T 166

TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	2.282	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	92.3	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

FOR 2ND CORE SUBLOT WHEN DENOTED IN QC PLAN

TECHNICIAN							
A = Weight of sample in air:							
B = Weight in water:							
C = Weight of surface dry sample:							
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

G_{mm} Portion

SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. #VALUE! LOT NO. 0

SUBLOT							
DATE							
AASHTO T 209	A2 required when T85 absorption >2.0% on any aggregate fraction.						
TECHNICIAN							
A = Wt. of sample:	1594.4						
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:	7472.2						
X = A + D (A2 used in lieu of A for dry-back)	9066.6	0.0	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:	8421.5						
Y = X - E	645.1	0.0	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	2.472	2.472	2.472	2.472	2.472	2.472	2.472

DRY-BACK

- If dry-back procedure is done, substitute "A_2" for "A" in the ***denominator***

DRY-BACK

SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. #VALUE! LOT NO. 0

SUBLOT							
DATE							
AASHTO T 209	A2 required when T85 absorption >2.0% on any aggregate fraction.						
TECHNICIAN							
A = Wt. of sample:	1594.4						
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:	7472.2						
X = A + D (A2 used in lieu of A for dry-back)	9066.6	0.0	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:	8421.5						
Y = X - E	645.1	0.0	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	2.472	2.472	2.472	2.472	2.472	2.472	2.472

USE of G_{mm}

- Calculate Air Voids
- Calculate Core Density

SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. #VALUE! LOT NO. 0

SUBLOT							
DATE							

AASHTO T 209 Rice Gmm

A2 required when T85 absorption >2.0% on any aggregate fraction.

TECHNICIAN							
A = Wt. of sample:	1594.4						
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:	7472.2						
X = A + D (A2 used in lieu of A for dry-back)	9066.6	0.0	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:	8421.5						
Y = X - E	645.1	0.0	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	2.472	2.472	2.472	2.472	2.472	2.472	2.472

AASHTO T 166

TECHNICIAN							
MOLDING TEMPERATURE							
A = Weight of sample in air:	4867.8						
B = Weight of sample in water: SPEC. 1	2801.9						
C = Weight of surface dry sample:	4880.4						
Gmb = BULK SP. G. = A / (C-B)	2.342	0.000	0.000	0.000	0.000	0.000	0.000
A = Weight of sample in air:	4899.1						
B = Weight of sample in water: SPEC. 2	2814.5						
C = Weight of surface dry sample:	4911.9						
Gmb = BULK SP. G. = A / (C-B)	2.336	0.000	0.000	0.000	0.000	0.000	0.000
AVG. Gmb	2.339	0.000	0.000	0.000	0.000	0.000	0.000

Gmb

TECHNICIAN							
MoDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							
AASHTO T 308 (IGNITION)							
GAUGE %AC	5.35						
NUCLEAR OR IGNITION							
% MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						

Pb

A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg.)	[illegible]	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.8	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = [(VMA-Va) / VMA] * 100	59	0	0	0	0	0	0

AASHTO T 166

cores

TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	[illegible]	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	[illegible]	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

FOR 2ND CORE SUBLOT WHEN DENOTED IN QC PLAN

TECHNICIAN							
A = Weight of sample in air:							
B = Weight in water:							
C = Weight of surface dry sample:							
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

SPREADSHEET CALCULATIONS

AASHTO R 35

A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg.)	2.339	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.8	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = (VMA-Va) / VMA	59	0	0	0	0	0	0

AASHTO T 166

TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	2.282	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	92.3	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

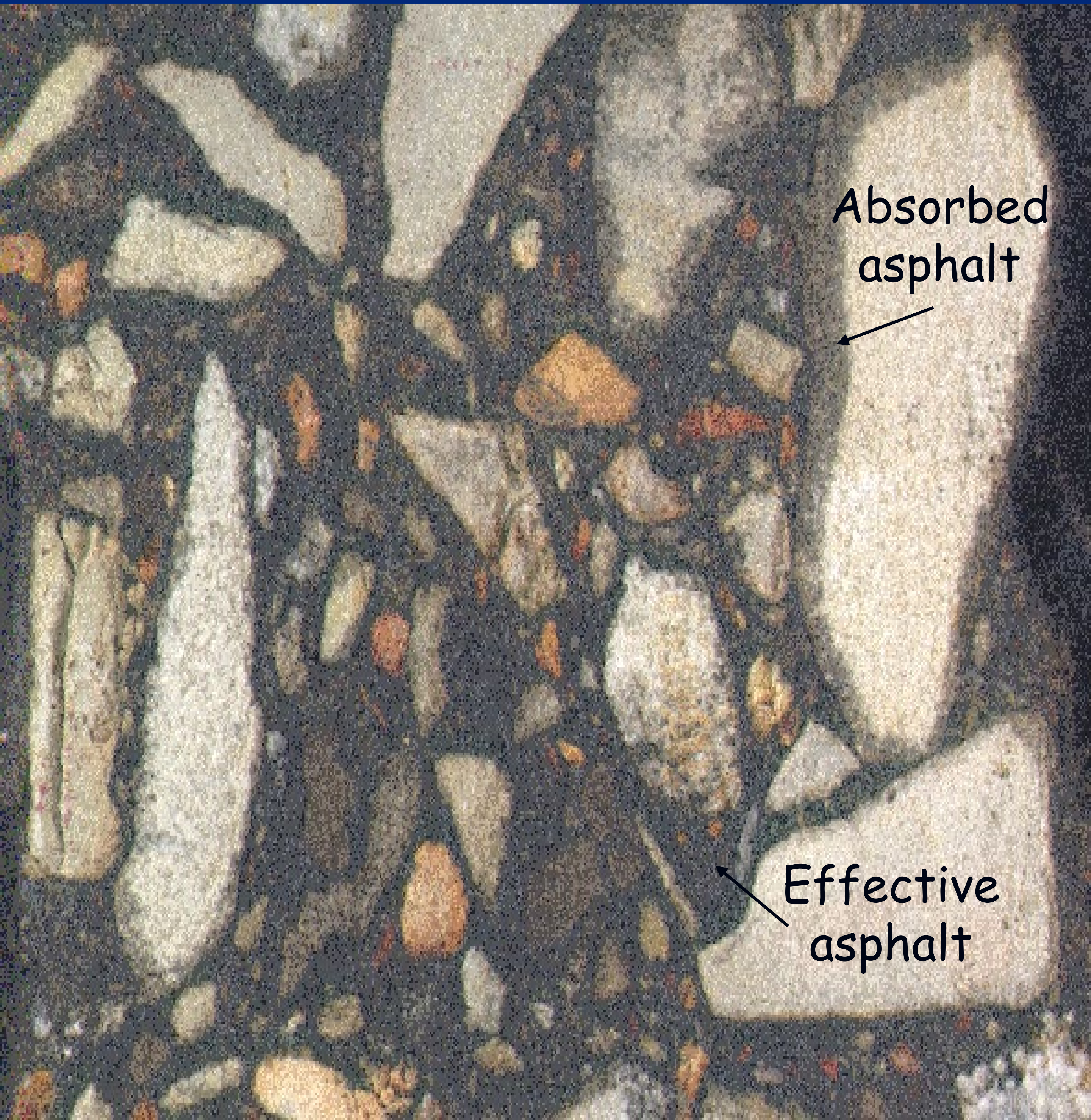
CHANGES IN "G_{mm}"
In silo, trucks, MTV

- Time interval at high temperature
- Absorptiveness of aggregate

TIME AT HIGH TEMPERATURE

SURGE SILO

ABSORPTIVENESS OF AGGREGATE



COMMON TESTING ERRORS

- Not allowing specimen to cool to proper temperature.
- Over-manipulating the specimen, producing broken, uncoated particles
- Not having a manometer connected directly to the pycnometer
- Not maintaining the proper level of vacuum.
- Not breaking up sample completely
- Not agitating sample enough
- Agitating sample too much

COMMON TESTING ERRORS, cont'd.

- If the specimen was too warm when placed in the pycnometer: after the vacuum step, if stirring is done, aggregate may be broken.
- Not placing the lid in the same position each time.
- Not sufficiently drying the outside of the pycnometer before weighing.

COMMON TESTING ERRORS, cont'd.

- Allowing entrapped air bubbles in pycnometer
- Not performing the dry-back procedure for highly absorptive aggregates
- Not calibrating the pycnometer often enough
- Not maintaining proper water temperatures

COMMON TESTING ERRORS, cont'd.

- Use of a dry towel may wick water out of the pycnometer hole.
- Not using approximately the same size specimen each time.
- Not changing vacuum level at proper rates

ASPHALT CONTENT IGNITION OVEN METHOD

AASHTO T 308-[22]

12-28-06 Revision
1-2-09 Revision
4-22-09 Revision
11-18-09 Revision
2-26-10 Revision
2-16-11 Revision
3-2-12 Revision
2-26-13 Revision
12-18-13 Revision
12-29-14 Revision
2-5-15 Revision
12-9-15 Revision
3-2-16 Revision
12-28-16 Revision
1-18-18 Revision
12-12-18 Revision
2-8-19 Revision
3-15-19 Revision
12-17-19 Revision
1-30-20 Revision
2-19-23 (ML Revision)

AASHTO T308

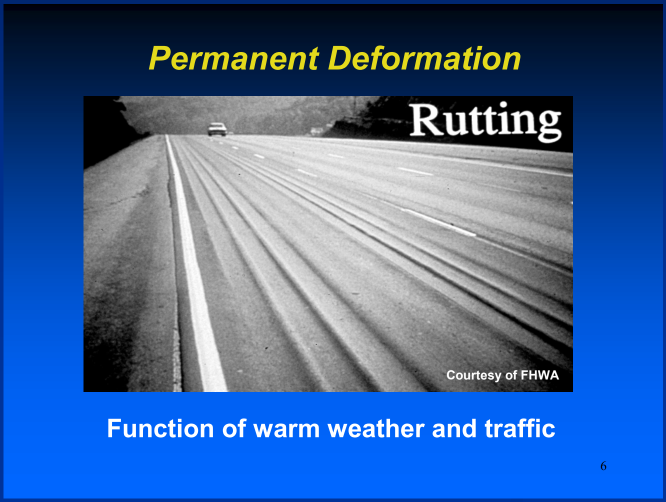
Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

SCOPE

- ***Background***
- Binder Content Role in QC/QA
- Sampling
- Test procedure
- Field verification
- Oven verification

BINDER CONTENT-WHY TEST?

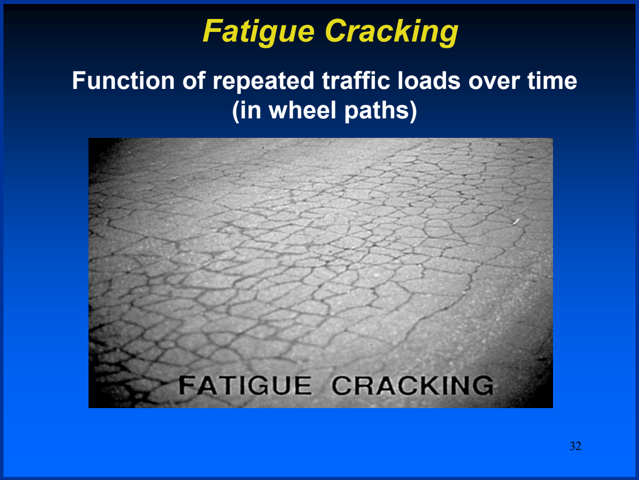
- Excessive binder can cause instability e.g. rutting, shoving, corrugations, bleeding



- Binder content is an important part of the dust-to-binder ratio which affects compactibility and cohesion

BINDER CONTENT- WHY TEST?

- Insufficient binder can lead to lack of adhesion, raveling, stripping, and cracking



AASHTO TEST METHODS & SPECIFICATIONS

- R 97 Sampling Hot Mix
- R 47 HMA Sample Splitting
- T 329 Moisture Content of Hot Mix
- ***T 308 Binder Content Ignition Oven***
- ***T 30 Sieve Analysis of Residue***
- ***R 96 Installation, Operation, and Maintenance of Ignition Furnaces***
- ***M 339 Thermometers Used in the Testing of Construction Materials (New)***

Equipment

- Ignition Furnace
- Basket assembly
- Oven (110 ± 5 C)
- Balance
- Safety Equipment: face shield, gloves, long-sleeved jacket, protective basket cage

BINDER CONTENT TEST METHODS

- Solvent extraction T 164
- Nuclear gage: T 287, TM 54
  - Low radiation
  - Regular radiation
- Ignition oven: T 308
  - Method A
    - Convection oven
    - Infrared oven
  - Method B

- Method A: internal scale
- Method B: no internal scale

SOLVENT EXTRACTION T 164

- Solvent health issues
- Solvent disposal issues
- Thus, expensive

NUCLEAR GAGE T 287, TM 54

- Health issues
- Interferences
- Calibration issues

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03 **CONTRACTOR = MY BUSINESS** **SP125 03-16**

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
35JSJ001	100207..LD1	/ Hard Rock Stone, Dig Deep, MO	2.515	2.713	2.9	Jet City Dolo.	5-8	25
35JSJ002	100204..LD1	/ Hard Rock Stone, Dig Deep, MO	2.476	2.725	3.7	Jet City Dolo.	5-8	25
35JSJ003	1002MS..MSLD	/ Hard Rock Stone, Dig Deep, MO	2.480	2.761	4.0	Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/ Missy Lime Co. #2, Ste. General, MO	2.303	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ Black Asphalt Products, Decoy, MO	1.023		PG70-22	Gyro Mold Temp. 300-310°F		

MATERIAL IDENT #	35JSJ001	35JSJ002	35JSJ003	30CAJ016	35JSJ001	35JSJ002	35JSJ003	30CAJ016	COMB.
03016	3/4"	3/8"	MAN SAND	Hyd. Lime	60.0	12.0	26.0	2.0	GRAD
1 1/2"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
3/4"	100.0	100.0	100.0	100.0	60.0	12.0	26.0	2.0	100.0
1/2"	97.6	100.0	100.0	100.0	58.6	12.0	26.0	2.0	98.6
3/8"	83.8	96.1	100.0	100.0	50.3	11.5	26.0	2.0	89.8
#4	31.8	35.0	99.9	100.0	19.1	4.2	26.0	2.0	51.3
#8	7.0	8.0	82.0	100.0	4.2	1.0	21.3	2.0	28.5
#16	2.6	3.5	40.7	100.0	1.6	0.4	10.6	2.0	14.6
#30	1.6	2.6	26.6	100.0	1.0	0.3	6.9	2.0	10.2
#50	1.6	2.1	13.5	100.0	1.0	0.3	3.5	2.0	6.7
#100	1.5	1.9	5.4	100.0	0.9	0.2	1.4	2.0	4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2	1.1	2.0	4.2

LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	3855.0	Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax =	205	ASPHALT CONTENT	6.2%
CALIBRATION NUMBER		90004			MASTER GAUGE BACK CNT. =	2196		A1 =	-5.234741		
MASTER GAUGE SER. NO. =		770			SAMPLE WEIGHT =	7200		A2 =	3.436895		

Aggregate & Mixture Properties Based on Contractors Mix Design

IGNITION OVEN
T 308

Method A:

- more convenient, higher lab production rates

METHOD "A"

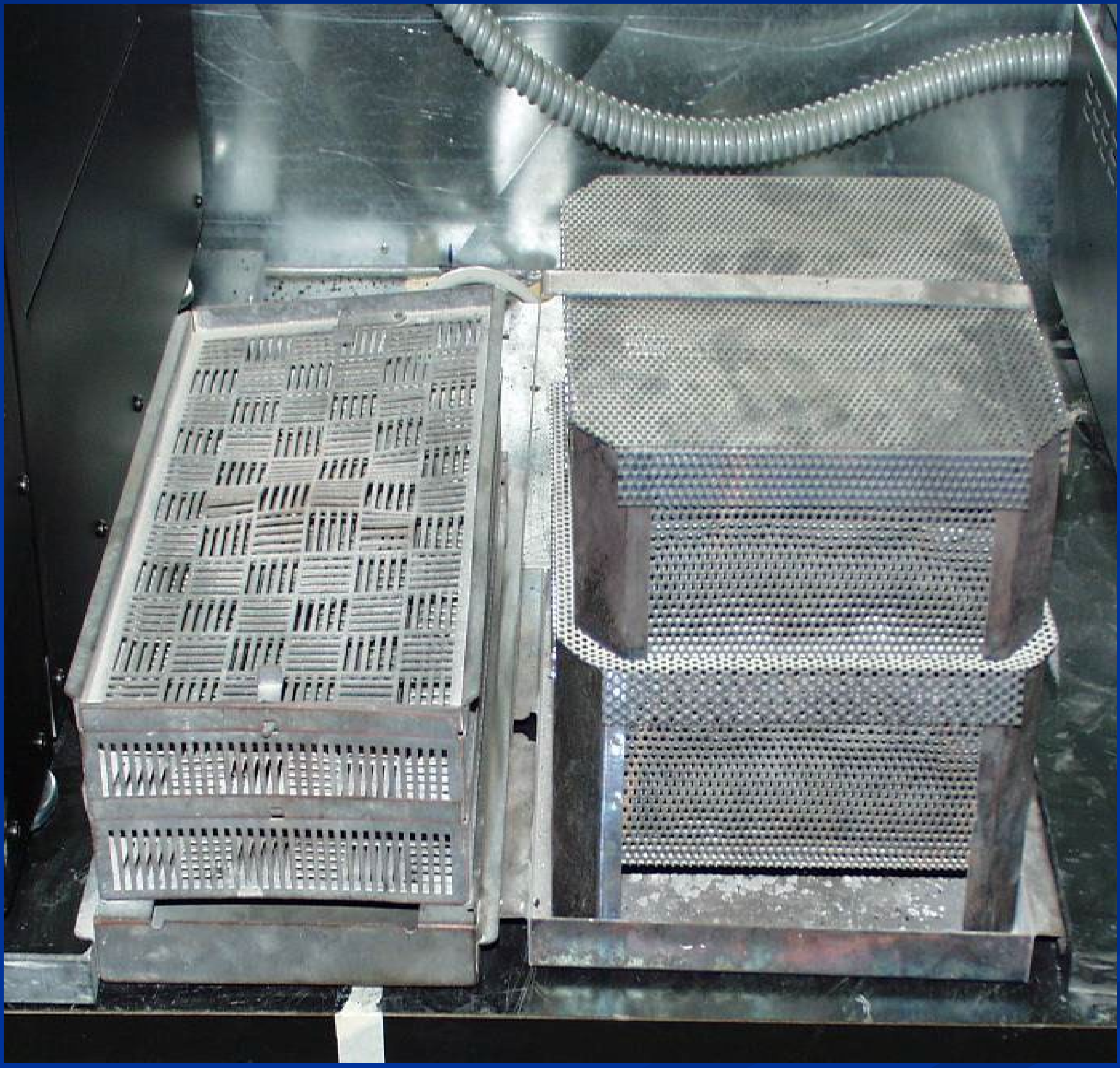
- Convection oven (NCAT)
- Infrared oven:
  - First generation
  - Second generation (NTO)

HEAT TRANSFER

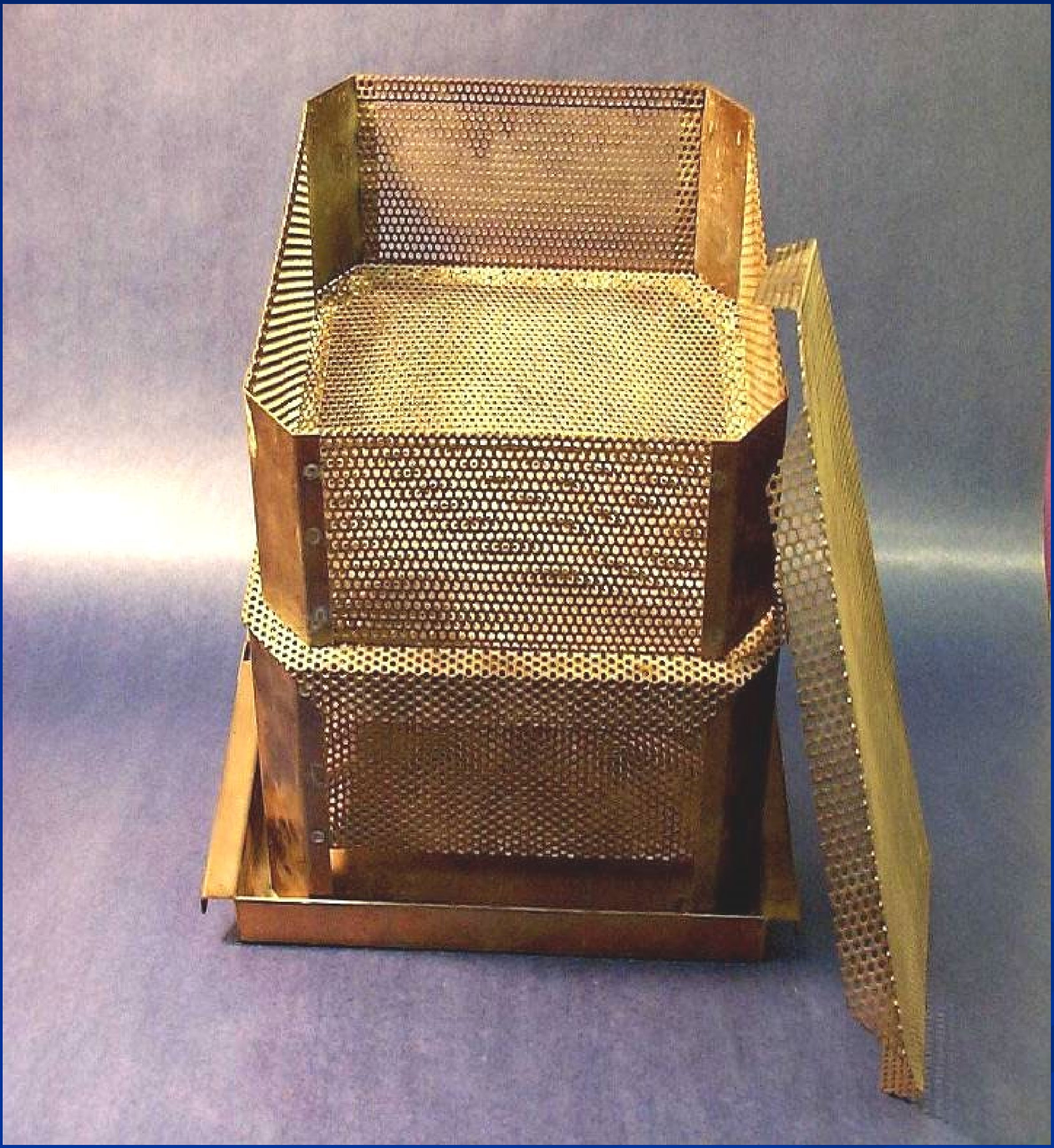
- ***Convection:*** heat warms the air, which warms the sample
- ***Infrared:*** electromagnetic energy waves directly heat the sample


Infrared
Convection
TROXLER
NTO

BASKETS



CONVECTION OVEN BASKET



INFRARED OVEN

Default - Normal

Option 1 - Less

Option 2 - More

SECOND GENERATION INFRARED

IGNITION OVEN

Method B: no internal scale

- lower oven cost; less operational problems

METHOD "B"

- Note the special heat resistant shirt

TYPES OF METHODS In Missouri

- NCAT oven - vast majority
- Nuclear – a few
- Low radiation nuclear - 1
- First generation infrared ignition oven – 1
- Second generation infrared ignition oven – 1

MATCHING AGGREGATE TYPE TO BINDER TEST METHOD

- Dolomite:
  - Nuclear
  - Low radiation nuclear
- All other: convection or infrared ignition ovens

SCOPE

- Background
- ***Binder Content Role in QC/QA***
- Sampling
- Test procedure
- Field verification
- Oven verification

Binder Content Role

- ***Mix design & acceptance***
- Field Verification of mix

Mix Design & Mix Acceptance

- Contractor designs mix & submits target binder content to MoDOT
- MoDOT approves and sets JMF target binder %

Binder Content Role

- Mix design & acceptance
- ***Field verification of mix***

CONTENT

- ***Binder content of mix***
- Binder content of RAP
- Aggregate gradation

% BINDER

- Design (target) binder content is determined during mix design and verified/approved by MoDOT
- May have to be adjusted in the field resulting in a new target binder content:
  - Different aggregate sources
  - Significant change in % of aggregate sources
  - Different oven

Binder Role

- Binder content is a pay factor in 403 projects

Location of Target Binder Content on JMF

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125HB

DATE = 10/29/03 | **CONTRACTOR = MY BUSINESS** | **SP125 03-16**

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
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35JSJ002	100204..LD1	/ Hard Rock Stone, Dig Deep, MO	2.476	2.725	3.7	Jet City Dolo.	5-8	25
35JSJ003	1002MS..MSLD	/ Hard Rock Stone, Dig Deep, MO	2.480	2.761	4.0	Jet City Dolo.	5-8	10
30CAJ016	1002HL..HL	/ Missy Lime Co. #2, Ste. General, MO	2.303	2.303		Hyd. Lime		
36DLJ016	1015ACPG..7022	/ Black Asphalt Product[illegible]				0°F		

MATERIAL IDENT #	35JSJ001	35JSJ002	35JSJ003	30CAJ016					COMB.
03016	3/4"	3/8"	MAN SAND	Hyd. Lime					GRAD
1 1/2"	100.0	100.0	100.0	100.0					100.0
1"	100.0	100.0	100.0	100.0					100.0
3/4"	100.0	100.0	100.0	100.0					100.0
1/2"	97.6	100.0	100.0	100.0	58.6	12.0	26.0	2.0	98.6
3/8"	83.8	96.1	100.0	100.0	50.3	11.5	26.0	2.0	89.8
#4	31.8	35.0	99.9	100.0	19.1	4.2	26.0	2.0	51.3
#8	7.0	8.0	82.0	100.0	4.2	1.0	21.3	2.0	28.5
#16	2.6	3.5	40.7	100.0	1.6	0.4	10.6	2.0	14.6
#30	1.6	2.6	26.6	100.0	1.0	0.3	6.9	2.0	10.2
#50	1.6	2.1	13.5	100.0	1.0	0.3	3.5	2.0	6.7
#100	1.5	1.9	5.4	100.0	0.9	0.2	1.4	2.0	4.5
#200	1.5	1.8	4.2	99.0	0.9	0.2	1.1	2.0	[illegible]

LABORATORY	Gmm =	2.405	% VOIDS =	4	TSR =	95	TSR Wt.	Nini =	9	MIX COMPOSITION	
CHARACTERISTICS	Gmb =	2.308	V.M.A. =	14.4	-200/AC =	1.1	3855.0	Ndes =	125	MIN. AGG.	93.8%
AASHTO T312	Gsb =	2.629	% FILLED =	72	Gyro Wt. =	4610		Nmax =	205	ASPHALT CONTENT	6.2%
CALIBRATION NUMBER		90004	MASTER GAUGE BACK CNT. =			2196		A1 =	-5.234741		
MASTER GAUGE SER. NO. =		770	SAMPLE WEIGHT =			7200		A2 =	3.436895		

Aggregate & Mixture Properties Based on Contractors Mix Design

MIX COMPOSITION

MIN. AGG. 93.8%

ASPHALT CONTENT 6.2%

SCOPE

- Background
- Binder Content Role in QC/QA
- ***Sampling***
- Test procedure
- Field verification
- Oven verification

Binder Content Samples

- 401: plant
- 403: roadway

Binder Content Field Verification

- 401: JMF - 0.3 to + 0.5%
- 403: JMF ± 0.3%

LOOSE MIX: 403

Volumetric/%Binder Sample

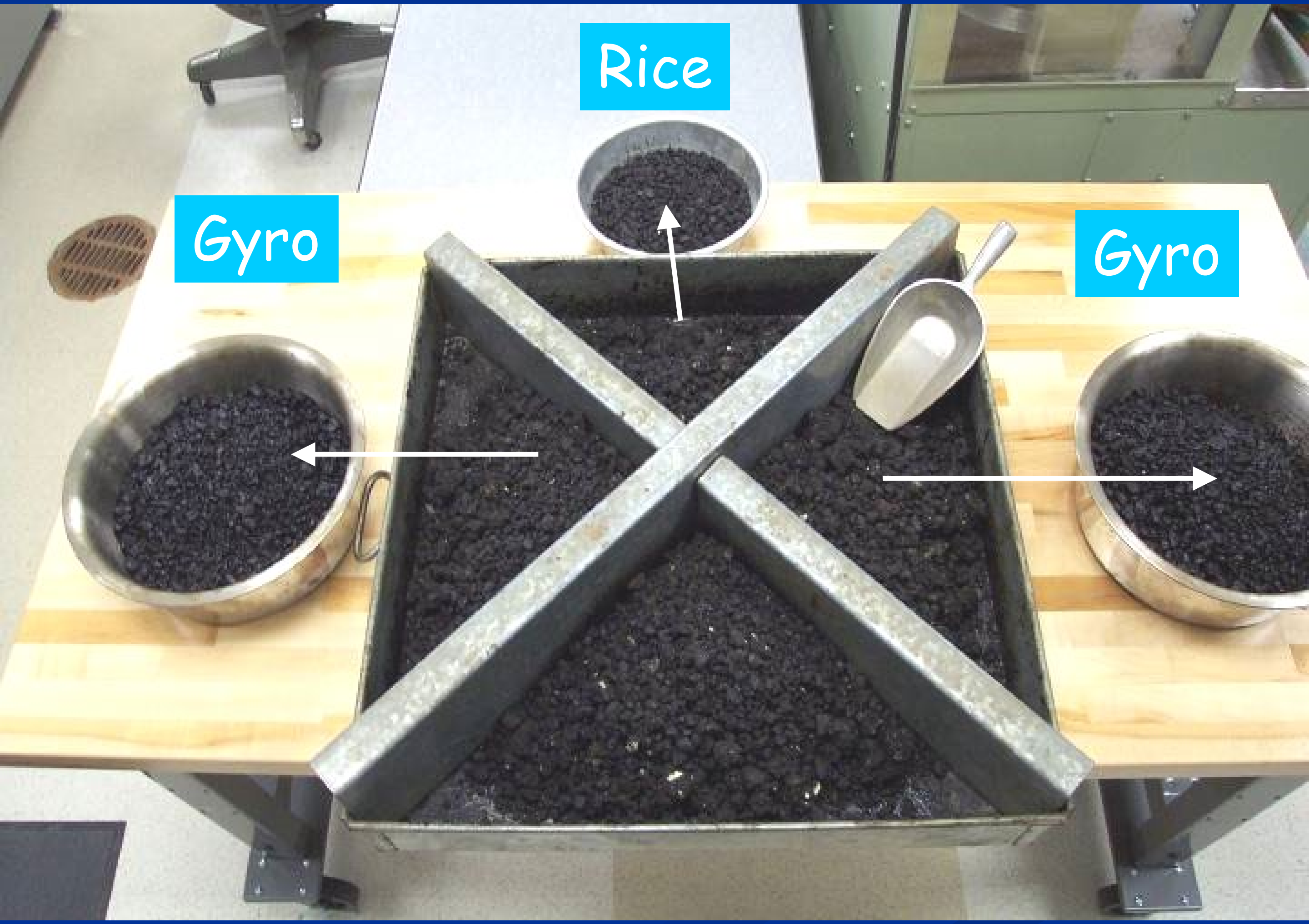
- Sampling Frequency:
  - QC: one per ***sublot***
  - QA: one per ***4 sublots***- "independent sample"
  - QA: once per ***day*** test QC "retained sample". This may be omitted on days when independent QA sample is taken, if confident and "favorable comparison" exists between QA's QC split and QC (within 0.1%)

Loose Mix: 401

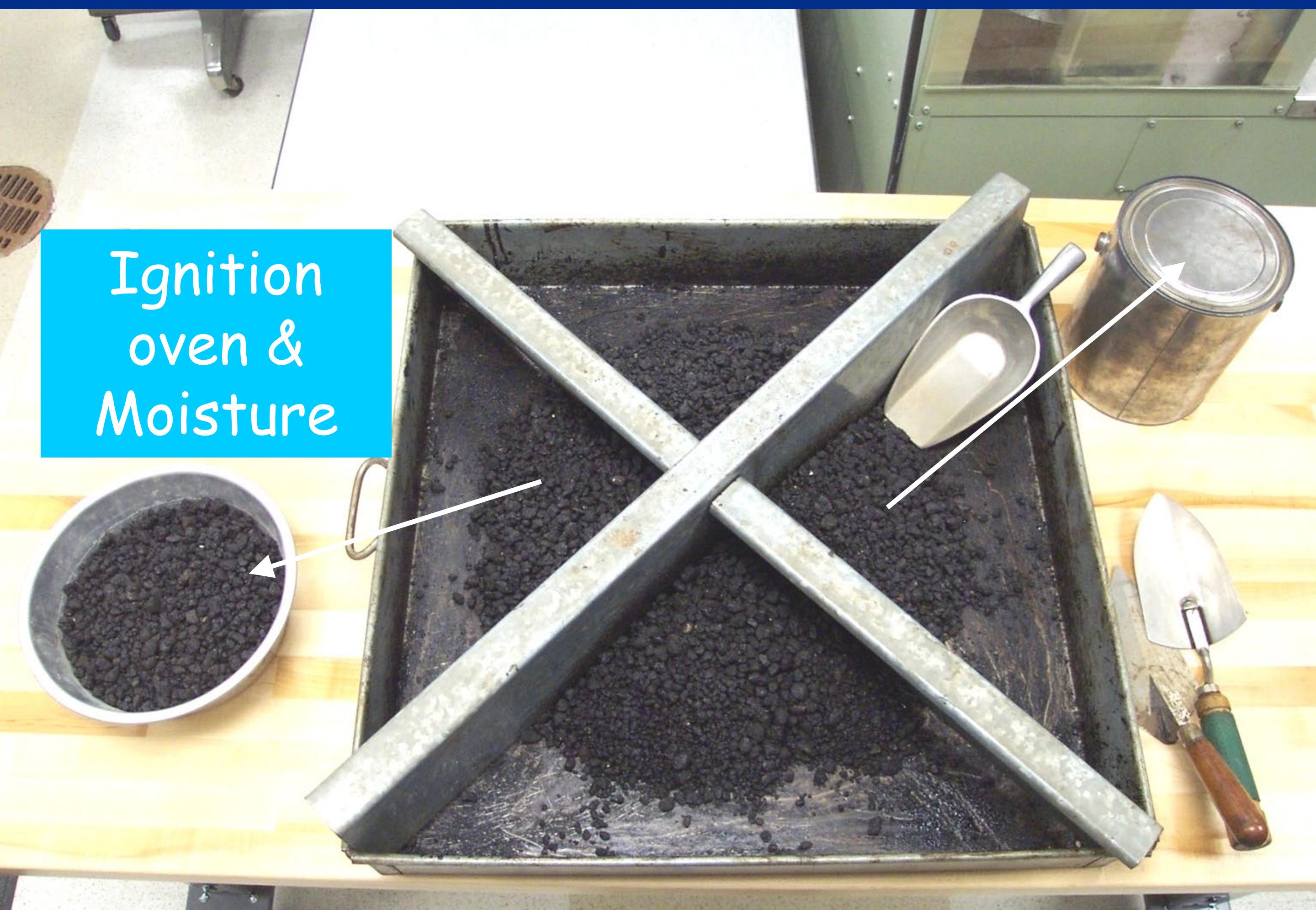
- QC: binder content-every 1000 tons. If less than 1000 tons per day, test at least once; RE may waive testing if less than 200 tons per day
- QA: one independent sample every 4 QC tests
- QA: Retained QC sample split: once per 5 days

403: SAMPLE

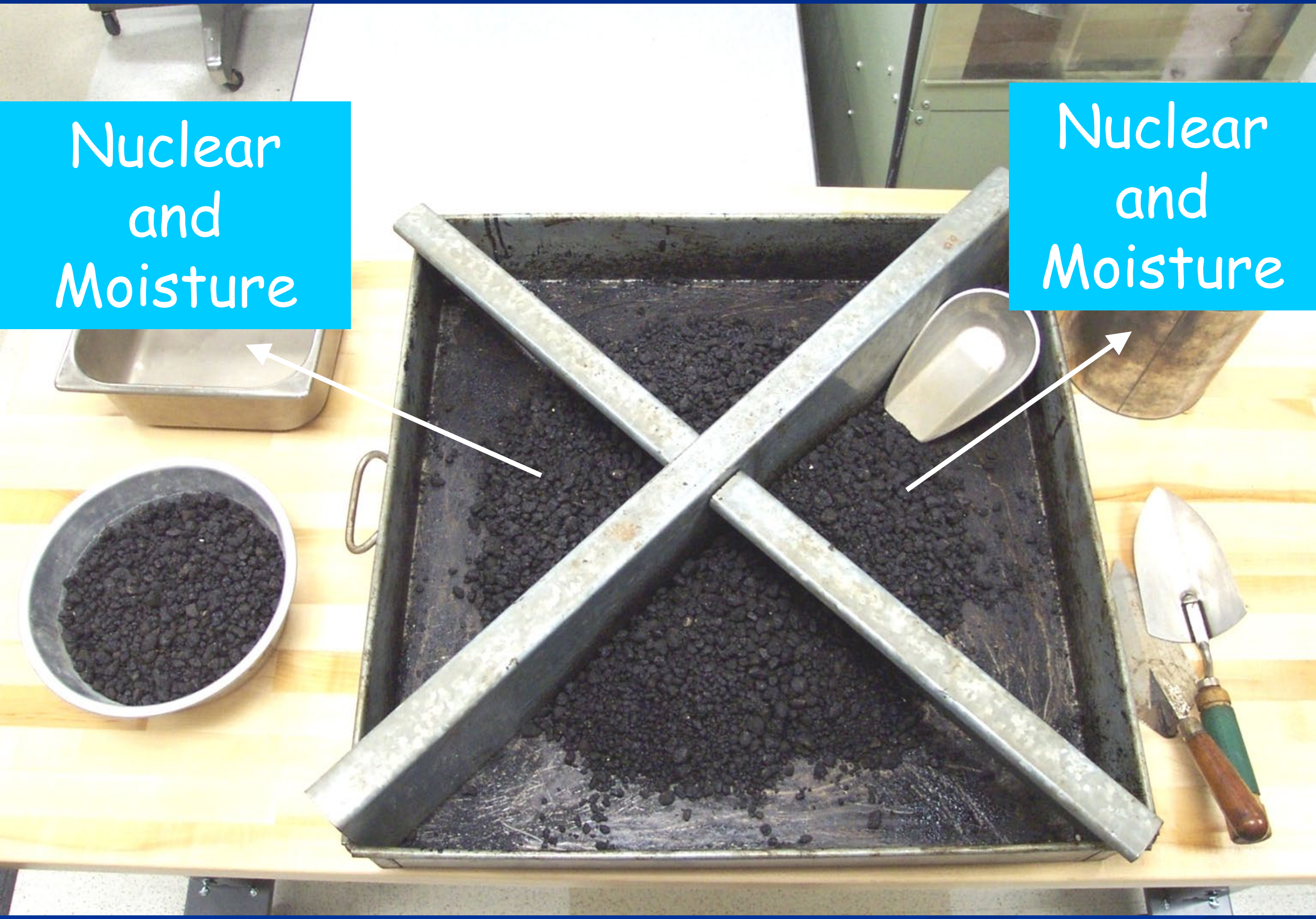
- 50 lb. sample –get 2 portions for the 2 volumetric pucks plus Rice



403
REMIX, QUARTER AGAIN
Ignition Oven & Moisture



Or
REMIX, QUARTER AGAIN
Nuclear & Moisture



IGNITION OVEN SPECIMEN SIZE

Mix	NMS in.	Specimen Size g
SP048 & BP-3	#4	1200-1700
SP095	3/8	1200-1700
SP125 & BP-1 & BP-2	1/2	1500-2000
SP190 & Bit Base	3/4	2000-2500
SP 250	1	3000-3500

IGNITION OVEN SPECIMEN SIZE

- Large specimens of fine mixes tend to result in incomplete ignition

SCOPE

- Background
- Binder Content Role in QC/QA
- Sampling
- ***Test procedure***
- Field verification
- Oven verification

TEST PROCEDURE

- Corrections
- Binder content test procedure

IGNITION OVEN BASICS

- % Binder: loss in mass of specimen
- Problem: other materials also burn off
  - moisture
  - aggregate

TEST PROCEDURE

- ***Corrections***
- Binder content test procedure

BINDER CONTENT CORRECTIONS

- ***Moisture***
- Aggregate burn loss
- Temperature effects on weighing

MOISTURE CORRECTION

- Moisture in mix will burn off, too.
- This will count as binder unless corrected
- Correction:
  - Dry mix to a constant mass at 110 ± 5 C prior to testing
  - "Aging"—must still verify that constant mass has been achieved

  Or
  - Determine moisture content of mix (AASHTO T 329), subtract it from the apparent binder content

AASHTO T 329-15

- Temperature now:
  - Within the JMF mixing temperature range
  - If unavailable, use 325 ±25 F
- Initial drying time is 90 ± 5 minutes
- Moisture is now calculated based on dry weight of HMA

$$MC = \left[\frac{M_{i(wet)} - M_{i(dry)}}{M_{i(dry)}} \right] X100$$

MC = % moisture

$M_{i(wet)}$ = initial mass of mix, wet

$M_{f(dry)}$ = final mass of mix, dry

Rounding

- When calculating, round to nearest 0.01% for moisture content, binder content, and C_f
- When comparing to specification, round to nearest binder content 0.1%

MOISTURE DATA SHEET

MOISTURE CONTENT OF HOT MIX ASPHALT (HMA) by OVEN METHOD AASHTO T 329-15 (for ignition oven correction purposes)			
Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.
Oven Temp.	Time in	Time out	Interval
		Sample:	Sample:
Pan wt. (g)		340	
Mix + pan wt., moist (g) = (W_{wet})		1840	
Mix + pan wt., dry (g) [Trial 1]		1839	
Mix + pan wt., dry (g) [Trial 2]		1838	
Mix + pan wt., dry (g) [Trial 3] = (W_{dry})		1838	
$\%Moisture = \frac{W_{wet} - W_{dry}}{W_{dry} - pan} \times 100$			

NOTE: All weights to nearest 0.1 gram and % moisture to nearest 0.01%

MOISTURE TESTING FREQUENCY: Several per Day

- High RAP/RAS mixtures especially prone to moisture
- Rainy weather
- "Warm mix"
- New aggregate
- If plant operator reports burning more fuel to maintain temperature
- Fluctuating volumetrics or binder contents
- Watering piles per DNR

MOISTURE TESTING FREQUENCY: Less Often

- Dry weather
- Same stockpiles
- No moisture when tested

BINDER CONTENT CORRECTIONS

- **Moisture**
- ***Aggregate burn loss***
- Temperature effects on weighing

Asphalt Binder Correction Factor
(Aggregate Correction Factor)

- To correct for loss of mass during the mix ignition due to aggregate burn-off
- Determined during mix design by mix designer (usually QC)
- Re-determined if mix design changes (e.g. >5% change in stockpiled aggregate proportions)
- Re-determined if a different oven is used (QA or QC)

Asphalt Binder Correction Factor (Aggregate Correction Factor), cont'd.

- C_F Procedure:
  - Mix specimen in lab with dry aggregate at a known (***actual***) % binder
  - Input "zero" for the C_F
  - Burn, obtain ***measured*** (***apparent***)% binder
  - The difference between the ***measured*** and the ***actual*** % binder is the Asphalt Binder Correction Factor (C_F)
  - If the C_F is > 1.0%, re-determine at a lower temperature

Definitions

- M = mass (g)
- $M_{i(dry)}$ = mass of mix before burning, dry already
- M_f = final mass of mix after burning (binder and some aggregate burned off)
- $(M_{i(dry)} - M_f)$ = binder & aggregate burned off
- M_{agg} = initial unburned mass of just the aggregate, dry
- $(M_{i(dry)} - M_{i(agg)})$= mix mass minus aggregate mass is the mass of binder, initially

Asphalt Binder Correction Factor (Aggregate Correction Factor), cont'd.

- Lab-produced sample (dry)

$$C_f = Measured - Actual$$

- Math:

$$C_f = \left[\frac{M_{i(dry)} - M_f}{M_{i(dry)}}\right] - \left[\frac{M_{i(dry)} - M_{i(agg)}}{M_{i(dry)}}\right]$$

- The difference is the aggregate mass loss
- The ***Measured*** binder content can be from the oven ticket
- The ***Actual*** binder content can be from a bench scale
- If the C_F is > 1.0%, re-determine at a lower temperature

CONVECTION OVEN TEMPERATURES

- AASHTO:
  - Normal: 538 C
  - High C_F's (>1.0%): 482 C
- MoDOT:
  - Normal: 538 C
  - High C_F's: if >1.0% try 482 C
  - Very high C_F's: if >1.0% at 482 C, use 427 C

Use of C_f

- Before production, when C_f is the ***unknown***:

C_f=Measured content–Actual content

- During production, when Actual content is ***unknown***:

Actual = Measured content - C_f

Number of Replicate Specimens

- Use two.
- If the difference in measured asphalt contents is > 0.15%, test 2 more replicates.
- For the four replicates, discard the high and low results.

Asphalt Binder Correction Factor (Aggregate Correction Factor) Data Sheet

ASPHALT CONTENT IGNITION METHOD
(AASHTO T 308-10)
METHOD A

Aggregate Correction Factor
[Asphalt Binder Correction Factor] Determination

Sample______________________Lab No.________Date______Initials______

Replicate	1	2	3	4
Test Temperature	538	538		
Tare (basket, etc.) Mass (g)	3000	3000		
Total Dry Mass (g)	5000	5005		
Initial Dry Specimen Mass (g)	2000	2005		
Loss in Weight (g)	125	126		
%AC, measured = M	6.25	6.28		
%AC, actual = A	6.00	6.01		
$\%AC_{diff}$ $(M_1 - M_2)$	0.03	> 0.15%? If so, 2 more replicates		
$C_F = M - A$	0.25	0.27		
C_F, average	0.26			

INFRARED BURN PROFILES

- "Default"- most mixes
- "Option 1" (Less)- for C_f > 1.0% eg. RAP containing dolomite
- "Option 2" (More) – hard to burn mixes

Asphalt Binder (Aggregate) Correction Factors

- Anecdotal: Infrared runs ~0.05% higher than convection oven
- AMRL Proficiency samples are comparable

RAP Aggregate Correction Factor
(Asphalt Binder Correction Factor)

- Follow TM-77:
  - Assumes aggregate C_F for RAP aggregate is same as C_F for virgin aggregate
  - Follow the standard procedure as if there was no RAP, i.e., use only the virgin aggregate, and only the binder content associated with the virgin aggregate portion when fabricating the specimen
  - So, the C_f from the virgin materials test is used as the C_f for the whole mix

BINDER CONTENT CORRECTIONS

- Moisture
- Aggregate burn loss
- ***Temperature effects on weighing***

CONVECTION OVEN: **TEMPERATURE COMPENSATION FACTOR**

- Material “weighs” differently at elevated temperatures
- Mass loss shown on the oven printout must be corrected
- Oven calculates and prints the “Temperature Correction Factor (TCF)” for the particular test run
- ***TCF = apparent loss in weight due to heating***

USE OF TEMPERATURE CORRECTION FACTOR

- When determining the Aggregate Correction Factor, if the oven printout is used for determination of the Measured Asphalt Content, include the Temperature Correction Factor (TCF)
- If all weighing is performed outside of the oven and specimen is cooled to room temperature, do not use the TCF

Second Generation Infrared oven

- No Temperature Correction Factor
- Scale is better insulated from the chamber

TEST PROCEDURE

- Corrections
- ***Binder content test procedure***

REHEATING

EPG 403.1.5

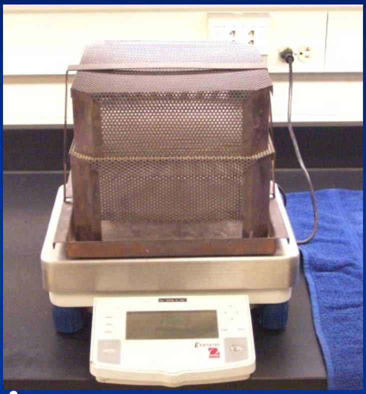
- If a retained sample must be reheated:
  - Warm the sample until workable
  - Spread it in a large pan and reheat—this will minimize the damage caused by reheating

CONVECTION OVEN TEST PROCEDURE: Method A

- 1. Dry specimen at 110 ± 5 °C or determine moisture content (T 329-15). Cool to room temperature.
- 2. Enter the ***chamber set point*** (desired oven temperature).
- 3. Enter the ***asphalt correction factor (C_F)***

CONVECTION OVEN TEST PROCEDURE: Method A

- 4. Weigh the test specimen.

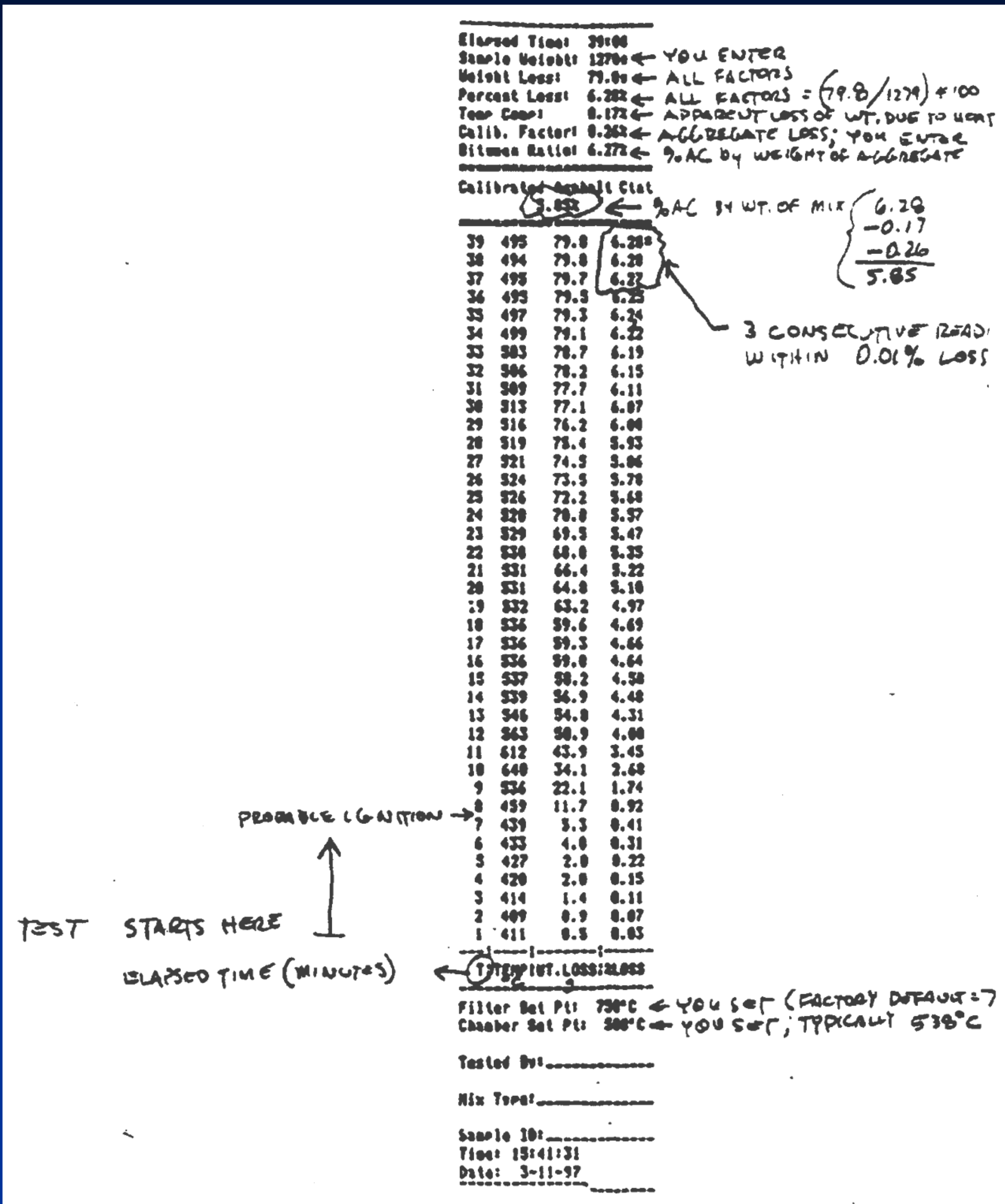


- 5. Enter the ***specimen weight***.
- 6. Place the sample in the oven and compare the weight indicated by the oven scale to that of the external scale the sample was first weighed on (this helps detect if basket is contacting the furnace wall)

CONVECTION OVEN
TEST PROCEDURE:
Method A

- 7. Burn
- 8. Oven will stop when burn is complete and will calculate % binder based on the:
  - Original specimen weight entered
  - Total loss
  - Asphalt correction factor (C_F) that you entered.
  - "Temperature Compensation" factor that the oven calculates = apparent loss in weight due to heating.
- 9. *You* must then correct (subtract) for ***moisture*** if started with a wet sample

Test Results Printout



Elapsed Time: 39:00
Sample Weight: 1279g ← YOU ENTER
Weight Loss: 79.8g ← ALL FACTORS
Percent Loss: 6.28% ← ALL FACTORS = (79.8/1279) * 100
Temp Comp: 0.17% ← APPARENT LOSS OF WT. DUE TO HEAT
Calib. Factor: 0.26% ← AGGREGATE LOSS; YOU ENTER
Bitumen Ratio: 6.27% ← %AC by WEIGHT OF AGGREGATE

Calibrated Asphalt Cnt
5.85% ← %AC BY WT. OF MIX

6.28
−0.17
−0.26
5.85

39	495	79.8	6.28*
38	494	79.8	6.28
37	495	79.7	6.27
36	495	79.5	6.25
35	497	79.3	6.24
34	499	79.1	6.22
33	503	78.7	6.19
32	506	78.2	6.15
31	509	77.7	6.11
30	513	77.1	6.07
29	516	76.2	6.00
28	519	75.4	5.93
27	521	74.5	5.86
26	524	73.5	5.78
25	526	72.2	5.68
24	528	70.8	5.57
23	529	69.5	5.47
22	530	68.0	5.35
21	531	66.4	5.22
20	531	64.8	5.10
19	532	63.2	4.97
18	536	59.6	4.69
17	536	59.3	4.66
16	536	59.0	4.64
15	537	58.2	4.58
14	539	56.9	4.48
13	546	54.8	4.31
12	563	50.9	4.00
11	612	43.9	3.45
10	640	34.1	2.68
9	536	22.1	1.74
8	459	11.7	0.92
7	439	5.3	0.41
6	433	4.0	0.31
5	427	2.8	0.22
4	420	2.0	0.15
3	414	1.4	0.11
2	409	0.9	0.07
1	411	0.5	0.03

T | TEMP | WT.LOSS | %LOSS

3 CONSECUTIVE READ[INGS]
WITHIN 0.01% LOSS

PROBABLE IGNITION →
TEST STARTS HERE
ELAPSED TIME (MINUTES) ←

Filter Set Pt: 750°C ← YOU SET (FACTORY DEFAULT = 7
Chamber Set Pt: 538°C ← YOU SET; TYPICALLY 538°C

Tested By: ____________

Mix Type: ____________

Sample ID: ____________
Time: 15:41:31
Date: 3-11-97

ASPHALT CONTENT IGNITION METHOD (AASHTO T 308-10) METHOD A
Reproducing Oven Ticket Values

Revised 12-9-15

Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.

Empty Basket Assembly Weight (g), [T_e]	3000
Basket Assembly + Wet (or dry) Sample Weight (g), [T_i]	4270
Wet (or dry) Sample Weight (g), [$W_i = (T_i - T_e)$]	
Loss in Weight (g), [L] (from tape)	
Total % Loss, [$P_L = (L / W_i) \times 100$]	
Temperature Compensation (%), [C_{tc}] (from tape)	
% AC, uncorrected, [$P_{bu} = P_L - C_{tc}$]	
Aggregate Correction (Calibration) Factor (%), [C_f] (from tape)	
Calibrated %AC (from ignition oven tape), [$P_{bcal} = P_{bu} – C_f$]	
% Moisture Content, [MC] (previous test)*	-0.13
% AC, corrected (by weight of mix), [$P_b = P_{bcal} – MC$]*	

Asphalt Binder Correction Factor

(formerly Aggregate Correction Factor) Calculation

If final weighing is performed on bench top scale, calculation:

$$P_b = \left[\frac{M_i - M_f}{M_i} \times 100 \right] - C_f - MC$$

Where:

M_i = initial mass of mix, wet or dry

M_f = final mass of mix

MC = % moisture

C_f = Asphalt Binder Correction Factor (old Aggregate Correction Factor)

Example
Manual Method

- Moisture = 0.05%
- C_f = 0.22%
- Initial wet mass = 5400 g
- Final burned mass (after cooling to room temperature) = 5256 g

ASPHALT CONTENT IGNITION METHOD (AASHTO T 308-10) METHOD A

Manual Weighing Method

Project No.	Job No.	Route	County
Technician	Date	Sublot No.	Mix No.
Empty Basket Assembly Weight (g), [T_e]			3000
Initial Basket Assembly + Wet (or dry) Sample Weight (g), [T_i]			5400
Initial Wet (or dry) Sample Weight (g), [$W_i = (T_i - T_e)$]			2400
Final Basket Assembly + Burned Sample Weight (g), [T_f]			5256
Loss in Weight (g), [$L = T_i - T_f$]			144
% Loss, [$P_L = (L / W_i)$ x100]			6.00
Aggregate Correction (Calibration) Factor (%), [C_f]			-0.22
Calibrated %AC, [$P_{bcal} = P_L – C_f$]			5.78
% Moisture Content, [MC]*			-0.05
% AC, corrected (by weight of mix), [$P_b = P_{bcal} – MC$]*			5.73

- *If non-dried specimen was used (w_i = wet)

TEST PROCEDURE Method B

- 1. Weigh out specimen.
- 2. Burn for about 45 minutes.
- 3. Remove, cool, weigh.
- 4. Burn for another 15 minutes.
- 5. Remove, cool, weigh.
- 6. Keep repeating until 2 consecutive mass weighings do not change by > 0.05%.
- 7. Subtract moisture %.

Common Testing Errors/Source of Non-Comparison/Early Shut-off

- Starting test when oven is cold: incomplete burn; can affect TCF
- Neglecting to push "Start" (binder burns but is not recorded)
- Not cleaning oven & vents often enough
- Using vent pipe less than 4 in, diameter (NTO clogs more quickly)

Common Testing Errors/Source of Non-Comparison/Early Shut-off

- Asphalt correction factor (C_F) not used
- Not cleaning baskets
- Allowing scale plate or support tubes to rub
- Not spreading specimen out
- Not tearing off ticket before opening oven door
- Allowing door to not latch correctly
- Not correcting for moisture (e.g. when plant speed increases, etc)

Common Testing Errors/Source of Non-Comparison/Early Shut-off

- Using an oversize specimen
- Not using the same size specimen for asphalt correction factor (C_F) determination and all production tests
- Using a plant-made specimen instead of a lab-made specimen for (C_F) determination
- Not double-checking specimen weight on oven scale against exterior scale weight

Common Testing Errors/Source of Non-Comparison/Early Shut-off

- Materials used for (C_F) determination not the same as project materials
- Inaccurate asphalt contents used for (C_F) determination
- QA & QC starting with different temperature specimens
- Door left open too long between loadings

Common Testing Errors/Source of Non-Comparison/Early Shut-off

- Wrong chamber set point
- Wrong burn profile
- Weighing on bench balance when specimen is hot

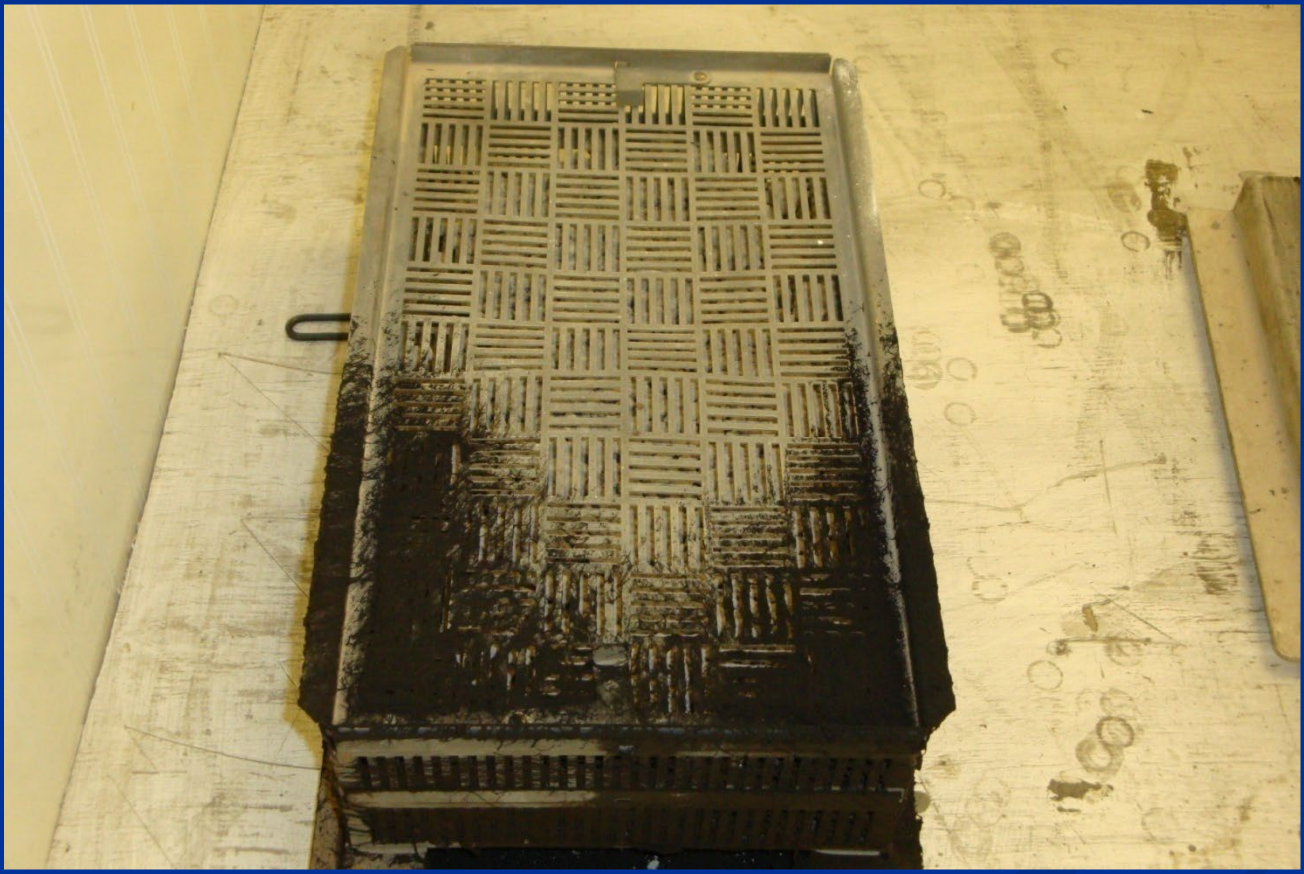
OPERATIONAL PROBLEMS

- Oven won't shut itself off—it's OK to manually shut off as long as 3 consecutive readings show less than 0.01% loss and the sample appears to be completely burned (EPG 403.1.5)

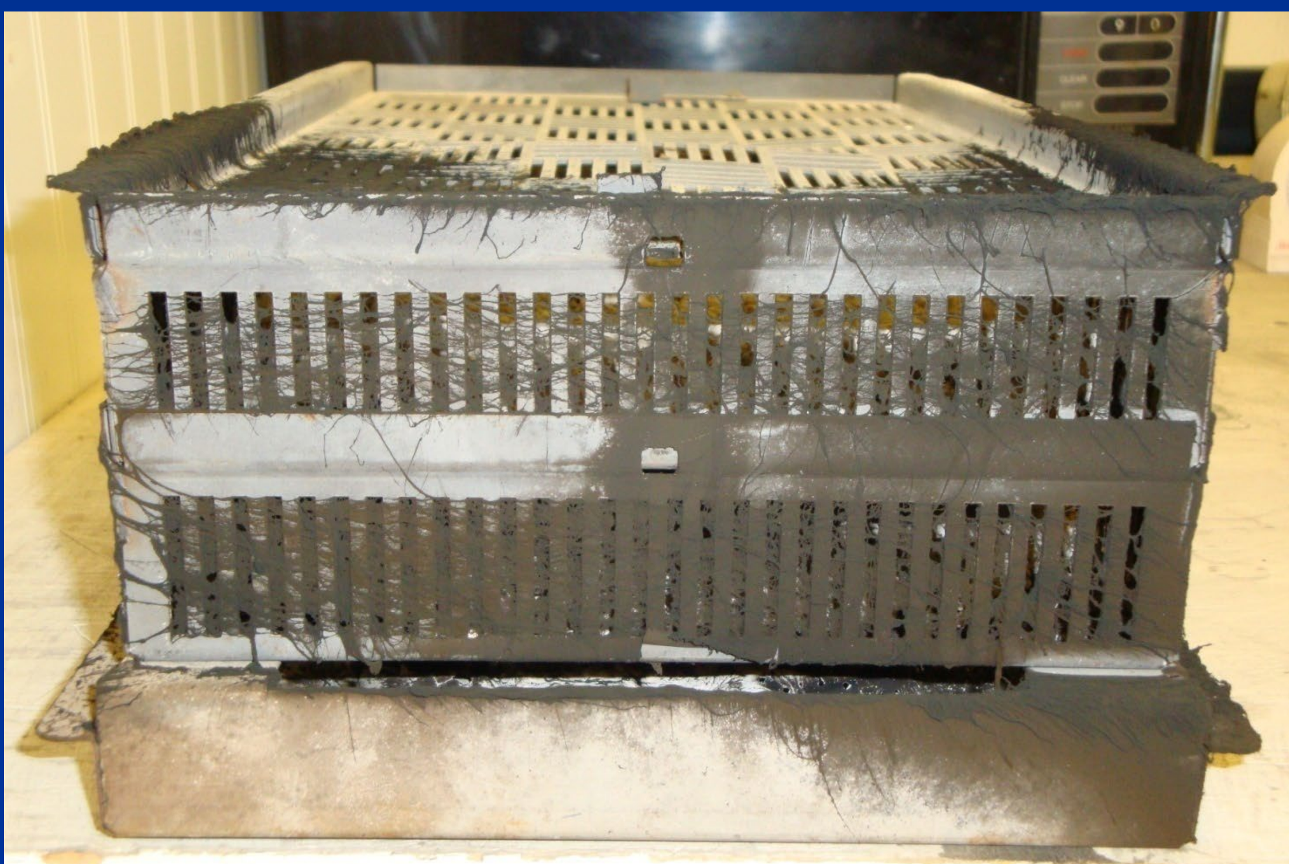
Premature Burn Stop

- Vibrations
- Basket or strap up against wall or top of chamber
- Clogged port
- Used U.S. date, not European date (1998-2000 NCAT models)

NTO Incomplete Burn Pattern: Shingle Mix



Soot

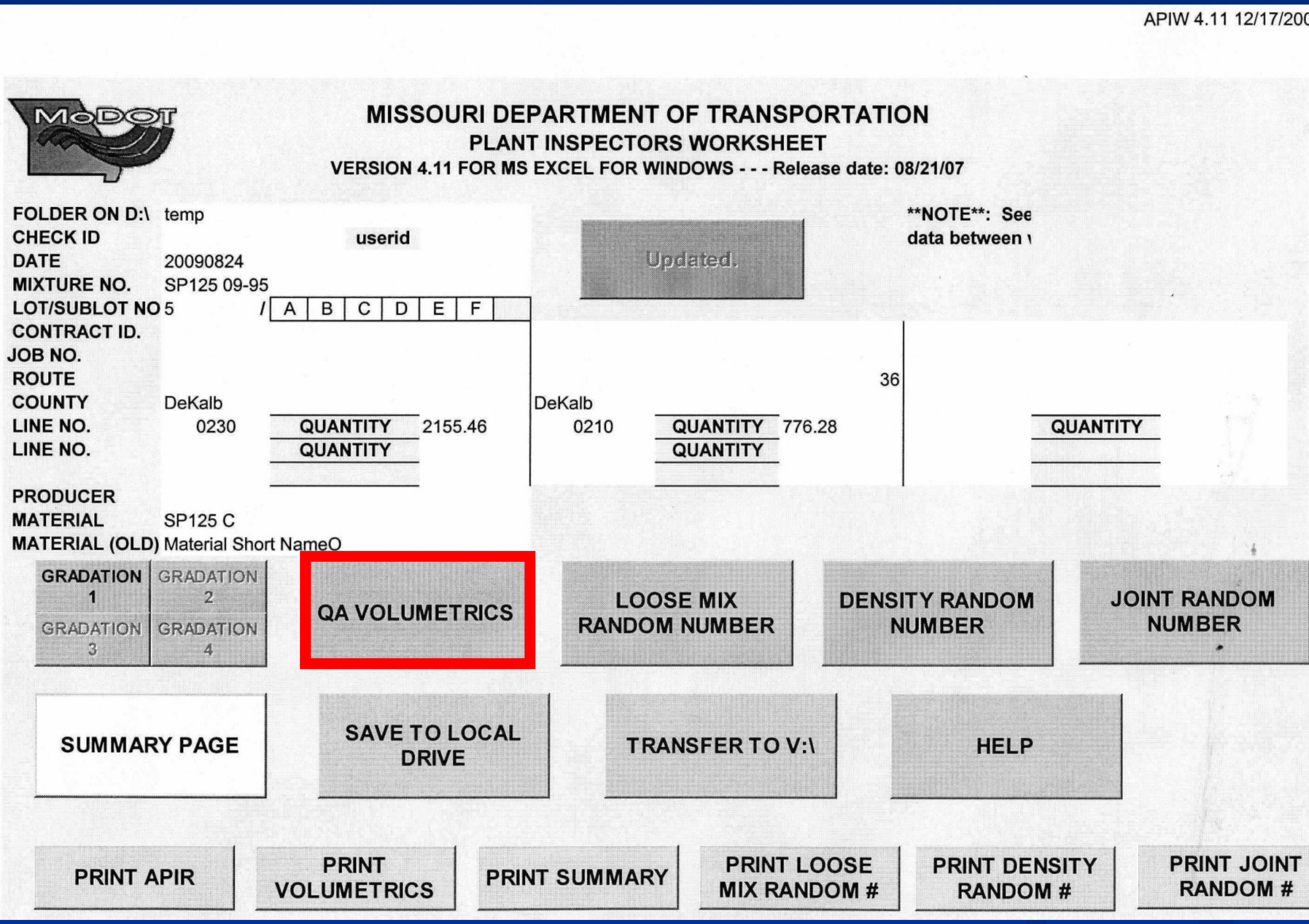


Coke

SCOPE

- Background
- Binder Content Role in QC/QA
- Sampling
- Test procedure
- ***Field verification***
- Oven verification

MoDOT SPREADSHEET


APIW 4.11 12/17/200

MISSOURI DEPARTMENT OF TRANSPORTATION
PLANT INSPECTORS WORKSHEET
VERSION 4.11 FOR MS EXCEL FOR WINDOWS - - - Release date: 08/21/07

FOLDER ON D:\ temp
CHECK ID userid
DATE 20090824
MIXTURE NO. SP125 09-95
LOT/SUBLOT NO 5 / A B C D E F
CONTRACT ID.
JOB NO.
ROUTE 36
COUNTY DeKalb DeKalb
LINE NO. 0230 QUANTITY 2155.46 0210 QUANTITY 776.28 QUANTITY
LINE NO. QUANTITY QUANTITY
PRODUCER
MATERIAL SP125 C
MATERIAL (OLD) Material Short NameO

NOTE: See data between

Updated.

GRADATION 1
GRADATION 2
GRADATION 3
GRADATION 4
QA VOLUMETRICS
LOOSE MIX RANDOM NUMBER
DENSITY RANDOM NUMBER
JOINT RANDOM NUMBER
SUMMARY PAGE
SAVE TO LOCAL DRIVE
TRANSFER TO V:\
HELP
PRINT APIR
PRINT VOLUMETRICS
PRINT SUMMARY
PRINT LOOSE MIX RANDOM #
PRINT DENSITY RANDOM #
PRINT JOINT RANDOM #

SUPERPAVE MIXTURE PROPERTIES

JOB 0 ROUTE 0 MIX NO. #VALUE! LOT NO. 0

SUBLOT							
DATE							

AASHTO T 209 — A2 required when T85 absorption >2.0% on any aggregate fraction.

TECHNICIAN							
A = Wt. of sample:	1594.4						
A2=Wt. of sample (dry-back):							
D = Wt. of flask filled with water:	7472.2						
X = A + D (A2 used in lieu of A for dry-back)	9066.6	0.0	0.0	0.0	0.0	0.0	0.0
E = Wt. of flask filled with water and sample:	8421.5						
Y = X - E	645.1	0.0	0.0	0.0	0.0	0.0	0.0
Gmm = MAX. SPECIFIC GRAVITY = A / Y	2.472	2.472	2.472	2.472	2.472	2.472	2.472

AASHTO T 166

TECHNICIAN								
MOLDING TEMPERATURE								
A = Weight of sample in air:	SPEC. 1	4867.8						
B = Weight of sample in water:		2801.9						
C = Weight of surface dry sample:		4880.4						
Gmb = BULK SP. G. = A / (C-B)		2.342	0.000	0.000	0.000	0.000	0.000	0.000
A = Weight of sample in air:	SPEC. 2	4899.1						
B = Weight of sample in water:		2814.5						
C = Weight of surface dry sample:		4911.9						
Gmb = BULK SP. G. = A / (C-B)		2.336	0.000	0.000	0.000	0.000	0.000	0.000
AVG. Gmb		2.339	0.000	0.000	0.000	0.000	0.000	0.000

Nuclear gage

TECHNICIAN							
MoDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							

Ignition oven

AASHTO T 308 (IGNITION)							
GAUGE %AC	5.35						
NUCLEAR OR IGNITION							
% MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						

AASHTO R 35

A = Gmm (FIELD)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
B = Gmb (FIELD) (Avg.)	2.339	0.000	0.000	0.000	0.000	0.000	0.000
C = Gsb (Job Mix)	2.557	2.557	2.557	2.557	2.557	2.557	2.557
D = Ps = Percent Agg. in mix	94.8	100.0	100.0	100.0	100.0	100.0	100.0
VMA = 100 - (B X D / C)	13.3	100.0	100.0	100.0	100.0	100.0	100.0
Va = 100 X ((A - B) / A)	5.4	100.0	100.0	100.0	100.0	100.0	100.0
VFA = (VMA-Va) / VMA	59	0	0	0	0	0	0

AASHTO T 166

TECHNICIAN							
A = Weight of sample in air:	1255						
B = Weight in water:	710						
C = Weight of surface dry sample:	1260						
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	2.282	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	92.3	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

FOR 2ND CORE SUBLOT WHEN DENOTED IN QC PLAN

TECHNICIAN							
A = Weight of sample in air:							
B = Weight in water:							
C = Weight of surface dry sample:							
Gmc = CORE SPECIFIC GRAVITY = A / (C - B)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gmm = MAX. SPECIFIC GRAVITY (T209)	2.472	2.472	2.472	2.472	2.472	2.472	2.472
% COMPACTION OF CORE = 100 x (Gmc / Gmm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THICKNESS							
SUBLOT							

Binder Portion

TECHNICIAN							
MoDOT TM54 (NUCLEAR)							
SAMPLE WEIGHT							
BACKGROUND							
COUNTS							
GAUGE % AC							
AASHTO T 308 (IGNITION)							
GAUGE %AC	5.35						
NUCLEAR OR IGNITION							
% MOISTURE	0.12						
% AC BY IGNITION OR NUCLEAR	5.2						

MODULE CONTENT

- Binder content of mix
- ***Binder content of RAP***
- Aggregate gradation

RAP Binder Content

- Per Spec 403.2.6, RAP binder content must be determined
- QC: 1 per 4 sublots
- QA: 1 per project
- T164 (solvent extraction)
- Can use T308 (ignition) if a correction factor is determined which is the difference between T164 & T308 (best to use your own oven when T164 is determined by another lab)

RAP & RAS

- Some contractors stockpile RAP & RAS, prepare (grind) it, and sample it.
- Send sample to a commercial lab to have extractions run (T164), obtain binder content & gradation
- This is what is submitted to MoDOT during mix design
- During production, RAP is sampled and ignition oven used to get binder content & gradation

MODULE CONTENT

- Binder content of mix
- Binder content of RAP
- ***Aggregate gradation***

GRADATION SAMPLES

- MoDOT allows gradation sample testing to be satisfied by using the residue from the HMA ignition oven sample.
- An aggregate (gradation) correction factor (AGCF) may be necessary to account for the breakdown in rock.
- RAP gradation in the field is determined with ignition oven

RAS Gradation

- Not recommended to use T308 on RAS (too dangerous)
- Fan will suck fines out
- Use extraction to get gradation or use the standard gradation

RAS Gradation

- Ground to minus 3/8 in.
- Gradation from solvent extraction, or assumed from table:

Sieve Size	% Passing
3/8"	100
#4	95
#8	85
#16	70
#30	50
#50	45
#100	35
#200	25

GRADATION SAMPLES

- When determining the ***aggregate (gradation) correction factor*** (AGCF), prepare a aggregate blank (no binder) specimen.
- Do a washed gradation analysis (T 30) of the blank
- Do a washed gradation analysis of the burned HMA specimen (T 30)

GRADATION SAMPLES Plus #200 Portion

- Determine a difference for each sieve, each replicate:

$(\%\text{-}\#4)_{blank} - (\%\text{-}\#4)_{burned\text{, replicate }\#1}$

$(\%\text{-}\#4)_{blank} - (\%\text{-}\#4)_{burned\text{, replicate }\#2}$

- Calculate the average difference for that sieve (#4) = AGCF for #4
- If the difference on ***any*** sieve exceeds the allowable (see below), then each sieve must have its AGCF applied to each sieve result.
- Allowable differences:
  - ≥ #8: ± 5.0%
  - ≥ #200 to < #8: ± 3.0%
  - ≤#200 ± 0.5%

GRADATION SAMPLES
Passing the #200 Portion

- If only the #200 sieve exceeds the limit, apply the AGCF only to the #200 sieve

Example

Sieve	Rep# 1	Rep# 2	Blank	Rep# 1 Diff	Rep# 2 Diff	Avg Diff= AGCF	Allow able
1"	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
¾"	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
½"	86.5	89.5	89.7	3.2	0.2	1.7	±5.0
3/8"	69.3	72.1	70.4	1.1	-1.7	-0.3	±5.0
#4	52.1	55.6	53.9	1.8	-1.7	0.1	±5.0
#8	38.5	42.3	41.0	2.5	-1.3	0.6	±3.0
#30	32.7	37.0	34.4	1.7	-2.6	-0.5	±3.0
#40	16.1	17.9	18.3	2.2	0.4	1.3	±3.0
#50	12.6	13.4	14.5	1.9	1.1	1.5	±3.0
#200	6.8	7.4	7.1	0.3	-0.3	0.0	±0.5

For #4 sieve:

Rep#1: 53.9-52.1 = 1.8

Rep#2: 53.9-55.6 = -1.7

Avg diff = 0.1

Compare to ±5.0 OK

SCOPE

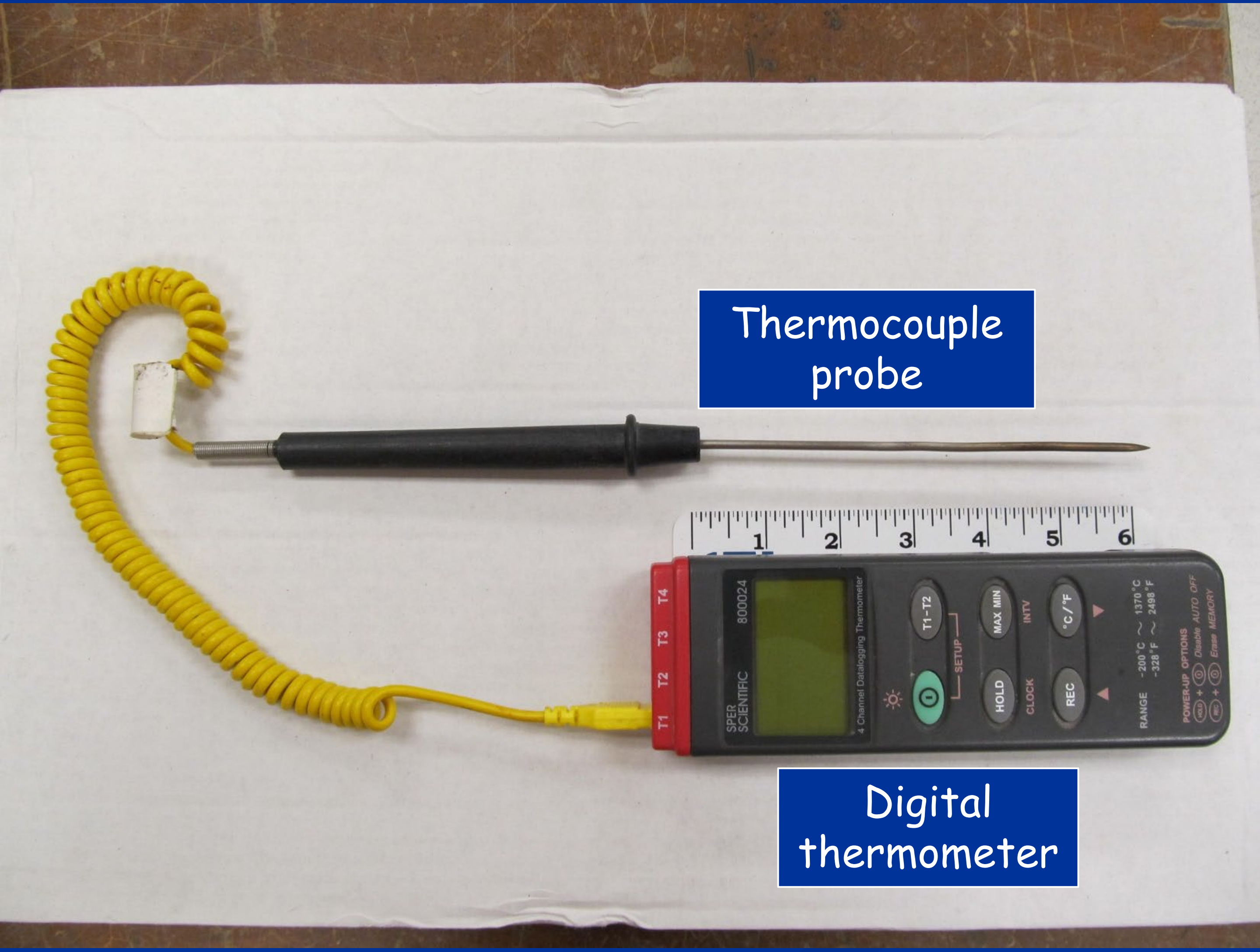
- Background
- Binder Content Role in QC/QA
- Sampling
- Test procedure
- Field verification
- ***Oven verification***

OVEN VERIFICATION

- The oven must be "verified' every 12 months and after each move.
  - Temperature
  - Balance
- Methods
  - Yearly outside service (usually along with gyro and mold calibrations, etc.)
  - In-house

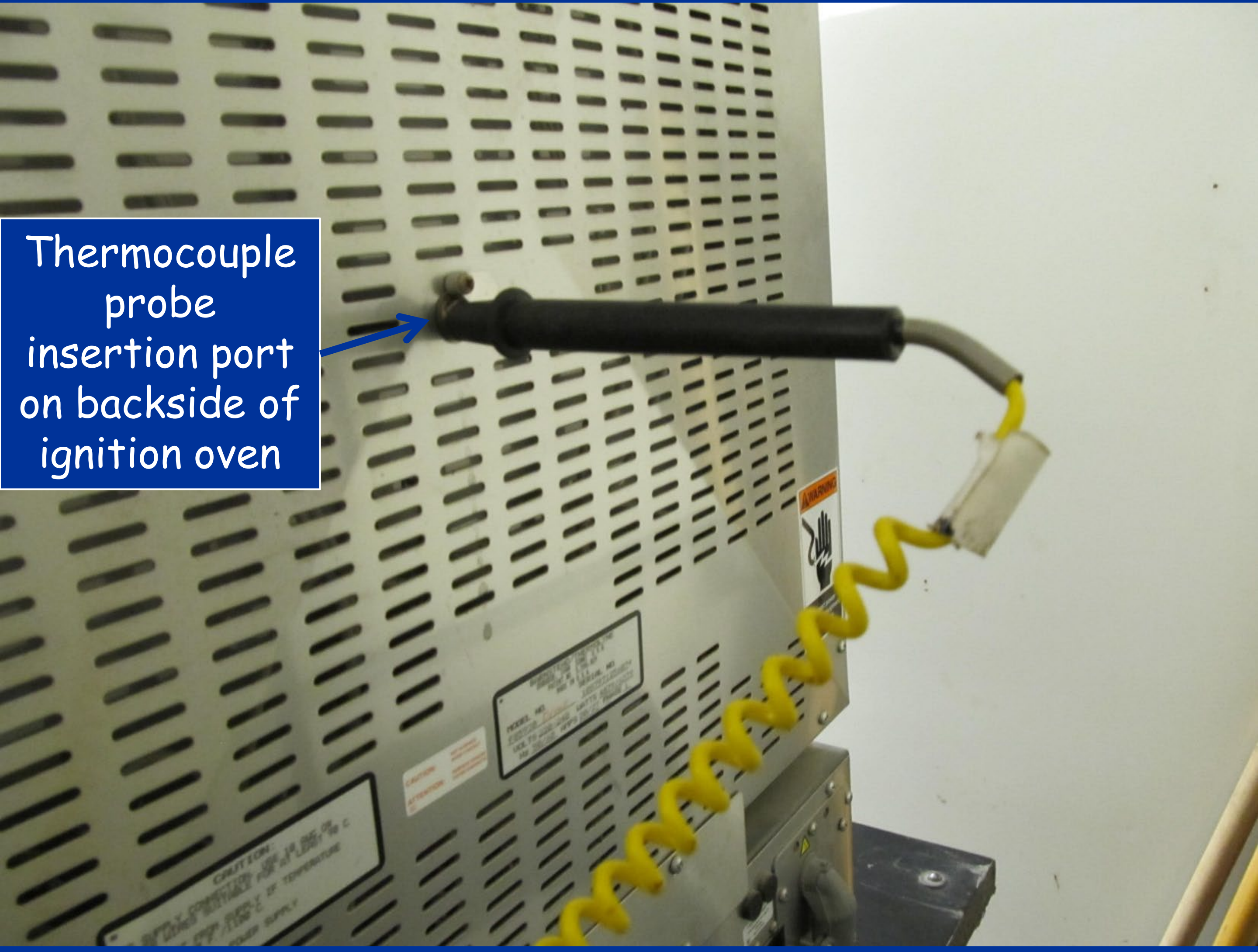
IN-HOUSE VERIFICATION: Temperature

- Equipment

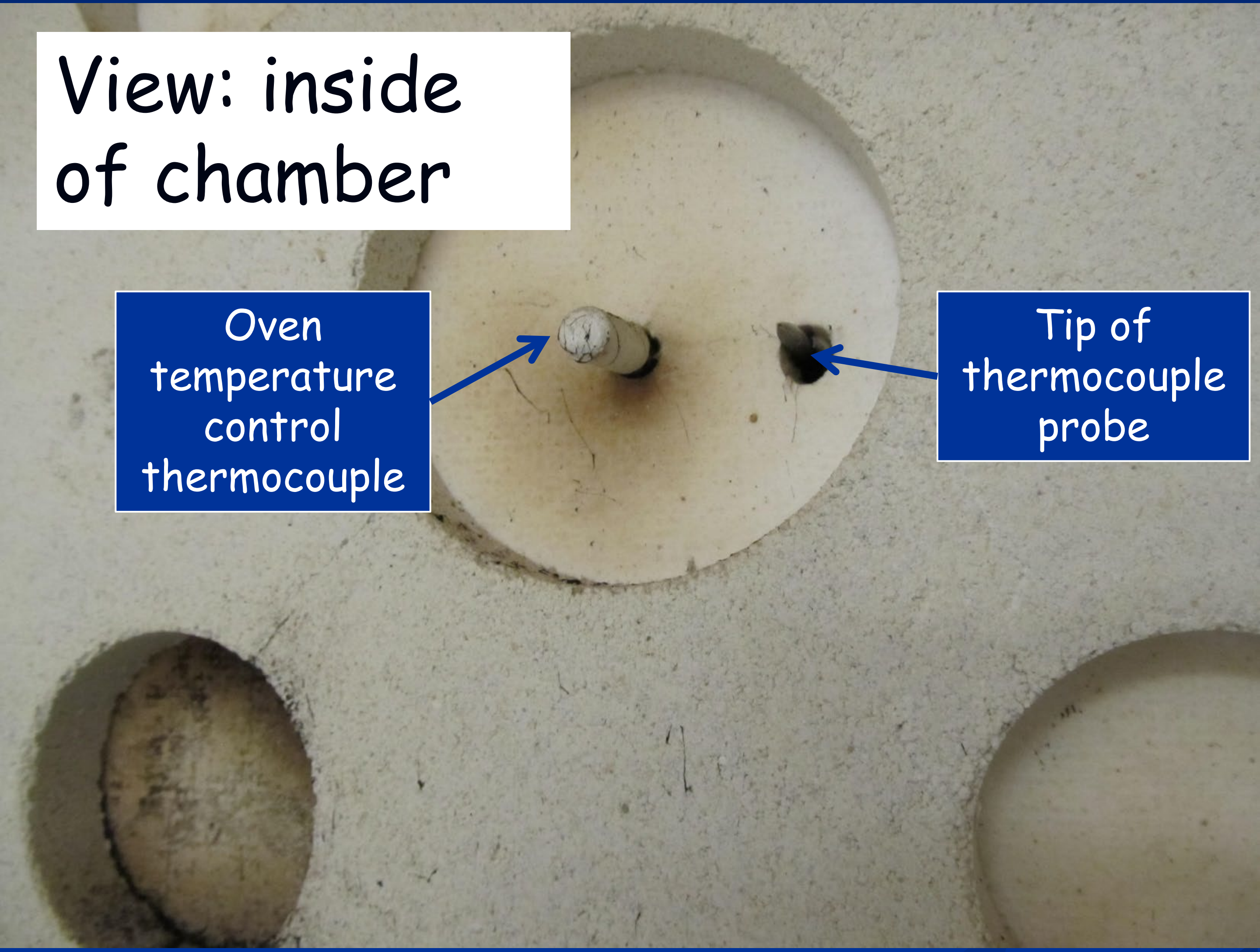


IN-HOUSE VERIFICATION: Temperature

- Insert temperature probe into furnace back; probe is attached to the digital thermometer



IN-HOUSE VERIFICATION: Temperature



IN-HOUSE VERIFICATION: Temperature

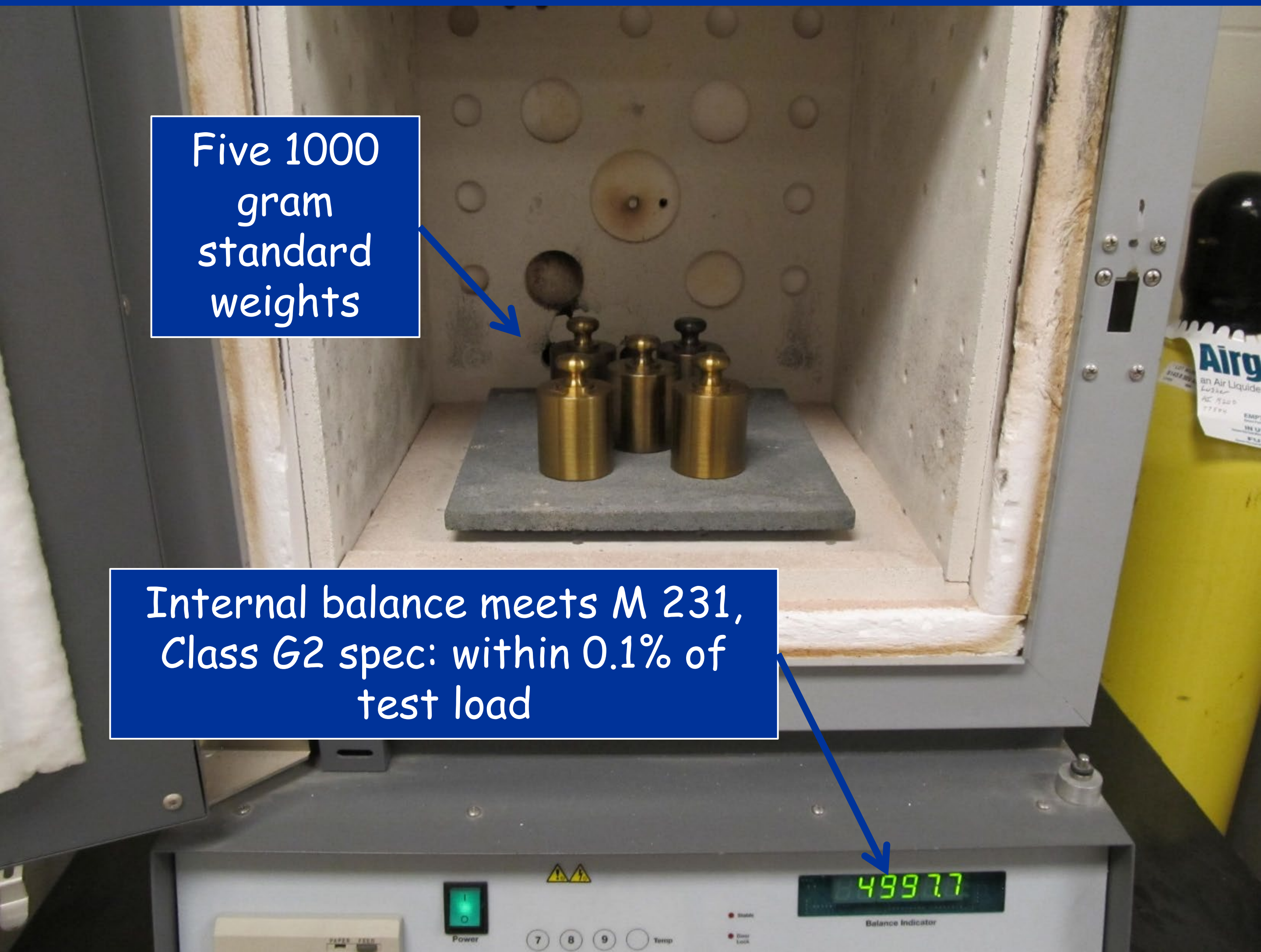
- Raise temperature to 538C
- Compare digital thermometer reading to Actual Chamber Temperature on oven display
- May wish to calibrate

Calibration

- Follow Owner's Manual
- In "calibration" mode, enter the digital thermometer reading

IN-HOUSE VERIFICATION: Internal Balance

- Balance should be checked at ≥ 5 points throughout the range of use
- Example: try nominal 5000g (these masses are Class 5, have a 0.050g tolerance)
- Balance requirement: 0.1% of 5000 is 5g
- 5000-4997.7 = 2.3 < 5 g OK



Balance Calibration

- Refer to operator's manual
- For ***calibration,*** get into "calibration" mode, use an 8000g weight on the ceramic plate

Conventional vs. Infrared

Conventional (NCAT)	Infrared (NTO)
Chamber temperature	Burn profile
240 v	120 or 240 v
Ceramic filter or afterburner	none
Reports burn time to the nearest minute	Reports burn time to the nearest second (thus is not an indication of operator interference)
Asterisk at end of machine stop	No asterisk

Conventional vs. Infrared

Conventional (NCAT)	Infrared (NTO)
Fan starts when "Start" is pressed	Fan does not start when "Start" is pressed: good for RAP/RAS- won't suck out fines; Bad: odors
	Reduced emissions, but still requires venting
	Requires cleaning more often
	No Temperature Compensation Factor

SUMMARY

- 1. Sample loose mix every sublot (QC) or every 4 sublots (QA).
- 2. Obtain specimen from quartered sample.
- 3. Specimen size is tied to NMS of gradation.
- 4. Burn
- 5. Loss of mass is the total of burned off binder, water, & aggregate.
- 6. Subtract the loss of aggregate & moisture.
- 7. Remains of the HMA burned specimen may be used for checking gradation.
- RAP binder content required

Presentation Topics

- Superpave QCQA Course Prerequisites
  - Aggregate Technician
  - Bituminous Technician
- Superpave QCQA Course
  - Gyratory Compactor
  - Maximum Specific Gravity (Rice)
  - Ignition Oven
- **Asphalt Aggregate (Consensus) Tests Course** (Agg Tech prerequisite)
  - Fractured Face Count
  - Uncompacted Voids
  - Sand Equivalent
- Tensile Strength Ratio (TSR) Course

Asphalt Aggregate (Consensus) Tests

- Coarse Aggregate (+#4)
  - Fractured Face Count (Coarse Aggregate Angularity in Sec 403)
  - Flat & Elongated (Thin & Elongated in Sec 403; covered in Agg Tech Course)
- Fine Aggregate (-#4)
  - Uncompacted Voids (Fine Aggregate Angularity in Sec 403)
  - Sand Equivalent (Clay Content in Sec 403)

Sand Equivalent

- Listing of Common Testing Errors

Common Testing Errors

- Concentrated stock solution has a shelf life notice with the material--old stuff gets used
- Calcium chloride working solution not mixed properly
- Calcium chloride solution not maintained properly (has a certain shelf life):
  - Used outside acceptable temperature range
  - Not checked for organic growth
  - Exposed to direct sunlight
  - Not discarded after 30 days
- New solution added to old solution

Common Testing Errors, cont'd.

- Organic (slimy) growth not removed from tubing and working solution container
- Improper sample preparation
- Sample not shaken properly in graduated cylinder
- Sample vibrated during sedimentation stage
- Sample not irrigated properly
- Irrigation tube holes clogged
- Hose gets soft and sticks together

Yours Truly In Action

Uncompacted Voids

- Listing of Common Testing Errors

Common Testing Errors

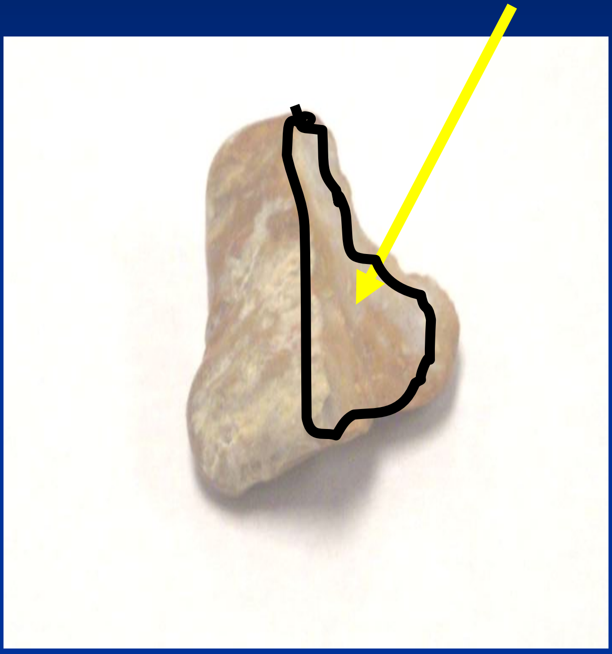
- Improper calibration or damage to test cylinder resulting in a change of volume
- Vibration in test area causing over-compaction of sample in test cylinder
- Erroneous specific gravity used in calculation
  - A difference of 0.05 specific gravity can cause an error of 1.0% FAA

Fractured Face Count

- A very subjective test

COARSE AGGREGATE ANGULARITY (CAA) [Fractured Face Count (FFC)]

Single Fractured Face



Multiple Fractured Faces

No Fractured Faces



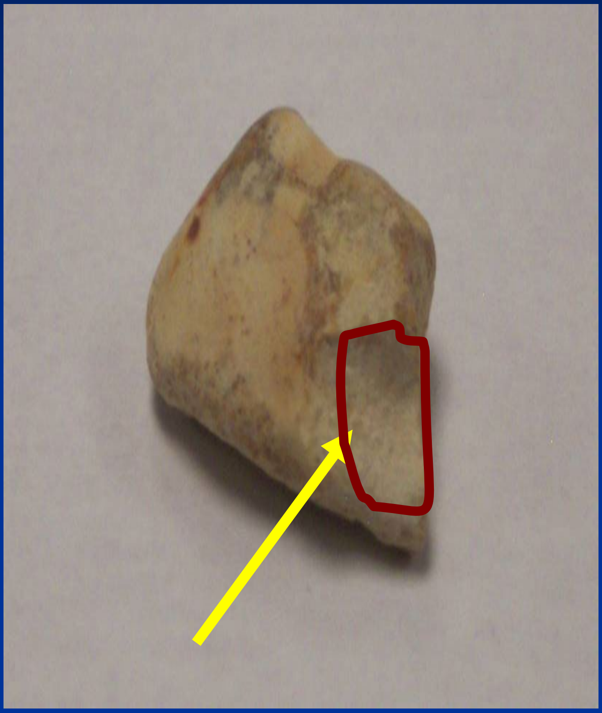






Judgment Call
1, 2, or 3?

Judgment Call
Big Enough?



Presentation Topics

- Superpave QCQA Course Prerequisites
  - Aggregate Technician
  - Bituminous Technician
- Superpave QCQA Course
  - Gyratory Compactor
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  - Ignition Oven
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  - Fractured Face Count
  - Uncompacted Voids
  - Sand Equivalent
- **Tensile Strength Ratio (TSR) Course**

Tensile Strength Ratio: TSR

- Common Testing Errors
- QC to QA Comparison
- Current thinking on moisture sensitivity testing

COMMON ERRORS/ Unfavorable Comparison

- Shaking saturated puck to "adjust" saturated mass
- Using pucks out of the acceptable air void range (7.0 ± 0.5 or 6.0 ± 0.5%)
- Proper water tank temperature not maintained (25 and 60° C)
- Using puck that has been over or under saturated instead of discarding or applying additional vacuum

COMMON ERRORS / Unfavorable Comparison

- Using incorrect maximum specific gravity to calculate voids and % saturation.
- Specimen in water bath for the incorrect amount of time.
- Not cleaning breaking apparatus when dirty.
- Not annually verifying breaking machine.

COMMON ERRORS / Unfavorable Comparison

- Not molding specimens at correct temperature (if cool, may break aggregate)
- Not aging lab specimens the correct time & temperature (lab-mixed only)
- Not adding 10 ml of water prior to freezing
- Allowing specimens to drain after saturation but prior to freezing.

COMMON ERRORS / Unfavorable Comparison

- Using vacuum out of allowable range (10-26 in. Hg)
- Not allowing specimen to "rest" 5-10 minutes after vacuum period.
- Exceeding time of vacuum
- Not air-drying bulked unconditioned pucks for 24 hrs prior to breaking
- Sample contaminated with dust, release agent overspray, etc.

COMMON ERRORS / Unfavorable Comparison

- Improper filling of sample into boxes
- Improper mixing and splitting procedures
- One or more mixture re-warmings
- Testing pucks at extreme ends of allowable range of voids [6.5, 7.5] may result in poor QC/QA comparison
- QC and QA not sampling at the same location-type (roadway vs plant) TSR and Rice gravity

COMPARISON: QC TO QA

TSR -favorable comparison is when QA and QC results are within 10% of each other.

If the difference is 5 to 10%, TSR's are evaluated by MoDOT field office.

If difference is >10%, initiate dispute resolution

QC and QA retained samples may have to be kept for extended periods

Current Thinking on TSR

- "Based on the precision estimates developed in this study, the allowable difference between two TSR values measured in one laboratory was found as high as 9 % and the allowable difference between two TSR values measured in two different laboratories was found as high as 25%." From "Precision Estimates of AASHTO T283: Resistance of Compacted Hot-Mix Asphalt (HMA) to Moisture-Induced Damage (2010)." NCHRP Web-Only Document 166.
- MoDOT published a RFP for "TSR Replacement and Stripping Tests" on February 1, 2023

Summary

- ACI still requires "performance" testing for new certs and re-certs.
- Renewing my Class A CDL in Valley Park Story…
- Story I would relate to my students about a consultant getting a phone call about a problem in the field.
- Accuracy, consistency and efficiency of testing by QC and QA can affect the $$$.