

## **APPENDIX A- SAMPLE PROCESSING PROCEDURE**

Samples which are received, tested, and reported by the STAFF MATERIALS LABORATORY, are processed in the following manner:

### **IDENTIFICATION**

All materials and samples must be logged-in at the receiving dock. Samples must be identified as to:

- DATE RECEIVED
- ITEM NUMBER
- PROJECT NUMBER
- PROJECT CODE
- NUMBER OF SAMPLES

### **SELECTION**

The selection of samples is handled by field project personnel. Staff Materials is responsible for the testing of samples submitted by field personnel. The only exceptions to this are samples of asphalt cement and liquid asphalt. In this case, one sample out of five is selected at random. If this sample meets specifications, the other four are discarded. If not, the other four samples are tested and reported.

### **CONDITIONING**

Samples which require conditioning will be conditioned per the appropriate test procedure.

### **STORAGE**

Samples will be stored in the proper environment prior to testing. An example of this is concrete cylinders, which must be stored (cured) in a 100% humidity environment.

### **RETENTION**

Samples of all materials will be retained until no further question remains as to the properties of the material.

### **DISPOSAL**

All materials which are not hazardous will be placed in the large trash container immediately adjoining the Laboratory. Materials which are hazardous will be handled per Staff Materials procedure for handling hazardous materials.

## APPENDIX B - DEFINITIONS

**Note:** Definitions applicable to a specific material can be found in the respective chapter.

**Acceptance Program:**

All factors that comprise CDOT's determination of the quality of the product as specified in the contract requirements. These factors include verification sampling, testing, and inspection.

**Accredited Laboratory:**

A laboratory that is accredited by the AASHTO Accreditation Program.

**Batch:**

A unit or subdivision of a lot, such as a mixer load of concrete, a batch of bituminous mix, or a square yard of base course.

**Bias:**

Constant error in one direction, which causes the average test result to be offset from the true average value.

**Central Laboratory Check Samples and Tests:**

Random representative samples submitted to CDOT's Central and/or Region Laboratory to additionally evaluate quality of field produced products and materials, and to perform tests not within the capabilities of the Field and/or Region Laboratories.

**Check Sample:**

A Replicate Sample, usually from Project Samples or Verification Samples, which is submitted to the Central or Region Laboratory for an independent check. Independent checks on HBP include: Hveem Stability (CP-L 5105), Lottman (CP-L 5109), and Air Voids (CP-L 5105). For Superpave mixes S, SX, and SG independent checks include: volumetric properties at  $N_{design}$  and Hveem Stability (CP-L 5106). The purpose of these samples is for the Central or Region Laboratory to verify acceptability and quality of field produced material and to perform tests that are not within the capabilities of the field.

**Coefficient of Variation:**

The Standard Deviation divided by the mean.

$$CV = \delta/\bar{x}$$

**Comparative Sample:**

One of several samples resulting from a closely controlled small Batch or increment which has been thoroughly mixed and then reduced by quartering or splitting into a number of Replicate Samples. For CDOT purposes the Central Laboratory will make Groups of Comparative Samples on various materials. One or more will be sent to each participating Region Laboratory for testing to determine acceptability of procedures, methods, and equipment.

**Control Chart:**

Chart or graph, usually conspicuously displayed in the field materials laboratory where an up-to-date plot of Control and Verification Test results is kept.

**Control Sample:**

A sample taken during the process from any of the components for a manufactured (constructed) product before being incorporated into the final mixture, or a sample taken from the final mixture or product before the material has reached its final position and condition in the completed construction.

**Designated Agent:**

An employee or employees of the State, local agency, or a consultant or independent laboratory which is employed, paid by, and / or directly accountable to CDOT or a public agency excluding the contractors' or vendors' personnel.

**Group:**

Replicate Test Specimens taken from the same Batch Sample.

**Independent Assurance Program (IA):**

Activities that are unbiased and an independent evaluation of all the sampling and testing procedures and testing equipment, and in some cases the witnessing of certain specified samples and sampling techniques used in the acceptance program.

**Independent Assurance Sampling-Testing and Witnessing of Testing or Sampling:**

A sample taken and tested, or a sample that is witnessed only at a random location or time, the point to be designated by: Region Laboratory personnel, or project personnel, or CDOT's designated agent not associated with Project Verification Sampling and Testing; or the Contractor's (or his representative) not associated with Project Quality Control Sampling and Testing; or by an FHWA Engineer. The person who designates the point for sampling and who performs the actual test may physically do the sampling or project testing personnel may do the sampling in the presence of the IA person. Certain specified IA samples may be witnessed only. These samples are to be taken in the presence of both the project and IA personnel. These samples shall be taken by contractor's personnel or his representative. For more details and information, see the CDOT, Quality Assurance Program for Construction and Materials Sampling and Testing.

**Lot:**

An isolated quantity of material from a single source. A measured amount of construction material assumed to be produced by the same process.

**Nominal Maximum:**

The size of aggregate is the smallest sieve opening through which the entire amount of aggregate is permitted to pass.

**Note:** For Item 403, Nominal / Maximum size should be defined as: one sieve size larger than the first sieve to retain more than ten percent of the aggregate.

**Owner Acceptance (OA):** All those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality.

**Owner Verification Testing (OVT):** All those planned and systematic testing verifications necessary to provide confidence that a product or service will satisfy given requirements for quality.

**Practice:**

A definitive procedure for performing one or more specific operations or functions that does not produce a test result.

**Precision:**

A generic concept related to the closeness of agreement between test results obtained under prescribed like conditions from the measurement process being evaluated.

**Proficiency Samples:**

Homogeneous samples that are distributed and tested by two or more laboratories.

**Process Control (PC):** All contractor/vendor operational techniques and activities that are performed or conducted to fulfill contract requirements

**Quality Assurance (QA):**

All those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality.

**Quality Control (QC):**

All contractor/vendor operational techniques and activities that are performed or conducted to fulfill contract requirements.

**Qualified Laboratories:**

Laboratories that participate in a qualification program, approved by CDOT that shall include provisions for checking testing equipment and maintaining records of all equipment calibrations and equipment checks. All testing equipment used to conduct testing shall conform to the standards specified in the testing procedure.

**Random Sample:**

A sample drawn from a Lot in which each increment in the lot has an equal probability of being chosen.

**Random Sample, Stratified:**

When a Lot is subdivided into approximately equal Sub-lots and samples are selected from each sub-lot by a Random process.

**Reasonable Conformance:**

When construction and materials substantially comply with the plans and specifications. Clearly stated acceptance plans assist the Project Engineer in making his decision as to reasonable conformance.

**Repeatability:**

The range within which repeated measurements are made by the same operator on the same apparatus on Replicate Test Specimens. Essentially, the precision of the test.

**Replicate Samples or Test Specimens:**

Multiple Samples or Test Specimens as nearly identical as possible, under the stated conditions, usually from a thoroughly mixed larger sample that has been reduced in size by quartering or splitting.

**Reproducibility:**

The range within which check measurements by different operators on different apparatus should agree under definitely stated conditions. Usually performed on Test Specimens from Replicate Samples.

**Sample:**

A small part of a Sub-lot or Batch, which represents the whole. A sample may be divided into several Test Specimens.

**Standard Deviation (  $\sigma$  ):**

A measure of the dispersion of measurements from their average; the square root of the quantity of individual deviations from the mean, squared, summed, and divided by the number of samples.

$$\sigma = \sqrt{\frac{\Sigma(X - \bar{X})^2}{N}}$$

**State personnel:**

An employee or employees of CDOT.

**Sub-lot:**

The largest, clearly identifiable subdivision of a Lot. Usually specified in the Field Materials Manual Sampling Schedule as the largest quantity that may be represented by a single sample.

**System Basis, IA:**

A system where the minimum frequency is based on a unit of material production and/or a unit of time.

**Test Method:**

A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system or service that produces a test result.

**Test Specimen:**

That part of a Sample actually tested. Usually obtained by reducing the Sample by quartering, splitting, or taking an aliquot (usually a liquid portion removed from the whole) quantity.

**Variation:**

Differences, due to any cause, in measured values of a measurable characteristic.

**Vendor:**

A supplier of materials incorporated into the project, which is not the contractor. May or may not be the Manufacturer.

**Verification Sampling and Testing:**

Sampling and testing performed to validate the quality of the product for acceptance.

**Verification Sample:**

A sample used to make a decision as to the acceptability of the material being sampled. Reasonable Conformance and amount of payment will be based on this sample. The specifications designate the point of verification sampling. Refer to the Schedule.

## APPENDIX C - ACRONYMS

3R	Resurfacing, Restoration, Rehabilitation
AAP	AASHTO Accreditation Program
AASHTO	American Association of State Highway and Transportation Officials
ABC	Aggregate Base Course
ACI	American Concrete Institute
ACPA	American Concrete Pavement Association
ACPA	American Concrete Pipe Association
AI	Asphalt Institute
AIF	Asphalt Industry Forum
AMRL	AASHTO Materials Reference Laboratory
APA	Asphalt Pavement Analyzer
APL	Approved Product List
ARA	Asphalt Rejuvenating Agent
ASTM	American Society of Testing and Materials
ATSSA	American Traffic Safety Services Association
BMP	Best Management Practices
CAGE	Colorado Association Geotechnical Engineers
CAPA	Colorado Asphalt Pavement Association
CBC	Concrete Box Culvert
CCA	Colorado Contractors Association
CCRL	Cement and Concrete Reference Laboratory
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CIP	Complete-in-Place
CIPR	Cold-in-Place Recycle
CIR	Cold-in-Place Recycle
COC	Certificate of Compliance
CMO	Contract Modification Order
CP	Colorado Procedure
CP-L	Colorado Procedure – Laboratory
CPM	Counts Per Minute
CRS	Colorado Revised Statutes
CRSI	Concrete Reinforcing Steel Institute
CTP	Check Testing Program
CTR	Certified Test Reports

CTS	Compaction Test Section
D/A	Dust to Asphalt
DMS	Dynamic Message Sign
DRB	Dispute Resolution Board
DSR	Dynamic Shear Rheometer
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPE	Expert Product Evaluator
FAA	Fine Aggregate Angularity
FAPG	Federal Aid Policy Guide
FDR	Full Depth Reclamation
FHWA	Federal Highway Administration
FIPI	Finding In the Public Interest
FIR	Field Inspection Review
FMM	Field Materials Manual
FOR	Final Office Review
FPOG	Flexible Pavement Operators Group
FQC	Field Quality Control
FWD	Falling Weight Deflectometer
HAZMAT	Hazardous Material
HBP	Hot Bituminous Pavement
HIPR	Hot-in-Place Recycle
HIR	Hot-in-Place Recycle
HITEC	Highway Innovative Technology Evaluation Center
HMA	Hot Mix Asphalt
HRI	Half-Car Roughness Index
HSP	High Speed Profiler
IA	Independent Assurance Program
IAT	Independent Assurance Sampling and Testing
I/D P	Incentive/Disincentive Payment
IGA	Inter-Governmental Agreement
IRI	International Roughness Index
JMF	Job Mix Formula
JSA	Job Safety Analysis
LabCAT	Laboratory for Certification of Asphalt Technicians
LA	Local Agency
LACA	Local Agency Certification Acceptance
LCCA	Life Cycle Cost Analysis

LIMS	Laboratory Information Management System
LMTP	Laboratory Manual of Test Procedures
LOI	Loss on Ignition
LOS	Level of Service
MAC	Materials Advisory Committee
MCR	Minor Contract Revision
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MQL	Moving Quality Level
SDS	Safety Data Sheets
MUTCD	Manual on Uniform Traffic Control Devices
NCAT	National Center for Asphalt Technology
NCHRP	National Cooperative Highway Research Program
NDT	Non-Destructive Testing
NEPA	National Environmental Protection Act
NHS	National Highway System
NICET	National Institute for Certification of Engineering Technologies
NIST	National Institute of Standards and Technology
NOV	Notice of Violation
NPCA	National Precast Concrete Association
NPS	Non-Project Specific
NTPEP	National Transportation Product Evaluation Program
OGFC	Open Grade Friction Course
OA	Owner Acceptance
OVT	Owner Verification Testing
PCCP	Portland Cement Concrete Pavement
PEC	Product Evaluation Coordinator
PF	Pay Factor
PG	Performance Graded
PPM	Parts Per Million
ProMIS	Project Management Information System
PS&E	Plans, Specifications and Estimate
PSI	Preliminary Site Investigation
QA	Quality Assurance
QAP	Quality Assurance Plan
QC	Quality Control
QCP	Quality Control Plan
QIC	Quality Implementation Council
QL	Quality Level



QML	Qualified Manufacturers List
QPM	Quality Pavement Management
RAP	Reclaimed Asphalt Pavement (previously Recycled)
RAS	Reclaimed Asphalt Shingles
RE	Resident Engineer
RECP	Rolled Erosion Control Product
RMAEC	Rocky Mountain Asphalt Education Center
RME	Region Materials Engineer
ROD	Record of Decision
ROW	Right of Way
RSAR	Roadway Surface Accomplishment Report
RSO	Radiation Safety Officer (Nuclear Gauge Equipment)
RSO	Region Safety Officer
RTD	Region Transportation Director
RTFO	Rolling Thin Film Oven
SHRP	Strategic Highway Research Program
SMA	Stone Matrix Asphalt
SME	Subject Matter Expert
SOW	Scope of Work
SpG	Specific Gravity
SSD	Saturated Surface Dry
SUPERPAVE	Superior Performing Asphalt Pavements
TCLP	Toxicity Characteristic Leaching Procedure
TCP	Traffic Control Plan
TRM	Turf Reinforcement Mat
VCA	Voids in Coarse Aggregate
VFA	Voids Filled with Asphalt
VMA	Voids in the Mineral Aggregate
VMA	Viscosity Modifying Admixture
VTM	Voids in Total Mix
WASHTO	Washington Association of State Highway and Transportation Officials
WAQTC	Western Alliance for Quality Transportation Construction
WCTG	Western Cooperative Test Group

## APPENDIX D - METRIC CONVERSION TABLES

### Conversion Factors - U.S. to Metric S.I.

Quantity	U.S.	Metric Unit (SI)	Multiply by
<b>Length</b>	mile	kilometer (km)	1.609 344
	yard	meter (m)	0.914 4
	foot	meter (m)	0.304 8
	foot	millimeter (mm)	304.8
	inch	millimeter (mm)	25.4
<b>Area</b>	acre	Hectares (ha)	0.404 685 6
	square yard	square meter (m <sup>2</sup> )	0.836 127 36
	square foot	square meter (m <sup>2</sup> )	0.092 903 04
	square inch	square millimeter (mm <sup>2</sup> )	645.16
<b>Volume</b>	cubic yard	cubic meter (m <sup>3</sup> )	0.764 555
	cubic foot	cubic meter (m <sup>3</sup> )	0.028 316 8
	cubic inch	cubic millimeter (mm <sup>3</sup> )	16 387.064
	gallon	Liter (L)	3.785 41
<b>Mass</b>	ton	metric ton (t)	0.907 184
	pound	kilogram (kg)	0.453 592
	ounce	gram (g)	28.3495
<b>Temperature</b>	°Fahrenheit	°Celsius	(°F-32) 5/9
<b>Pressure</b>	psi	kilopascals (kPa)	6.894 76

### Conversion Factors - Metric S.I. to U.S.

Quantity	Metric Unit (SI)	U.S.	Multiply by
<b>Length</b>	kilometer (km)	mile	0.621 371
	meter (m)	yard	1.093 6
	meter (m)	foot	3.280 84
	millimeter (mm)	foot	0.003 28
	millimeter (mm)	inch	0.039 37
<b>Area</b>	Hectares (ha)	acre	2.471 054
	square meter	square	1.195 99
	(m <sup>2</sup> ) square	yard	10.763 91
	meter (m <sup>2</sup> )	square	0.001 55
square millimeter (mm <sup>2</sup> )	foot		
<b>Volume</b>	cubic meter (m <sup>3</sup> )	cubic	1.307 95
	cubic meter (m <sup>3</sup> )	yard	35.314 72
	cubic millimeter	cubic	0.000 061
	Liter (L)	gallon	0.264 172
<b>Mass</b>	metric ton (t)	ton	1.102 31
	kilogram (kg)	pound	2.204 62
	gram (g)	ounce	0.035 274
<b>Temperature</b>	°Celsius	°Fahrenheit	(°C x 1.8) + 32
<b>Pressure</b>	kilopascals (kPa)	psi	0.145 038

**Metric Decimal Prefixes**

<b>Prefix</b>	<b>Magnitude</b>	<b>Expression</b>
kilo	$10^3$	1000 (one thousand)
milli	$10^{-3}$	0.001 (one thousandth)

For a more information on Metric S.I. units see CDOT's *Metric Conversion Manual*. Other good reference include AASHTO R1-91 and ASTM E 380-92.

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**Sieve Sizes English - Metric**

<b><u>English</u></b>	<b><u>Metric</u></b>
3"	76.2 mm
2 1/2"	63.5 mm
2 "	50.8 mm
1 1/2 "	38.1 mm
1 "	25.4 mm
3/4 "	19.0 mm
1/2 "	12.7mm
3/8 "	9.51 mm
# 4	4.75 mm
# 8	2.36 mm
# 16	1.18 mm
# 30	600 mu
# 50	300 mu
# 100	150 mu
# 200	75 mu

## APPENDIX E - MATERIALS TESTING ACCURACY CRITERIA

The following table is the official testing accuracy criteria for the Colorado Department of Transportation and shall be strictly adhered to.

		MEASURE TO NEAREST	REPORT TO NEAREST
<b>SOILS</b>	Sieve Analysis		
	(Except - #200)	1.0 g .....	1%
	Minus No. 200	0.1 g .....	0.1%
	Atterberg Limits	0.01 g .....	1%
	Density	---- .....	0.1 lb/ft <sup>3</sup> (1 kg/m <sup>3</sup> )
	Relative Compaction	0.1 lb/ft <sup>3</sup> (1 kg/m <sup>3</sup> ) .....	0.1%
	Moisture Content		
	D/M Gauge	0.1 lb/ft <sup>3</sup> (1 kg/m <sup>3</sup> ) .....	0.1%
	Dry Weight	0.1 g .....	0.1%
	<b>BASE AGGREGATES</b>	Sieve Analysis	
(Except - #200)		1.0 g .....	1%
Minus No. 200		0.1 g .....	0.1%
Atterberg Limits		0.1 g .....	1%
Density		---- .....	0.1 lb/ft <sup>3</sup> (1 kg/m <sup>3</sup> )
Relative Compaction		0.1 lb/ft <sup>3</sup> (1 kg/m <sup>3</sup> ) .....	0.1%
Moisture Content			
D/M Gauge		0.1 lb/ft <sup>3</sup> (1 kg/m <sup>3</sup> ) .....	0.1%
Dry Weight		0.1 g .....	0.1%
<b>CONCRETE</b>		Sieve Analysis	
	(Except -#200)	1.0 g .....	1%
	Minus No. 200	0.1 g .....	0.1%
	Sand Equivalent	0.1 % .....	1 %
	Moisture in Aggregate	0.1 g .....	0.1%
	Air Content	---- .....	0.1%
	Fineness Modulus	---- .....	0.01
	Slump	---- .....	1/4 inch (5 mm)
	Compressive Strength	1 psi (0.01 MPa).....	10 psi (0.1 MPa)
	Flexural Strength	1 psi (0.01 MPa).....	5 psi (0.05 MPa)
	Thickness	0.05 in (1.3 mm).....	0.1 in (2.5 mm)

<b>BITUMINOUS PVMT.</b>	Moisture in Mix	0.1 g .....	0.1%
	Sieve Analysis		
	(Except - #200)	1.0 g .....	1%
	Minus No. 200	0.1 g .....	0.1%
	Asphalt Content		
	(Methods A, B, D, F, and G)	0.1 g .....	0.01%
	(Method E)	1.0 g .....	0.01%
	Hveem Stability	---- .....	1
	Voids in Mineral Aggregate	---- .....	0.1%
	Air Voids	---- .....	0.1%
	Lottman TSR	---- .....	0.01
	Lottman Dry TS	1 lb.f (1 N) .....	1 psi (1 KPa)
	Filler	0.1 g .....	0.1%
	Specific Gravity	0.1 g .....	0.001
	Specific Gravity		
	D/M Gauge	---- .....	0.001
Relative Compaction	0.01 .....	0.1%	

## **APPENDIX F – JOB SAFETY ANALYSIS (JSA) – MATERIALS INDEX**

The following documents are intended to assist with the safe implementation and interpretation of the AASHTO, ASTM, CDOT Miscellaneous, Colorado Procedures, and Colorado Procedures for Laboratory Testing.

Job Safety Analysis (JSA) documents are posted on CDOT's Materials and Geotechnical web site at the address of <http://www.codot.gov/business/designsupport/materials-and-geotechnical/manuals/jsa>. The JSA's shall be reviewed and updated.

Questions or perceived errors should be directed to the applicable Region Materials Engineer or Program Manager within the Central Laboratory. The following test methods and procedures have applicable JSAs or are under development.

### **AASHTO Test Methods:**

- R 28
- T 59
- T 84
- T 85
- T 90
- T 96
- T 190
- T 240
- T 313
- T 331
- T 334

### **ASTM Test Methods:**

- A 370 (Rebar)
- A 370 (Strand)
- C 39
- C 78
- C 114
- C 138 / C 231
- C 143
- C 151
- C 185
- C 452
- C 496
- C 535
- C 617
- C 1260
- D 244

### **CDOT Miscellaneous:**

- Continuous Sampler Penetration
- FWD Testing
- Hard Rock Coring
- Soil (Auger) Drilling
- Soil Profile
- Standard Penetration Test

**CP Test****Methods:**

- CP 20
- CP 21
- CP 30
- CP 31
- CP 31A / CP 31B
- CP 32
- CP 34 / CP 35
- CP 34
- CP 37
- CP 41A
- CP 41B
- CP 41C
- CP 43
- CP 44
- CP 45
- CP 46
- CP 51
- CP 53
- CP 55
- CP 58
- CP 61
- CP 66
- CP 67
- CP 68
- CP 80
- CP 81
- CP 82
- CP 85

**CP-L Test****Methods:**

- CP-L 2103
- CP-L 2104
- CP-L 2212
- CP-L 3101
- CP-L 3103
- CP-L 4209
- CP-L 4211
- CP-L 4301
- CP-L 4302
- CP-L 5106
- CP-L 5109
- CP-L 5115
- CP-L 5120
- CP-L 5301
- CP-L 5302 / CP-L 5304
- CP-L 5303
- CP-L 5305
- CP-L 5305

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