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Employees should be made aware that the Contractor is obligated to make the work-site safe, to their satisfaction, for inspection activities. Anyone who is uncomfortable with access for inspection should inform their supervisor of the situation and expect resolution. Project personnel should also be made aware of project specific hazards and be trained in specific areas as the project warrants. For example; fall protection, confined space requirements, respirator training, lead paint hazards, hazardous material training, and exposure to medical waste (sharps). It is suggested that the expertise of the Regional Safety Officers or Headquarters Safety Office be utilized as appropriate.

Be aware that the construction contract requires the contractor to perform any measures or actions the Engineer may deem necessary to protect the public, and that the Engineer may suspend work if the Contractor fails to correct unsafe conditions. Project staff should continuously monitor the Contractors’ work activities for potential violations of legal safety requirements, and for any condition that poses an immediate threat to the health of any person. Immediately notify the Contractor upon becoming aware of any such condition.

Additional information, such as safety regulations and Department of Labor and Industry (L&I). Keep in mind that many WSDOT employees are not trained to interpret and apply safety regulations; however, employees need to have a reasonable understanding of what hazards may be encountered on a project. Many, but not all, of the requirements are listed under WAC 296-155 Safety standards for construction work under the various “Parts a through V.”

State L&I offers consultation service (advise is given) and enforcement (assessment of a violation would result in a citation being issued). A listing of phone numbers for the various L&I field offices is as follows:

- **Region 1**
  - Bellingham Field Services Location 360-647-7300
  - Everett Field Services Location 425-290-1300
  - Mount Vernon Field Services Location 360-416-3000

- **Region 2**
  - Bellevue Field Services Location 425-990-1400
  - Seattle Field Services Location 206-515-2800
  - Tukwila Field Services Location 206-835-1000

- **Region 3**
  - Bremerton Field Services Location 360-415-4000
  - Port Angeles Field Services Location 360-417-2700
  - Tacoma Field Services Location 253-596-3800

- **Region 4**
  - Aberdeen Field Services Location 360-533-8200
  - Kelso Field Services Location 360-575-6900
  - Tumwater Field Services Location 360-902-5799
  - Vancouver Field Services Location 360-896-2300
When the work area encroaches upon a sidewalk, crosswalk, or other areas that are near an area utilized by pedestrians or bicyclists, special consideration should be given to their accommodation and safety. Pedestrians are more susceptible to personal injury in work areas than are motorists. Visibility and recognition of hazards is an important requirement for the safety of pedestrians and bicyclists.

Protective barricades, fencing, handrails, and bridges, together with warning and guidance devices, should be used so that pathways for pedestrians, bicyclists, equestrians, and other non-motorists are safe and well defined. Where walks are closed by construction or maintenance, an alternate walkway should be provided where feasible. Where it is necessary to divert pedestrians into the parking lane of a street, barricades and delineation should be provided to separate the pedestrian walkway from the adjacent traffic lane. Pedestrians should not be diverted into a portion of the street used by vehicular traffic. At locations where adjacent alternate walkways cannot be provided, pedestrians can be diverted across the street by placing appropriate signs at the construction limits and at the nearest crosswalk or intersection. When hazardous work conditions exist overhead, it may be necessary to install a fixed pedestrian walkway of the fence or canopy type to protect and control pedestrians. In such cases, wood and chain link fencing can be used with warning lights and illumination to warn and guide both pedestrians and motorists. These accommodations for pedestrians and bicycles should be included in Traffic Control Plans.

Fences around a construction area are often necessary and may be a requirement of the local jurisdiction building code. They are often constructed in conjunction with a special pedestrian walkway or when there are deep excavations or when pedestrian access to the job site is not desirable. Installation of such fencing must take into account relocation of existing control devices and facilities such as traffic signals, pedestrian signals, traffic signs, and parking meters. The use of chain link fencing which can be seen through may be needed at intersections to provide adequate sight distance.

Relocating a walkway without unreasonable inconvenience to pedestrians, residents, or commercial interest, is the safest practice of all. Remember, however, that pedestrians like to “see what’s going on.” Simply denying them access does not, of itself, prevent their encroachment onto the worksite. Sometimes it is advisable to design and construct a pedestrian observation area for this purpose.
The remaining devices listed in the provisions are the following:

- Sequential Arrow Signs
- Portable Changeable Message Sign
- Barricades
- Traffic Safety Drums
- Barrier Drums
- Traffic Cones
- Tubular Markers
- Warning Lights and Flashers
- Truck-Mounted Attenuator
- Tall Channelization Devices
- Portable Temporary Traffic Control Signal

The specifications for these devices should be sufficient to explain their use and requirements.

1-2.3C(4) Measurement

Measurement is the key element of the new provisions, which now contain lump sum bid items. The provisions will define one of several pay item strategies, which will determine the measurements to be made.

First, the “normal” project with these provisions will contain items. The items are different from previous contracts and are non-standard, although several have very similar item names. Each of these is described below.

Instead of items, the project may be designated as a “Total Project Lump Sum.” This will be the case if the item “Project Temporary Traffic Control, Lump Sum” is included in the proposal. If this is the strategy of the project, then all measurement and payment provisions for all other pay items are deleted from the contract. When this occurs, then all temporary traffic control costs of whatever nature (everything defined in Section 1-10) are included in the lump sum.

The project may be a lump sum hybrid. In this case, the Total Project Lump Sum item will be present, but the provisions will reinstate one or more of the deleted standard items. If that happens, the measurement and payment of the reinstated item(s) will be separate from and not included in the lump sum.

These are the items and a discussion of the features of the measurement spec for each:

- **Traffic Control Supervisor (Lump Sum)** – Previously paid by the hour, this item is now a fixed cost. Overtime is not considered, a second TCS for a night shift makes no difference. This lump sum status will likely cause TCS to become a part of change order negotiations. If the change does, in fact, require additional TCS work, then there would be entitlement. This will also apply to extended contract duration, as the TCS can be considered part of on-site overhead.
• **Flaggers and Spotters (Per Hour)** – This contract activity is separated from other kinds of traffic control labor. It is measured according to the hours that an approved flagging station is manned. We will not count minutes and seconds; time will be rounded up to the half hour as specified in *Standard Specifications* Section 1-09.1. If a station is manned, but full-time presence of the flagger is not necessary (trucks entering roadway, equipment crossing) then the flagger is expected to step back out of harm’s way until the next event. No deduction will be made for this stepping back, provided the flagger cannot be assigned to other duties while waiting. In measuring flagging, disregard overtime, split shifts, union rules for show-up time, the trade classification of the flagger and any other payroll issues. The flagging is a service that is provided and paid by the hour. It is only peripherally related to the flagger’s paycheck.

Spotters may be used when required to improve safety. Spotter stations must be shown on the TCP and approved. Once approved, the item will be measured when the approved station is manned. The same rules apply to the non-relationship between Spotter payment and the paycheck of the spotter employee.

• **Other Traffic Control Labor (Per Hour)** – There are other duties for traffic control labor besides flagging and spotting. Some of them are included in this item for separate measurement. If one of the activities listed in the provision is provided, then measurement of that activity is appropriate. Only the hours that the activity is performed will be measured. Again, this is not a payroll measurement.

Note the limit under patrolling and maintaining. No matter how many people are involved in this activity, measure only one hour for each hour that each approved route is operated.

Another little feature shows up under the last bullet (Installing and removing devices). Time spent ahead of the setup marking layout points on the shoulder or getting signs ready in the yard will be measured under this item.

Do not succumb to pressures to add other hours to this item. As the payment spec for “Other Temporary Traffic Control” states, all costs not compensated by other items are covered there.

Construction Signs, Class A (per sq. ft.) to qualify for payment under this item, the sign must be designated as Class a on an approved TCP or be directed installed by the Engineer and designated as Class a at the time of direction. After-the-fact re-designations of signs that have been originally thought to be Class B should not be considered.

• **Other Unit Price Items** – The traffic control provisions limit unit items to major devices. These include Sequential Arrows, Changeable Message Signs, Portable Signal and Transportable Attenuators. The measurement and payment requirements for these are similar or identical to those which have been in use for some time and are relatively straightforward.

One point to make is with the force account item for Repair Transportable Attenuator. Because this is a temporary installation and not a part of the permanent work, the Third Party Damage item does not apply and that is why a separate force account is established. If the damage was caused by a third party, the department may well be
• In the absence of the Manager of Terminal Maintenance and Construction, that Manager’s execution authority may be further subdelegated to the Assistant.

(III) Local Agency Projects

When the project being administered includes local agency participation, the project engineer should coordinate with the Regional Local Programs Engineer and the local agency to establish an approval process acceptable to all the parties. Any funding constraints and timelines for reviews and approvals should be established and specified in the contract, if appropriate.

1-24C(5) Approval to Proceed

All change orders require an approval to proceed with the change work prior to the change work being performed. The best business practice is to have a signed change order in place prior to proceeding with the work. Occasionally it may be necessary to proceed with the change work prior to the execution of the change order, but this should be the exception. Such an approval to proceed might be warranted if it will provide a cost/time benefit to WSDOT or minimize a cost/time disadvantage to the contractor. In the event that the Project Engineer determines that it is in the State’s best interest to proceed with the work prior to having a signed change order, the permission of the executing authority to proceed with the change under these circumstances must be documented in the file. The executing authority is the person who will ultimately execute the change order. The project engineer must have either an executed change order or documented approval to proceed in place prior to proceeding with the work.

1-24C(6) Documentation

(I) State Construction Office Role

The State Construction Office will review Region executed change orders and provide appropriate feedback. Four main areas the Construction Office will review are:

• Whether the change is appropriate and there is entitlement.
• Determine compliance with the change order checklist.
• Check for existence of supporting documentation.
• Determine if eligibility for federal-aid participation has been addressed.

(II) Project Files

A. CCIS Input – The Project Engineer shall ensure that the following information is input into CCIS accurately and in a timely manner:

• Page 1
  – Contract No.: (in 6-digit format)
  – Proposed By: C(Contractor), E(Engineer), or B(Both)
  – Order Date: Date change order entered into CCIS
  – Unilateral Change: Y/N
  – PE Stamp required: Y/N
Short Description: Descriptive title for change order
Is this a MINOR CHANGE?: Y/N

**Page 2** – (Use only if approval to proceed is requested)
- Approval Date: The date approval given
- Requested By: Who requested approval
- Approved By: Who gave approval
- Estimated Amount: The estimated dollar amount of the change order
- Narrative: Description of why approval is needed

**Page 3** – (Use only if this change order is a CRIP)
- CRIP Amount
- Commentary on CRIP

**Page 4**
- Sent To Contr: The date the change order was sent to the contractor for signature/concurrence
- Rec’d From Contr: The date the change order was returned from the contractor
- Surety Consent: Was surety consent obtained
- Surety Date: Date Surety consent obtained
- PE Recom: Is PE recommending approval by Region or HQ
- Exec: Initials of PE if executing change order
- Date: Date that PE executed or recommended execution (Note: the date field on line 4 is for Region or HQ use only)
- By Whom: Who voided change order (if applicable)
- Date: Date change order was voided (if applicable)

**Page 5**
- Phase: Contract phase affected by change order (if days added/deleted)
- Description: Phase description (if days added/deleted)
- Net Change: Number of days added/deleted by change order

**Page 6**
- Description: Change order text (uploaded from MS Word)

**Page 7**
- What Section of contract changed?
- Describe the Detail Change:
- What created the need or caused the change?
- What is the purpose of this change order?

If new items are created, contract items modified, or Condition of Award is modified by the change order, this information must be input into CCIS as well.
<table>
<thead>
<tr>
<th>Working Drawing, Shop Plan, or Submittal Type</th>
<th>Const. Manual Ref.</th>
<th>Standard Spec. or Other References</th>
<th>Number of Paper Copies (Contact Bridge and Structures to discuss the option of electronic submittals)</th>
<th>Reviewer Prior to Approval</th>
<th>Approving Authority</th>
<th>PE Distribution of approved drawings (surplus copies stay @ PE)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding Steel Piling</td>
<td>6-5.6</td>
<td>6-05.3(6) 6-03.3(25)</td>
<td>8 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 sets to Contractor 2 sets to Fabrication Inspector</td>
<td>Weld splices of steel casing for cast-in-place conc. Piles shall be the Contractor’s responsibility 4 additional sets to Bridge if RR is involved. (per RR)</td>
</tr>
<tr>
<td>Pile Driving Equipment Adequacy Submittals</td>
<td>6-05.3(9)</td>
<td></td>
<td>6 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Geotech. Engr., Bridge &amp; Structures and State Construction Engr. (Bridge)</td>
<td>Bridge &amp; Structures Engr.</td>
<td>2 sets to Contractor</td>
<td></td>
</tr>
<tr>
<td>Painting Plan</td>
<td>None</td>
<td>6-07.3(2)</td>
<td>3 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 sets to Contractor</td>
<td></td>
</tr>
<tr>
<td>Modified Concrete Overlays (Mix Design, Equipment Specifications and Procedures)</td>
<td>None</td>
<td>6-09.3(2)</td>
<td>3 sets to State Bridge Const. Engineer 2 sets to Project Engineer</td>
<td>State Bridge Const. Engr.</td>
<td>State Bridge Construction Engr.</td>
<td>2 sets to Contractor</td>
<td></td>
</tr>
<tr>
<td>Shaft Installation Plan for Noise Walls, Soldier Pile Walls, Signal Standard Foundations, and Luminaire Bases</td>
<td>6-2.3E</td>
<td>6-12.3(1) 6-16.3(2)</td>
<td>4 sets to Bridge &amp; Structures 1 set to Project Engineer</td>
<td>Bridge &amp; Structures Engineer, State Construction Engineer (Bridge), &amp; Geotech. Engr.</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 Sets to Contractor</td>
<td></td>
</tr>
<tr>
<td>Structural Earth Wall Submittals</td>
<td>None</td>
<td>6-13.3(2)</td>
<td>3 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer, &amp; Geotech. Engr.</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 sets to Contractor</td>
<td>PE Stamp Required</td>
</tr>
<tr>
<td>Geosynthetic Retaining Wall Plans (Includes Std. Plan Type 1-6 Walls)</td>
<td>None</td>
<td>6-14.3(2)</td>
<td>3 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer, &amp; Geotech. Engr.</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 sets to Contractor</td>
<td></td>
</tr>
</tbody>
</table>

**WSDOT Construction Manual M 41-01.11**

Chapter 1

July 2011

**Figure 1-6**

**Shop Plans and Working Drawings (continued)**
<table>
<thead>
<tr>
<th>Working Drawing, Shop Plan, or Submittal Type</th>
<th>Const. Manual Ref.</th>
<th>Standard Spec. or Other References</th>
<th>Number of Paper Copies (Contact Bridge and Structures to discuss the option of electronic submittals)</th>
<th>Reviewer Prior to Approval</th>
<th>Approving Authority</th>
<th>PE Distribution of approved drawings (surplus copies stay @ PE)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Nail Walls</td>
<td>None</td>
<td>6-15.3(3)</td>
<td>3 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer, &amp; Geotech. Engr.</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 sets to Contractor</td>
<td>Include State Bridge Const. Engr. if shotcrete facing is permanent (6-18.3(1)) Experience criteria to be verified by Project Engineer</td>
</tr>
<tr>
<td>Soldier Pile Walls</td>
<td>None</td>
<td>6-16.3(2)</td>
<td>3 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer, &amp; Geotech. Engr.</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 sets to Contractor</td>
<td>PE Stamp Required</td>
</tr>
<tr>
<td>Permanent Ground Anchor Submittals</td>
<td>None</td>
<td>6-17.3(3)</td>
<td>3 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer, &amp; Geotech. Engr.</td>
<td>Bridge &amp; Structures Engineer</td>
<td>2 sets to Contractor</td>
<td>PE Stamp Required</td>
</tr>
<tr>
<td>Roadside Plant/Weed &amp; Pest Control Plan</td>
<td>None</td>
<td>8-02.3(2)</td>
<td>4 sets to Project Engineer</td>
<td>Project Engineer</td>
<td>Project Engineer</td>
<td>2 sets to Contractor 1 set to Region Const. Signed by Licensed Chemical Pest Control Consultant</td>
<td></td>
</tr>
<tr>
<td>Shop Plans for Light Standard and Traffic Signal Standards</td>
<td>8-20.2B</td>
<td>8-20.2(1)</td>
<td>6 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer</td>
<td>Bridge &amp; Structures for light standards and Types II, III, IV, V and SD signal standards. Project Engr for Types PPB, PS, &amp; I signal standards</td>
<td>2 sets to Contractor 2 sets to Fabrication Inspector</td>
<td>Shop drawings are required for all signal standards and for those light standards without pre-approved plans. (per Std. Spec)</td>
</tr>
<tr>
<td>Shop Plans for Sign Structures</td>
<td>8-21.3</td>
<td>8-21.3(9) A refers to Section 6-03.</td>
<td>8 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer</td>
<td>Bridge &amp; Structures Engineer, &amp; Geotech. Engr.</td>
<td>2 sets to Contractor 2 sets to Fabrication Inspector</td>
<td>4 additional sets to Bridge if RR is involved. (per RR)</td>
</tr>
<tr>
<td>Column Jacket Shop Drawings &amp; Installation Plans</td>
<td>None</td>
<td>See BSP 02300403. GB6 02300404. GB6</td>
<td>8 sets to Bridge &amp; Structures 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Engineer</td>
<td>Bridge &amp; Structures Engineer, &amp; Geotech. Engr.</td>
<td>2 sets to Contractor 1 set to Fabrication Inspector</td>
<td>PE Stamp required.</td>
</tr>
<tr>
<td>Form Liners (Various patterns per GSP)</td>
<td>None</td>
<td>See GSP 0231405. GB6</td>
<td>2 sets to Bridge &amp; Structures Architect 2 sets to Project Engineer</td>
<td>Bridge &amp; Structures Architect</td>
<td>Bridge &amp; Structures Architect</td>
<td>1 Set to Region Const 2 sets to Contractor</td>
<td>Include 2ft X 2ft sample with drawing to Bridge &amp; Struct. Architect</td>
</tr>
</tbody>
</table>

Shop Plans and Working Drawings (continued)  
*Figure 1-6*
noncompliance. When the Project Engineer’s Office receives the Prime Contractor’s M/WBE Participation Plan, it should be transmitted to the WSDOT Office of Equal Opportunity for review and comment.

**MBE/WBE Reporting**

- Quarterly Report of Amounts Paid MBE/WBE Participants (WSDOT Form 421-023). In accordance with *Standard Specifications* Section 1-08, a Quarterly Report of Amounts Paid MBE/WBE Participants (WSDOT Form 421-023) is required from the prime contractor for all projects funded entirely by State funds. When a project contains Federal assistance, the Federal quarterly reporting requirements for DBE utilization override the States requirements, eliminating the need for the State’s MBE/WBE report of amounts paid.

The Quarterly Report of Amounts Paid MBE/WBE Participants reflects the State fiscal quarters. Quarterly reports are to be submitted to the Contracting Agency within 20 calendar days of the end of each quarter and within 20 calendar days of physical completion of the contract. The dollar amounts shown in each report are those amounts paid to the MBE/WBE firms during the respective quarter. The final report is to show only the dollar amounts paid during the remaining partial quarter ending on the Physical Completion date. The Region is responsible for entering this data into CCIS. The Region Documentation/Equal Employment Opportunity (EEO) Officer needs to verify the information has been entered and validate the information. The completed form is maintained as a part of the project records and becomes a part of the temporary final records upon completion.

**1-2.7F Disadvantaged Business Enterprise (DBE)**

DBE is the designation for holding Federal certification as a Disadvantaged Business Enterprise. On Federally funded projects there will normally be a DBE requirement of some sort specified by the contract special provisions. This special provision will be one of two types:

**1-2.7F(1) GSP Includes No Goal**

When *No Goal* is specified, the contractor is encouraged to take actions that promote DBE participation. The goal is intended to draw the attention of bidders to the opportunity to subcontract with DBE’s. However, these requirements are indeed voluntary and there are neither preferences for accomplishment nor sanctions for non-compliance. They do contribute to the overall goal established by the Department. It is therefore important that the Department capture the work that is being performed. This can be done through “Quarterly Report of Amounts Credited as DBE Participation.”

**1-2.7F(2) GSP Includes Condition of Award (COA) Goal**

When a *Condition of Award Goal* (COA) is specified, the Contractor is required to employ DBE participation to at least the extent identified in the contract special provisions. This is a condition of awarding the contract to the Contractor and a project can not be considered successful unless the Contractor meets the COA DBE participation goal, or the Contractor demonstrates that a good faith effort was made to deliver on the Condition of Award. These specifications are placed in contracts as a condition of continued Federal Funding for the Department.
• As a *Condition of Award*, the Contractor must commit to, and follow through on, subcontracting at least the work and the amount identified by the COA to certified DBE firms or make a good faith effort to do so.

• Measurement of attainment is not simply the payments made to the DBE. Attainment is measured in accordance with the provisions of the “DBE Participation” section of the contract special provisions.

• Changes to the amounts specified for COA must be made in accordance with the procedures outlined in this section.

1-2.7F(3) **Additional Execution Documents**

Successful bidders will be required to provide a “Bidders List” to the Department. This list is to include the names and addresses of every firm that submitted a bid or quotation to the Prime, whether or not that bid was used as part of the overall proposal. The Contractor is directed to send this list directly to the WSDOT Office of Equal Opportunity in Olympia and normally the Project Engineer will have no involvement.

1-2.7F(4) **DBE Reporting**

The contract special provisions require the Contractor to submit to the Project Engineer a “Quarterly Report of Amounts Credited as DBE Participation” for each quarter and upon completion of the project. Again, the measurement is not simply the payments made to the DBEs, rather it is in accordance with the “DBE Participation” section of the contract special provisions. This report should contain all DBEs utilized on the contract not just the COA DBEs. The information is used to track the Departments attainment of our overall goal and it is important to insure that they are received and processed in a timely manner. The Region Documentation/EEO Officers shall track and verify that the reports are being received and entered for all applicable contracts. The Region Documentation/EEO Officers shall also compare the reports with the Condition of Award requirements.

1-2.7F(5) **On Site Reviews**

On-site reviews shall be conducted on all Federal-aid contracts where there is DBE participation (with or without Condition of Award (COA) goals). On-site reviews shall be conducted at periodic intervals – when the DBE begins work, during the peak period of the DBE’s work, and any time there is a change in the nature or methods of the DBE’s work. An on-site review must also be conducted when there is a change in the DBE performing the work (substitution of a DBE firm). These on-site reviews shall be performed for all DBE’s performing work on the project, whether Condition of Award work or other work. On multi-year projects a new review will be performed for each DBE performing work on the contract each year. An on-site review is a “snapshot in time” and should record personal observations, documentation reviews and personnel interviews, as applicable. A copy of the completed on-site review (WSDOT Form 272-051) should be forwarded to WSDOT’s Office of Equal Opportunity (OEO).

One of the requirements of the overall DBE Program is that all DBE firms working on Federal-aid project are in control of their specific items of work and are performing a “Commercially Useful Function” (CUF), as described by the specification. An on-site review may lead to a more in-depth CUF review, conducted by the OEO.
These in-depth CUF reviews may be a result of concerns identified during the initial on-site review, or the OEO may select DBE firms on a periodic basis for a more in-depth review. The OEO uses these in-depth reviews to stay abreast of the DBE firm’s capabilities. The OEO will contact the Project Office directly to schedule these reviews. The fact that the OEO is going to conduct a review shall be kept in confidence in order to ensure that the review truly reflects a sampling of the typical work of the DBE firm. The CUF review will include observations of the work, as well as interviews with key staff of all parties on the contract, in addition to the DBE firm.

On those projects containing a COA goal, the COA letter requires that the identified DBE firms perform specific items of work for the estimated dollar amounts included in the proposal. The COA letter also identifies whether the DBE firm will be performing as a “subcontractor,” “manufacturer,” or “regular dealer (supplier).” Any issues regarding DBE compliance should be brought to the attention of the OEO and the State Construction Office.

In order for WSDOT to take credit for DBE participation (as reflected by the quarterly reports), WSDOT must ensure that all DBE firms perform a “Commercially Useful Function.” Determination of whether or not a firm is performing a “Commercially Useful Function” requires on-site monitoring. The Project Office plays a key role in this monitoring by acting as the Departments “eyes and ears” in the field.

1-2.7F(6) Changes to the Condition of Award (COA)

The Contractor is required to utilize the COA subcontractors, manufacturers, etc., to perform the work as listed in the COA letter. Substitution of another DBE is allowed if:

- A COA DBE firm becomes decertified, or
- The Contractor proposes a change to the contract, that is subsequently approved by WSDOT, which reduces DBE COA participation, or
- The prime contractor provides documentation that a DBE firm is unwilling or unable to perform the work.

Exceptions to the substitution requirement may be allowed under any of the following circumstances:

- WSDOT deletes the COA firm’s intended work.
- The COA work accomplished under runs the original planned quantity.
- The Contractor can show substantial financial loss if a substitution is required.
- The work has progressed to the point where no other work remains to be subcontracted.
- The DBE subcontractor has taken the positive step of graduating from the DBE program.

The State Construction Office must approve any substitution with concurrence from the Office of Equal Opportunity.
1-2.7F(7)  **Substitution**

Substitutions must meet the following requirements:

- The new firm must do an equal dollar value of work on the contract.
- The change order does not increase the dollar amount of the original goal.

1-2.7F(8)  **Condition of Award (COA) Change Orders**

Changes to the contract COA amounts must be made through a change order executed by the Headquarters Construction Office. Approval is granted after consultation with the Office of Equal Opportunity. This approval shall be obtained and documented prior to the changed work, and any related work, being performed. The amounts shown in the COA change order should be limited to the credit necessary to accomplish the original contract goal amount. The request for approval and the change order as well as the change order package needs to contain the following information:

- An explanation of why the change is necessary.
- Identification of both the deleted work and the added work.
- Revised subtotals for all COA DBE firms. The change order only needs to address each affected DBE firm, not all COA DBE firms.
- Revised total attainment for DBE participation.
- Documentation of a good faith effort to substitute should go in the change order file (if required, see *Construction Manual* Section 1-2.7F(6)).

1-2.7F(9)  **Consulting With the Office of Equal Opportunity**

The Department’s DBE program is managed by the External Civil Rights Branch of the Office of Equal Opportunity (OEO) at Headquarters. The Project Engineer must communicate extensively and continuously with that office about any aspect of the DBE activities on the project. Any questions received from the Contractor or subcontractor about DBE provisions or enforcement should be answered only with full knowledge of the opinions and directions of the OEO. The OEO phone number at Headquarters is 360-705-7085.

The Office of Equal Opportunity is also required to approve DBE firms that are manufacturers and regular dealers (suppliers).

The State Construction Office must execute any change orders that revise the COA commitment. When preparing the change order in CCIS pending CO’s menu use option 3, “Condition of Award Items.” Include the first three items listed above in the change order document. When submitting the change order to the Contractor for signature, the Project Engineer should also send copies to the affected DBE firms and should advise the Contractor that this has been done.
1-3.1D Final Estimates – State Construction Office

The final estimate package submitted to the State Construction Office consists of the following:

- **Project Status Report** – the Project Status Report should address:
  - Contract time and recommendations for liquidated damages related to contract time.
  - Amount of railroad flagging used if any.
  - Miscellaneous Deductions identified.
  - Explanation of any Monies Due WSDOT as indicated in the Contract Estimate Payment Totals.
  - Identification of overruns/underruns in contract quantities and a brief explanation of resolution.
  - In addition, the report should indicate whether or not all Affidavits of Wages Paid have been received for the Contractor, and all subcontractors, agents or lower-tier subcontractors. List all Contractors, subcontractors, etc. for whom an Affidavit has not been received.

- **Final Contract Voucher Certification** – WSDOT Form 134-146, original only.
  - If an assessment of liquidated damages has been made previously, include a copy of the letter from the State Construction Engineer to the Contractor assessing these.
  - If an assessment of miscellaneous damages or liquidated damages resulting from causes other than time, include copies of letters from the Region to the Contractor for assessment of these.

- **Contract Estimate Payment Totals** – RAKC300F-EA.

The final estimate package is reviewed by the State Construction Office, and submitted to the State Construction Engineer for acceptance of the contract. The date on which the State Construction Engineer signs the Final Contract Voucher Certification becomes the final acceptance date for the contract itself. The final estimate package is then submitted to the State Accounting Services Office.

1-3.1D(1) Final Estimate Claim Reservations

Should the Contractor indicate a claim reservation on the Final Contract Voucher Certification, it must be accompanied by all of the requirements of *Standard Specifications* Section 1-09.11(2) (provided these have not been met in a previous claim submittal). The Project Engineer must assure that the requirements have been met prior to submitting the final estimate package to the State Construction Office. If the claim package is incomplete, return the voucher to the Contractor with notice of the missing parts.
1-3.1D(2) **Unilateral Acceptance of Final Estimates**

The Project Engineer cannot establish a completion date for the contract if the Contractor is unwilling or unable to submit one or more of the required documents noted in *Standard Specifications* Section 1-08.5. However, the Region can request that the State Construction Engineer accept the contract by signing the Final Contract Voucher Certification (FCVC) in spite of the missing documents.

If the Contractor has not signed the FCVC, the Region can request that the State Construction Engineer accept the contract without the Contractor’s signature. The Region is responsible for notifying the Contractor before such a request is made. The State Construction Office will generate the certified letter notice mentioned in *Standard Specifications* Section 1-09.9. The date of the State Construction Engineer’s signature of the FCVC becomes both the acceptance date and the completion date of the contract, both established unilaterally.

1-3.1E **Supplemental Final Estimates**

A Supplemental Final Estimate is a payment adjustment made to a contract after the Final Estimate has been processed and the project has been accepted by the State Construction Engineer. A Supplemental Final Estimate may be necessary to correct an inadvertent under payment or where a claim settlement may require additional payment be made to the Contractor. In order to complete a Supplemental Final Estimate, the Project Engineer should complete and assemble the following items, routing them through the Region to the State Construction Office for review and further processing:

1. Complete any corrections or additional postings necessary in CAPS, including any postings to change order items added to CAPS for the settlement of a claim. (Please note, where additional CAPS postings are necessary after the Physical Completion date has been established, the “Work Done To” date in CAPS must be entered as the Physical Completion date or prior.)

2. Complete a Pre-Estimate report including the Project Engineer’s recommendation for payment.

3. Assemble the backup information supporting the necessity and substantiating the cost of the changes to be made.

4. Complete a supplemental Final Contract Voucher Certification (WSDOT Form 134-146) reflecting the changes made and showing the new total “Final Amount.”

After review, the Pre-Estimate report will be signed by the State Construction Engineer authorizing payment to proceed.

While postings and corrections to CAPS may continue, once the Completion date has been established for a contract, CAPS will no longer allow the Project Engineer or the Region to process further payments to the Contractor. As a result, payment of the Supplemental Final Estimate will need to be completed for the Project Engineer by the WSDOT HQ Accountability and Financial Services Office.
If this process requires a more timely response, the above documentation may be scanned and e-mailed to the State Construction Office and CAPS; and the contract payments section can be requested to print out the pre-estimate report to be taken to the State Construction Engineer for signature prior to processing the supplemental final estimate. Once the supplemental payment is completed, the signed and executed Pre-Estimate report will be returned to the Project Engineer where it can be maintained as a part of the project payment files and made a part of the Region Temporary Final Records.

While a new Final Contract Voucher Certification is completed as a part of the Supplemental Final Estimate, the Acceptance date will remain the same as established by the State Construction Engineer’s signature on the original Final Contract Voucher Certification.

The above process may not be used when there has been an inadvertent over payment to the Contractor, the Final Estimate has been processed, and the project has been accepted by the State Construction Engineer. In this case, the Project Engineer must work with the Region, the contract payments section of the WSDOT Accountability and Financial Services Office, and the State Construction Office to make the correction. All dates in the system will be deleted, the correction made, and the Final Estimate process will begin again with the Region Final Estimate (see Construction Manual Section 1-3.1C).

1-3.1F Retained Percentage

Retained percentage withholding is based upon RCW 60.28, which provides that:

- A sum not to exceed 5 percent of the money earned by the Contractor on estimates for projects containing no Federal funds is to be retained by the Contracting Agency.
- The Contractor may submit a bond for all or any portion of the amount of funds retained by WSDOT.

When a contract is awarded, the Division of Accountability and Financial Services (AFS)/Contract Administration and Payments System (CAPS) unit or the Region Plans Office sends a package of contract documents to the Contractor. This package of contract documents also includes the necessary instructions for the Contractor to make application for a bond to replace all or any portion of the retainage. The bond form will be processed by AFS/CAPS without involvement from Project Engineer’s Office, although the payment system will not allow them to process a payment until some form of retainage is in place.

The Contractor, at any time during the life of the contract, may make a request to the Project Engineer for the release of all or any portion of the amount of funds retained. This request does not need consent of surety since the retainage bond form, for this purpose, requires their consent. The Region must forward this request by transmittal letter to AFS/CAPS, which will furnish the appropriate bond form to the Contractor for execution. The Contractor may return the executed bond form directly to AFS/CAPS for final approval and signature by WSDOT.
• Effective June 27, 2011, for projects containing no Federal funds that include landscaping work the Contractor may request that, 30 days after completion of all contract work other than landscaping work, WSDOT release and pay in full the amount of funds retained during the life of the contract for all work except landscaping. In order to initiate this release of funds, WSDOT Form 421-009 should be completed by the Contractor and submitted to the Project Engineer. In signing the request, the Project Engineer will confirm that all work, except landscaping work, is in fact physically completed. For any landscaping work that may have been completed, the Project Engineer will designate the amount of landscaping moneys, if any, that have been earned to date by the contractor. In the space designated for remarks the Project Engineer will identify the landscaping or plant establishment work that remains to be completed and its approximate value. Except for landscaping work, the Project Engineer will determine if all Statements of Intent and Affidavit of Wages Paid have been received for the work that has been physically completed. The Project Engineer will transmit to the Contractor a list of all subcontractors, including UBI numbers, believed to have performed work on the project. The Contractor will verify which subcontractors did work on the project and that the UBI number listed is correct for each subcontractor. WSDOT Form 421-009 will not be transmitted to AFS/CAPS until the Contractor has verified the subcontractors and UBI numbers. WSDOT will continue to withhold a 5 percent retainage of any moneys earned for landscaping work that may have been completed to date and will continue to retain 5 percent of the moneys that are to be earned for landscaping that is yet to be completed. A bond is not required.

The completed request along with the Project Engineer’s cover memo confirming receipt of Statement of Intent and Affidavit of Wages Paid for the Contractor, subcontractor, and any lower-tier subcontractors who were involved in the completed work, is then forwarded to the State Construction Office, through the Region Construction Office, for approval. Once approved, the Construction office will submit the request to AFS/CAPS for further processing. If there are no claims against the retainage still in place and releases have been received from Revenue and Employment Security within the designated 60 day period, AFS/CAPS will release the appropriate portion of retainage to the Contractor.

1-3.2 Final Records for Projects Constructed by Contract

The Project Engineer is responsible for preparing all necessary records in order to document the work performed on the contract. Detailed instructions on the records required and methods of preparing them are covered in Chapter 10.
2-3.5C Use of Photogrammetry Service

The photogrammetry service may be used to create a 3D Digital Terrain Model (DTM) files for use with the department’s current design software in order to produce cross sections, contours, and quantity information. Photogrammetry can also provide Digital Ortho Photos as a by product instead of the DTM files. The Ortho Photo has the same accuracy characteristics as a map but without the elevation data. The type and size of the project and the amount of time that can be saved will be considerations in the selection of the method of obtaining the ground line cross-sections. The Project Engineer must also ascertain that the work schedule of the Photogrammetry Section will permit them to provide the DTM files and Digital Ortho Photos by the time they are required. If proper ground control was established on the project during the design stage, considerable savings in time may be realized by using this service.

It is recommended that the State Photogrammetry Office be contacted at the earliest possible date when it is determined that this service may be needed, since the process requires significant time and the weather and position of the sun (angle of the sun’s rays) in Washington can affect Photogrammetric mapping schedules by weeks or even months. The 3D DTM files and Ortho Photos are obtained from aerial photographs and will show the ground as it existed at the time the photographs were taken. This data is measured in the Stereo plotter and transferred to computer files. The State Photogrammetry Office will design each photo mission and mapping process to best fit the needs of the project as defined by the Project Engineer. The State Photogrammetry Office maintains an active archive of each new project’s files and all DTM data produced since 1989. It is easily accessible via WSDOT LAN on a file server type computer. Contact the State Photogrammetry Office for specific information on past projects and archived data.

2-4 Haul

2-4.1 General Instructions

Haul is the transportation of excavated material. Measurement and payment for haul is made on material hauled.

The measurement of haul is expressed as a unit of one hundred cubic yards hauled 100 feet.

Haul quantities can be computed using the PC and associated programs on all earthwork projects and the limits of each segment of haul and the “Haul” units can be identified.

Haul shall be calculated and included in the section from which the material is hauled. Haul on roadway quantities, including borrow obtained by the widening of cuts and including waste deposited along roadway embankment slopes, will be computed on the basis of transporting material along the centerline or base line of the highway.

2-4.2 Vacant

2-4.3 Haul on Borrow or Waste

Quantities of material hauled from a borrow site to the roadway or from the roadway to a waste site are computed normal to the long axis of the borrow or waste site. When computing the amount of haul, determination of the direction of movement of the mass and the distance it is transported requires good, practical judgment by the Engineer. The size and shape of a borrow pit and egress from the pit to the highway improvement must be considered in the proper determination of the amount of haul. The same conditions are true in the case of waste sites. Instructions herein for computing haul from borrow pits shall be applicable to computing haul to waste sites.

The long axis of the borrow pit should be used for the base line of the cross-section which, theoretically, would pass through the centers of gravity of the sections; however, the base line may approximate the centers of gravity of the sections. Borrow pits which are provided by widening of the roadway cuts would be an exception to this since the Standard Specifications define them as “Roadway Excavation” and not “Borrow.”

The measurement of the distance from the pit to the center line of the roadway should originate at the center of mass as measured in the pit and be computed via the most direct and feasible route to the nearest practical point on the center line of the roadway.

The route of haul will be indicated on the plans, and, where possible, will be via existing roads. If no road exists, provision will be made in the plans for constructing a haul road and for rights therefor.

If the Contractor chooses to haul over a route shorter than the computed or designated route, payment for haul will be based on the length of the actual haul route. If the Contractor chooses to haul over a longer route than the computed or designated route, payment for haul will be based on the length of the computed or designated route.

2-5 Slope Treatment

2-5.1 General Instructions

Earth cuts, soft or decomposed rock cuts, and overburden in all rock cuts shall have the tops of the slope rounded in accordance with Standard Plan for Slope Treatment to produce an aesthetic and pleasing appearance. The slope treatment shall be constructed at the time of excavation so the material resulting from the rounding of the slopes may be disposed of along with the excavation from the cut.

The Project Engineer should go over the slope treatment procedure with the Contractor at the beginning of the excavation operation to ascertain that proper rounding is being constructed and reduce extensive reworking.
2-5.2 Measurement and Payment
Slope treatment shall be measured and paid for in accordance with Section 2-03.3(5) of the Standard Specifications.

2-6 Subgrade Preparation
2-6.1 General Instructions
The subgrade shall be constructed in accordance with the lines, grades, and typical sections shown on the plans or as established by the Engineer and the Standard Specifications.

The entire subgrade should be uniformly compacted to the density specified. The subgrade shall meet the tolerance in Chapter 1-6 of this manual. On some separate grading projects where the surfacing Contractor will be required to or elects to trim the subgrade with an automatically controlled mechanical trimmer, the tolerances for the subgrade must be changed to provide material for the subgrade trimmer to trim, but the trimmed subgrade must meet the tolerance stated above.

After the subgrade is prepared, the Contractor shall maintain it in the required condition until the next course of work is performed.

2-6.2 Measurement and Payment
The quantities of work involved in constructing and maintaining the subgrade shall be measured and paid for in accordance with the provisions of Section 2-06.5 of the Standard Specifications.

2-7 Watering
2-7.1 General Instructions
Water shall be applied as ordered by the Engineer, in accordance with the specifications, uniformly to the material so that all of the material will have approximately the same moisture content. It is more economical and effective to apply water at night or in the early morning hours when loss from evaporation is lower. In many instances, this is the only time that it is possible to increase the moisture content to that required.

The Inspector should be alert to see that the subgrade is not damaged from too much water being applied or that more water is being applied than is necessary. Usually light applications applied more frequently are more advantageous than heavy applications. The water should not be applied on surfacing materials with such force that it will wash the fine particles off the coarser ones causing segregation.

If water is a pay item, the Project Engineer shall verify the size of the water truck by measuring or weighing and if gauges are used, he should also verify the accuracy of the gauge. A record of measurements or weights, and calculations must be made for future references.

A Daily Delivery Record, Form 422-024, showing the time of each load and where it was placed should be maintained on the project. The Inspector will issue a ticket for the amount of water used.

2-7.2 Measurement and Payment
Water shall be applied as ordered by the Engineer, in accordance with the provisions of Sections 2-07.4 and 2-07.5 of the Standard Specifications.

2-8 Vacant

2-9 Structure Excavation
2-9.1 General Instructions
Before starting structure excavation, stakes should be set to locate the structure and cross-sections should be taken to determine the quantities of material involved.

During the progress of excavation, the character of material being removed and exposed should be examined to determine if it is suitable for use as backfill and to ensure that acceptable foundation conditions exist. This should be done especially on streams subject to high velocity flood water and which carry drift. Open pit excavation “glory holes” are not allowed without permission. This specification is of special importance in application to the construction of foundations in or adjacent to running streams, where the approval of the State Construction Office should be secured.

Material obtained from structure excavation may be used for backfilling over and around the structures, for building embankments, or it may be wasted. When this material is stockpiled for backfilling, the Contractor is required to protect it from contamination and the elements. If not properly protected, the Contractor must replace the lost material with acceptable backfill material at no expense to WSDOT. The backfilling of openings made for structures must be made with acceptable material from the excavation, other acceptable backfill materials indicated in the plans and special provisions, or as specified in Section 2-09.3(1)E of the Standard Specifications.

When specified in the Contract or approved by the Engineer, acceptable material may include Controlled Density Fill (CDF) – also known as Controlled Low-Strength Material (CLSM).

Before the CDF is placed, the Contractor is required to develop a mix design in accordance with Standard Specification Section 2-09.3(1)E and to submit the CDF mix design in writing to the Project Engineer on WSDOT Form 350-040. Section 2-09.3(1)E requires the Contractor to utilize ACI 229 and testing methods ASTM D-4832, ASTM D 6023 and WSDOT FOP for AASHTO T 119 in developing the CDF mix design. The ASTM and AASHTO tests required in Section 2-09.3(1)E are for use by the Contractor in developing the CDF mix design, and with the exception of providing the 28 day compressive strength test results on WSDOT Form 350-040, the test results are not required as part of the CDF mix design submittal. The Project Engineer must review the mix design before placement of the CDF will be allowed.

The Inspector should verify and document that each truckload of CDF is accompanied by the producer supplied Certificate of Compliance, meeting the requirements of Standard Specification Section 6-02.3(5)B. The Inspector
8-20  Illumination, Traffic Signal Systems, and Electrical

8-20.1  General

Illumination and traffic signal systems, due to the very nature of the work, are a highly specialized type of installation. In designing these systems, every effort is made to avoid problems for construction, maintenance, and the utility company. If problems arise, the Engineer should contact those responsible for the design and operations for help in solving them.

8-20.2  Materials

8-20.2A  Approval of Source

All materials for installation on illumination and traffic signal projects shall be selected off the Qualified Products List (QPL) or be listed on a Request for Approval of Material (RAM). Items not selected off the QPL shall be submitted to the State Materials Laboratory for appropriate action on a RAM. This list shall be complete and cover all materials which are identified on the plans or in the specifications. The list shall include the source of supply, name of manufacturer, size and catalog number of the units, and shall be supplemented by such other data as may be required including catalog cuts, detailed scale drawings, wiring diagrams of any nonstandard or special equipment. All supplemental data shall be submitted in six copies.

The Record of Materials (ROM) from the State Materials laboratory will list items for which preliminary samples or data are required. Preliminary and acceptance samples shall be submitted as required by the ROM, received from the State Materials Laboratory at the beginning of the project or as noted on the RAM. See Construction Manual Section 9-4 for material specific acceptance requirements.

8-20.2B  Shop Drawings for Illumination and Signal Standards

The Contractor is required to submit shop drawings for all types of signal standards and for light standards without pre-approved plans. Pre-approved plans are listed in the Contract Provisions. If light standards with pre-approved plans are proposed, no shop drawing submittal is required. There are two different approval procedures for shop drawings. They are the State Bridge and Structures office approval, and Project Engineer approval only. In either case, the Contractor is required to submit six sets of drawings. The two approval procedures include the following:

A.  Bridge and Structures Office Approval
   - Light standards without pre-approved plans.
   - Types II, III, IV, V signal standards without pre-approved plans.
   - Type SD (Special Design) signal standards.

B.  Project Engineer Approval Only
   - Types PPB, PS, I, RM and FB signal standards.
   - Types II, III, IV, V signal standards with pre-approved plans.
After the Contractor has submitted shop drawings, the Engineer shall make a field check of both contract plans and shop drawings. The Project Engineer is responsible for checking the geometric features of these items. Specific items that should be checked include the following:

- Foundation locations.
- Light source to base dimension (H1), if required in the special provisions and clearance to overhead utility wires.
- Mast arm lengths. If foundation offsets are changed, mast arm lengths must be adjusted.
- Horizontal dimensions from single standard pole centerline to signal head attachment points.
- Vertical dimensions from signal standard base plate to signal mast arm connection points. Assistance is available from the Traffic Design office in estimating mast arm deflection to ensure vertical clearance requirements are met.
- Orientations of mast arms and all pole-mounted appurtenances.
- Signal head mounting details.
- Hand hole location and orientation.
- Base treatment for lighting standards (fixed, or slip, or breakaway).

If there are no changes to dimensions or orientations, the Project Engineer shall mark the drawings with a statement that all standards shall be fabricated according to dimensions and orientations shown in the Contract.

If there are corrections, the Project Engineer shall note all corrections on one set of shop drawings, with green markings only, and attach copies of signal standard chart and/or luminaire schedule from contract, noting any dimension changes in green. A Publications Transmittal (WSDOT Form 410-025) shall be used to submit the entire package.

The State Bridge and Structures office will conduct a structural review, and mark all sets in red, incorporating the Project Engineer’s geometric review comments.

The six sets of shop drawings for supports without pre-approval shall be submitted to the State Bridge and Structures office, which will coordinate approval with the State Materials Laboratory. After approval, the State Bridge and Structures office will retain one set and forward two sets to the State Materials Engineer and send three sets to the Project Engineer. One of the State Materials Engineer’s sets will be forwarded to the Fabrication Inspector. The Project Engineer will send two sets to the Contractor, who will forward one set to the Fabricator. See the Shop Plans and Working Drawings Table in Construction Manual Section 1-2.4H.

If pre-approved shop plans have been submitted, a structural review by the State Bridge and Structures office is not required. The Project Engineer shall mark all changes in red on all six copies. The Project Engineer will then retain one set of plans, forward one set to the Regional Operations/Construction Engineer, two...
8-20.6B Conduit

Generally, conduit runs should be located on the outer shoulder areas, well away from the position where signs, delineators, guardrails and other facilities will be placed.

On new construction, all conduit located under paved surfaces shall be placed prior to construction of base course and pavement. It shall be the responsibility of the Project Engineer to see that all contractors on any project coordinate their work to this end.

Sufficient cover must be provided to protect the conduit from damage as provided in Standard Specifications Section 8-20.3(5).

At locations where plastic conduit is allowed and hard rock is encountered within the minimum depth required, steel conduit should be substituted for the affected runs, and the depth adjusted as necessary.

8-20.6C Junction Boxes

In most designs, precast concrete junction boxes are being used. These boxes are simple to install. A sump is excavated and partially filled with gravel. The open-bottom box is then seated by working it into the gravel until the required grade is reached. Care must be taken in junction box location to provide for drainage. Junction boxes and conduit should be placed away from areas that water is funneled to prevent it from entering into the conduits. For example, the bottom of ditches, sag vertical curves should be avoided or other low spots where water is likely to collect.

8-20.6D Wiring

An electrical system is only as good as its conductors, terminals and splices, and it is important that the requirements of Standard Specifications Section 8-20.3(8) be strictly adhered to. If there is any doubt concerning the adequacy of a connector, the advice of the Regional Electrical Inspector should be obtained.

Practically all wiring for traffic signal and illumination systems is exposed to the elements, and it is very important that all splices be insulated with waterproof material, as prescribed in Standard Specifications Section 8-20.3(8) and 9-29.12.

8-20.6E Ground

Because of the hazards of electrical shock, all grounds and ground bonds referred to in the plans and in the special provisions should be given special attention to ensure their effectiveness and completeness. See Standard Specifications Section 8-20.3(9) and Standard Plan for Typical Grounding Detail.

8-20.6F Lighting Standards, Strain Poles

In erecting lighting standards or signal standards, rope or fabric slings should be used to reduce the danger of damage to galvanized or finished aluminum surfaces.
8-20.6G Existing Illumination Systems

Where existing illumination or traffic signal systems are to be removed, and the material stockpiled at the site of the work for delivery to WSDOT, it will be advantageous if prior arrangements are made to have Department personnel meet the contractor at the delivery storage site. These arrangements should be made with either the Regional Maintenance Engineer or the Regional Traffic Engineer.

8-20.6H Service Equipment

Generally, Type “B,” “C,” “D,” and “E” service equipment, cabinets etc., will be factory assembled from drawings submitted with the material lists. Type “A” service equipment will be assembled in the field. Care shall be taken to ensure compliance with all provisions of the plans and specifications, and to determine that all bonds and grounds are complete.

8-20.6I Traffic Signal Systems

Traffic signal systems are a very specialized type of work. All work shall be done in strict accordance with the plans, the special provisions, and the Standard Specifications. The Regional Traffic Engineer will be responsible for the proper timing of each signal installation and will assist the Engineer in any way needed to ensure the proper completion of the work. The checklist (Figure 8-1) is provided to assist the Project Engineer in identifying the specific tasks that must be completed prior to signal turn-on. This checklist is a guide, and line items may be added or deleted as necessary to fit each specific signal installation.
### 9-3.7 Acceptance Sampling and Testing Frequency Guide

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<td>Crushed Coverstone</td>
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#### Crushed Screening

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#### PCC Paving

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<td>Grading</td>
<td>1 – 2000 CY</td>
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<td>Fine Aggregate See Note 7</td>
<td>Grading</td>
<td>1 – 2000 CY</td>
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<td>Combined Aggregate See Note 7</td>
<td>Grading</td>
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<tr>
<td>Air Content</td>
<td>Air</td>
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<td>Compressive Strength</td>
<td>1 – 500 CY</td>
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<td>Density</td>
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<td>Core</td>
<td>Thickness</td>
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<td>Cement See Note 5</td>
<td>Chemical &amp; Physical Certification</td>
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<td>Coarse Aggregate See Note 7</td>
<td>Grading</td>
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</tr>
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<td>Fine Aggregate See Note 7</td>
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<tr>
<td>Combined Aggregate See Note 7</td>
<td>Grading</td>
<td>1 – 1000 CY</td>
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<tr>
<td>Consistency</td>
<td>Slump</td>
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<td>Air Content</td>
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<td>1 for every 5 trucks, See Note 8</td>
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<td>Cylinders (28-day)</td>
<td>Compressive Strength</td>
<td>1 for every 5 trucks, See Note 8</td>
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<td>Cement</td>
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<td>Grouts See Note 5</td>
<td>Compressive Strength</td>
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<td>Completed Mix, See Note 3 and 4</td>
<td>Grading &amp; Asphalt Content</td>
<td>1 – 800 Ton</td>
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<td></td>
<td>Compaction</td>
<td>1 – 80 Ton</td>
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<td>Blend Sand</td>
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<td>Grading See Note 1 &amp; SE</td>
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<td>See Note 4</td>
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<td></td>
<td>Grading &amp; Asphalt</td>
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<td>Compaction, See Note 2</td>
<td>5 – Control Lot</td>
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<tr>
<th>Asphalt Materials</th>
<th>Certification</th>
<th>Note 1</th>
<th>Tests for grading will be performed only when aggregates are being produced and stockpiled for use on a future project.</th>
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<tr>
<td>Asphalt Binder (PG, Etc.)</td>
<td>Verification: 2-1 quart</td>
<td>Note 2</td>
<td>A control lot shall be a normal day’s production.</td>
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<td>Emulsion for Bituminous Surface Treatment (BST)</td>
<td>Verification: 2-1 quart</td>
<td>Note 3</td>
<td>For projects under statistical acceptance, the sampling shall be performed on a random basis and the sublot size shall be determined to provide not less than three uniform-sized sublots with a maximum sublot size of 800 tons. Should a lot contain less than three sublots, acceptance will be in accordance with nonstatistical evaluation. For projects under nonstatistical acceptance, sample frequency shall be one sample per sublot, and the sublots shall be approximately uniform in size with a maximum sublot size of 800 tons.</td>
</tr>
<tr>
<td>Emulsion for HMA Tack Coat</td>
<td>Verification: 2-1 quart</td>
<td>Note 4</td>
<td>Mix design conformation samples shall be submitted to the State Materials Laboratory Bituminous Concrete Section. For all projects, submit one sample per day from the first five days of production for each plant and one sample every fifth day of production thereafter. The conformation samples should be taken in conjunction with and be a representative quarter, of the acceptance samples taken for the project as described in WSDOT Test Method 712. If no acceptance sample is required for any day of production no conformation sample will be required either.</td>
</tr>
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<thead>
<tr>
<th>Compaction See Note 9</th>
<th></th>
<th>Note 5</th>
<th>Cement may be accepted by the engineer based on the Manufacturer’s Mill Test Report number indicating full conformance to the Specifications. The engineer has the option of taking samples at the job site for submission to the State Materials Laboratory for testing.</th>
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<td>Embankment</td>
<td></td>
<td>Note 6</td>
<td>The first sample of asphalt binder will be taken with the second Hot Mix Asphalt (HMA) mix sample. For nonstatistical HMA, take one sample for every 1,600 tons of mixture.</td>
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<tr>
<td>Cut Section</td>
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<td>The frequency for fine, course, and combined concrete aggregate samples for PCC Paving and PCC Structures shall be based on the cubic yard (CY) of concrete.</td>
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<td>Surfacing</td>
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<td>Sample the first truck, and each load until two successive loads meet specifications, and then randomly test one load for every five loads. If at any time one load fails to meet specifications, continue testing every load until two successive loads meet specifications, and then randomly test one load for every five loads.</td>
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<tr>
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<td></td>
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<td>For materials placed in a non-structural application outside the roadway prism such as slope flattening or shoulder dressing, acceptance for compaction may be based on visual inspection to the satisfaction of the engineer.</td>
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v. Wire Fence Line Posts

vi. (Coated) Fencing Materials

b. Gates and Miscellaneous fence hardware: Visual Acceptance per Section 9-1.4C.

Miscellaneous fence hardware includes such items as tie wire, hog rings, galvanized bolts, nuts, washers, fence clips, stays, post caps, tension band and bars, rail end caps, etc.

4. **Field Inspection** – Field verify per Construction Manual Section 9-1.5. Check for damage to zinc or other coating on posts, rails, hardware, etc.


6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.51 Beam Guardrail and Guardrail Anchors

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). An on-site inspection by the WSDOT Materials Fabrications Inspection Office of the fabricating facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**
   
a. W Beam and Thrie Beam Rail Elements, components and hardware shall be accepted by a Manufacturer’s Certificate of Compliance per Section 9-1.4D of this manual.

b. A307 bolts, nuts and washers shall be accepted by Visual Acceptance per Section 9-1.4C of this manual.

4. **Field Inspection** – Field verify per Section 9-1.5 of this manual:

a. W Beam and Thrie Beam Rail Elements are stamped with the same heat number displayed on the Manufacturer’s Certificate of Compliance.

b. Bolt heads are stamped 307A.
c. Components and hardware are accepted by an approved Manufacturer’s Certificate of Compliance and field verification is not required.

Check material delivered to the project for damage to galvanizing.


6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.52 Guardrail Posts and Blocks

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or *Request for Approval of Material* (WSDOT Form 350-071). An on-site inspection by the WSDOT Materials Fabrications Inspection Office of the Fabrication and Treatment Facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**
   a. **Treated Timber Posts and Blocks** – Shall be accepted by a Lumber Grading Stamp or Grading Certificate for Timber and Lumber and Certificate of Treatment.
   
   b. **Steel Post and Blocks** – Shall be accepted by a Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D.
   
   c. **Alternate Block Material** – Shall be accepted by documentation demonstrating conformance to the requirements of NCHRP Report 350.

4. **Field Inspection** – Field verify per Section 9-1.5 of this manual.
   a. Treated Timber Posts and Blocks field verified.
   
   b. Steel Posts and Steel Blocks are accepted by receipt of an approved Manufacturer’s Certification of Compliance and field verification is not required. Check Steel Post and Steel Blocks delivered to the project for damage to galvanizing.
   
   c. Alternate Block Materials must be field verified.

5. **Specification Requirements** – See *Standard Specifications* Section 9-16.3 and *Standard Plans*. 
6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.53 Miscellaneous Precast Concrete Products (Block Traffic Curb, Precast Traffic Curb)

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). An on-site inspection by the WSDOT Materials Fabrication Office of the fabricating facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**
   
a. **Precast Traffic Curb** – Visual Acceptance per *Construction Manual* Section 9-1.4C. Unless the curb sections have been inspected prior to shipping they are to be carefully inspected upon arrival on the project site. Check for surface color and damage, such as cracks, broken corner or edges, contour and alignment. Surface color and texture should match advanced sample provide by the manufacturer. See *Standard Plans* for details.

   b. **Block Traffic Curb** – Visual Acceptance per *Construction Manual* Section 9-1.4C. Check exposed faces of curb sections for damage such as chips, cracks, and air holes. See *Standard Specifications* Section 9-18.3 for details. Compressive strength may be determined in accordance with the FOP for ASTM C 805.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5.


6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.54 Prestressed Concrete Girders

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do...
not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the Fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

   The Materials Fabrication Inspector will provide a weekly Fabrication Progress Report to the Project Engineer while the girders are being fabricated.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.

5. **Specification Requirements** – See *Standard Specifications* Section 6-02.3(25), 6-05.3(3), 6-02.3(28), and Section 9-19. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

   For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.55 Pavement Marking Materials

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   **RAM Submittal** – Pavement Marking Paint and Plastic that are not listed on the QPL shall provide test data from an independent laboratory and field test documentation from northern NTPEP (National Transportation Product Evaluation Program) or test deck information conducted by other public entities may be considered provided the data is similar to a northern NTPEP Test Deck.

   Raised Pavement Markers that are not listed on the QPL shall provide a sample and test data from an independent laboratory and field test documentation from northern NTPEP (National Transportation Product Evaluation Program) or test
deck information conducted by other public entities may be considered provided the data is similar to a northern NTPEP Test Deck.

Glass Beads that are not listed in the QPL shall provide test data from an independent laboratory demonstrating compliance with *Standard Specifications* Section 9-34.4.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Visual Acceptance per *Construction Manual* Section 9-1.4C.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. A visual inspection shall be made to ensure that cracked or damaged lane markers are not incorporated in the work.

5. **Specification Requirements** – See *Standard Specifications* Section 9-21 and 9-34. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – There may be special shipping requirements for epoxy and adhesive. These samples shall be transported to the Region Materials Laboratory for proper shipping.

### 9-4.56 Signing Materials and Mounting Hardware

1. **Approval of Material** – Approval of the Sign Fabricator as well as the manufacturer of the sign blanks, panels and the reflective sheeting is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

   A RAM will not be required for sign mounting hardware provided by the Sign Fabricator. Mounting hardware from a source other than the sign fabrication facility will require approval by Request for Approval of Material (WSDOT Form 350-071). Provide the Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material may be required only if coded on the Request for Approval of Material (WSDOT Form 350-071), or as requested by the Sign Fabricator Inspector.

3. **Acceptance**
   
   a. **Sign** – Acceptance is based on a “FABRICATION APPROVED” Decal (Figure 9-8).
b. **Sign Mounting Hardware** – Hardware supplied by the Sign Fabricator will have the mounting hardware certifications verified at the sign fabricator’s facility by the Materials Fabrication Inspector to ensure the materials meet the contract requirements. These records will be kept at the sign fabrication facility. Fabrication inspectors will verify sign mounting hardware as it is packaged for shipment and stamp it “WSDOT INSPECTED” (Figure 9-3). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

Contractor’s who purchase sign mounting hardware separately from a source other than a WSDOT approved sign fabrication facility will be required to supply a Manufacturer’s Certificates of Compliance per Section 9-1.4D and it will be the responsibility of the Contractor to supply the certifications to the Project Engineer’s Office prior to use.

c. **Bolts for Roadside Wood Posts** – Acceptance for A307 bolts, nuts and washers shall be by Visual Acceptance per *Construction Manual* Section 9-1.4C.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5 that bolt heads are stamped 307A. Check for a “WSDOT INSPECTED” Stamp to the sealed hardware package (Figure 9-3), Document the “F” or “D.” Check for “FABRICATION APPROVED” Decal (Figure 9-8) on the back of the sign and document in Inspector’s Daily Report. Double-faced signs, which do not receive decals, will be approved on visual inspection at the fabricator’s facility and in the field. A list/invoice of all inspected and accepted signs will be kept in the WSDOT Materials Fabrication Inspection Office files. Check that all overhead signs are mounted with stainless steel bolts, u-bolts, washers, nuts, locknuts, mounting brackets and straps. Mounting hardware shall include bolts, nuts, washers, locknuts, rivets, post clips, windbeams, angles, “Z” bar, straps and mounting brackets.

If there is not a Decal present, inform the Contractor that the item is not acceptable and contact the WSDOT Materials Fabrication Inspection Office to determine the status of the inspection. Items lacking Decals or Stamps, or which are damaged during shipping, should be rejected and that material tagged or marked appropriately.


6. **Other Requirements**

a. **Materials Fabrication Inspected CMO** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
b. Non-Fabrication Inspected CMO – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.57 Liquid Concrete Curing Compound

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – If the lot is listed on the QPL, it may be used without testing on current projects per Construction Manual Section 9-1.4A(1). If the lot is not on the QPL, submit a one-quart sample taken by, or in the presence of, an agency representative for each lot. Samples must be submitted for testing 10 days prior to use of curing compound. Samples submitted shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5.


6. Other Requirements – None.

9-4.58 Admixtures for Concrete

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – Materials shall be accepted on the basis of a Certified Concrete Delivery Ticket indicating the product and dosage of the admixture conform to the concrete mix design.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5.


6. Other Requirements – Check Concrete Delivery Ticket for proper admixture dosage.
9-4.59 **Plastic Waterstop**

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Material shall be accepted by a Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5.


6. **Other Requirements** – None.

9-4.60 **Epoxy Systems**

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**

   a. **Epoxy Bonding Agents** – Materials shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory. For epoxy bonding agents, submit mix ratios, intended use and a representative sample of each component with MSDS sheet for each batch or lot number. Samples shall be submitted to the State Materials Laboratory. A period of 21 calendar days should be allowed for testing.

      **Sample** – A representative sample shall be a minimum of a 1 pint container of each component or a pre-packaged kit. The sample size shall represent the mixing ratio, (for example; 1 pint of a and 2 pints of B, or 1 pint a and 3 pints of B). Containers shall be identified as “Component A” (Epoxy Resin) and “Component B” (Curing Agent) and shall be marked with the name of the manufacturer, the date of manufacture and the lot number.

   b. **Epoxy Grout/Mortar/Concrete** – Materials shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory. For epoxy grout/mortar/concrete, submit mix ratios, intended use and a representative
sample of each component for each batch or lot number. Samples shall be submitted to the State Materials Laboratory. A period of 15 working days should be allowed for testing.

**Sample** – A representative sample shall be a minimum of a 1 pint container of each component or a pre-packaged kit. The sample size shall represent the mixing ratio, (for example; 1 pint of a and 2 pints of B, or 1 pint a and 3 pints of B). Containers shall be identified as “Component A” (Epoxy Resin), “Component B” (Curing Agent), and “Aggregate Component” and shall be marked with the name of the manufacturer, the date of manufacture and the lot number.

Acceptance for aggregate for non-Prepackaged Epoxy Grout/Mortar/Concrete shall be by the Certificate of Compliance per *Construction Manual* Section 9-1.4E.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for uniformity of color and conformance to required mix proportions. Streaking is an indication of inadequate mixing. Check for set and hardness with your thumbnail. You should not be able to dent the properly mixed and cured material. Epoxies shall be mixed and applied in conformance to manufacturer’s written instructions unless otherwise modified in writing by the manufacturer’s agent.


6. **Other Requirements**
   - Type IV epoxy bonding agent may be substituted for and be tested to the same criteria as Type I when used in the application identified in *Standard Specifications* Sections 5-01.3(6) and 5-05.3(10). Ensure that the transmittal states the *Standard Specifications* for which the material is being tested for.
   - Aggregate for non-Prepackaged Epoxy Grout/Mortar/Concrete shall meet the requirements of *Standard Specifications* Section 9-03.1(2).
   - There may be special shipping requirements for epoxy. These samples shall be transported to the Region Materials Laboratory for proper shipping.

### 9-4.61 Resin Bonded Anchors

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   **RAM Submittal** – If approval is being requested by the Request for Approval of Material process, submit independent laboratory test report indicating resin bonded anchor system, for the specified size rods, meets specification requirements when tested in accordance with ASTM E 488.
2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**
   a. **Resin adhesive** – Acceptance shall be by Visual Acceptance per *Construction Manual* Section 9-1.4C.
   b. **Threaded Rod, Nut, and Washer or Other Inserts** – Acceptance shall be by the Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for proper embedment depths. Check that holes are properly cleaned. Check that the installation is in accordance with the manufacturers written instructions.

5. **Specification Requirements** – Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements**
   - For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
   - There may be special shipping requirements for resin adhesive. These samples shall be transported to the Region Materials Laboratory for proper shipping.

### 9-4.62 Gabion Cribbing, Hardware, and Stone

1. **Approval of Material**

   **Gabion Cribbing and Hardware** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   **Stone** – Approval of materials is required prior to use. Materials will be approved by Request for Approval of Material (WSDOT Form 350-071). Consult the Aggregate Source Approval (ASA) database for sources with degradation factor of a minimum of 30.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**

   **Gabion Cribbing and Hardware** – Acceptance shall be by the Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D.

   **Stone** – Visual Acceptance per *Construction Manual* Section 9-1.4C.
4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5.

5. **Specification Requirements** – See *Standard Specifications* Section 9-27.3. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.63 Steel Sign Structures – Cantilever, Sign Bridge, Bridge Mounted, Roadside

1. **Approval of Material** – Approval of the fabricator is required prior to the start of fabrication. The fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – The fabricated sign structure and associated hardware will be accepted on the basis of an “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

   a. **Sign Structure – Cantilever, Sign Bridge, Bridge Mounted, and Roadside**

      **Type PLT/PLU** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

      **Note:** The Materials Fabrication Inspector will inspect hardware if it is available at the time of inspection at the point of manufacture. Acceptance for Roadside Sign Structure Hardware not present during Materials Fabrication inspection and delivered to the job site without an approval stamp shall be by the Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D. High strength bolts, nuts and washers in quantities over 50 require sampling.

   b. **Roadside – Except Type PLT and PLU** – Acceptance for Roadside sign structures except for Types PLT and PLU shall be by the Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D.
4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) on the sign structure and associated hardware. Check for and the “F” or “D” indicator Stamp for foreign or domestic steel and document it.


6. **Other Requirements**

   a. **Materials Fabrication Inspected CMO** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

      For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

   b. **Non-Fabrication Inspected CMO** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

**9-4.64 Conduit**

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   **RAM Submittal** – Attach Catalog Cuts using the Catalog Cut Transmittal (WSDOT Form 350-072) to assist in the approval process.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Visual Acceptance per *Construction Manual* Section 9-1.4C is required for Rigid Galvanized Steel, Aluminum, PVC, PE, HDPE, Fiberglass, and Flexible Metal Conduit including hardware such as (fittings, couplings, spacers, adapters, split internal expansion plugs, duct plugs, connectors, clamps, conduit bodies, and conduit supports), Expansion Fittings, Deflection Fittings, Combination Deflection and Expansion Fittings.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “Nationally Recognized Testing Laboratories” (NRTL) approval labels. Check for damage to coatings caused by shipping and handling, and see that damaged areas and field cut threads are protected with an approved coating.
5. **Specification Requirements** – See *Standard Specifications* Section 9-29.1. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.65 Electrical Conductors and Fiber Optic Cable

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**
   
a. **Single/Multiple Conductors**
   
i. **QPL Acceptance** – Visual Acceptance per *Construction Manual* Section 9-1.4C.

   ii. **Non-QPL Acceptance** – Materials shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory. A sample shall be a length of wire that shall include the complete printed/stamped designation: manufacturer, size, and insulation type.

   b. **Fiber Optic Cable** – Materials shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory. A sample of the Fiber Optic cables shall be a length of cable (minimum 2 feet) that shall include the complete printed/stamped designation: manufacturer, size, and fiber count.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. A visual inspection shall be made to ensure that no conductors with damaged insulation are incorporated into the project.

5. **Specification Requirements** – See *Standard Specifications* Section 9-29.3. Review Contract Documents to determine if supplemental requirements apply.

6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for “aluminum cable steel reinforced” (ACSR) or other steel and iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.66 Steel Poles – ITS, Pedestrian, Light, Signal Standards, and High Mast Light Poles

1. Approval of Material – Approval of the fabricator is required prior to the start of fabrication. The fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance
   a. Steel Light and Signal Standards Type II – V, ITS, and High Mast Light Poles – As determined by the Materials Fabrications Inspection Office, Steel Light, Signal Standards and High Mast Light Poles may be inspected at the point of manufacture prior to shipping or at the jobsite by the Materials Fabrication Inspector. Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

   Steel Light, Signal Standards and High Mast Light Poles delivered to the job site without “APPROVED FOR SHIPMENT” stamps and/or tags require Materials Fabrication Inspection. Contact the WSDOT Materials Fabrication Inspection Office for inspection. Provide the Materials Fabrication Inspector the following documentation for their review prior to their physical inspection of the Steel Light, Signal Standards and High Mast Light Poles.
   - Approved shop drawings not listed in Contract General Special Provisions.
   - Manufacturer’s Certificate of Compliance for all steel and associated hardware.
   - Nondestructive test reports generated by the fabricator for inspection of welds.

   Note: The Materials Fabrication Inspector will inspect hardware if it is available at the time of inspection at the point of manufacture or at the jobsite. Hardware not present during Materials Fabrication inspection and delivered to the job site without an approval stamp may be accepted by the project office based on Manufacturer’s Certificate of Compliance with supporting material certifications and Certificate of Material Origin. When high strength bolting materials are received on the job site without Fabrications Inspection Stamp, acceptance shall be by the Manufacturer’s Certificate of Compliance per Construction Manual Section 9-1.4D for each heat number or manufacturing
lot. Acceptance shall also be by a “Satisfactory” test report from the State Materials Laboratory, when samples are required, for each consignment lot as defined by Standard Specifications Section 9-06.5(3). A separate transmittal and materials certification shall accompany each sample of bolts, nuts, and washers.

b. Standards Type Pedestrian Push Button, Pedestrian Signal, Type I, Ramp Meter & Flashing Beacon – Acceptance shall be by the Manufacturer’s Certificate of Compliance with supporting Mill Certification per Construction Manual Section 9-1.4D and:

- Approved shop drawings not listed in Contract General Special Provisions.
- Manufacturer’s Certificate of Compliance for all steel and associated hardware.
- Nondestructive test reports generated by the Fabricator for inspection of welds.

High strength bolting materials acceptance shall be by the Manufacturer’s Certificate of Compliance per Construction Manual Section 9-1.4D for each heat number or manufacturing lot. Acceptance shall also be by a “Satisfactory” test report from the State Materials Laboratory, when samples are required, for each consignment lot as defined by Standard Specifications Section 9-06.5(3). A separate transmittal and materials certification shall accompany each sample of bolts, nuts, and washers.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Contact WSDOT Materials Fabrication Inspection Office for inspection of Light and Signal Poles delivered to the jobsite without “APPROVED FOR SHIPMENT” Tag and/or Stamp.

5. Specification Requirements – See Standard Specifications Sections 9-06.5(3) and 9-29.6. Review contract documents to determine if supplemental specifications apply.

6. Other Requirements

a. Materials Fabrication Inspected CMO – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in Construction Manual Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

b. Non-Fabrication Inspected CMO – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.67 Vacant

9-4.68 Luminaires, Lamps, and Light Emitting Diodes (LED)

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   RAM Submittal – Luminaires and Lamps – Attach Catalog Cuts using the Catalog Cut Transmittal (WSDOT Form 350-072) to assist in the approval process.

   LED – Submit Independent Test Report verifying compliance with the Contract Document requirements along with Catalog Cuts using the Catalog Cut Transmittal (WSDOT Form 350-072) to assist in the approval process.

2. Preliminary Samples – Preliminary samples will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – Visual Acceptance per Construction Manual Section 9-1.4C.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5.
   a. Luminaires – A visual inspection shall be made to ensure damaged equipment is not installed and that luminaires are mounted level. Confirm the socket position is the same as that noted on the catalog cut.
   b. Lamps for Luminaires – Check that all lamps are of the proper wattage, see contract documents.
   c. LEDs for Signal Heads – Check that LEDs are as specified, see contract documents.


6. Other Requirements – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.69 Water Distribution System

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   RAM Submittal – Attach Catalog Cuts using the Catalog Cut Transmittal (WSDOT Form 350-072) to assist in the approval process.
2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance
   a. QPL Acceptance
      i. Ductile Iron Pipe and Fittings, PVC Pipe and Fittings, Restrained Joints, Restrained Flexible Couplings, Gate Valves (3-inches to 16-inches), Butterfly Valves, Saddles, Corporation Stops – Visual Acceptance per Construction Manual Section 9-1.4C.
      ii. Copper Tubing and Polyethylene Tubing – Manufacturer’s Certificate of Compliance per Construction Manual Section 9-1.4D.

   b. Non-QPL Acceptance
      i. Ductile Iron Pipe, Steel Pipe, Polyvinyl Chloride (PVC) Pipe, Polyethylene (PE) Pressure Pipe, Polyethylene Encasement – Manufacturer’s Certificate of Compliance per Construction Manual Section 9-1.4D.
      ii. Fittings for Ductile Iron, Steel, PVC, and PE Pipe. Restrained Joints, Bolted Sleeve-type Couplings for Plain End Pipe, Restrained Flexible Couplings, Grooved and Shoulder Joints, Fabricated Mechanical Slip-type Expansion Joints, Gate Valves (3-inches to 16-inches), Butterfly Valves, Valve Stem Extensions, Combination Air Release/Vacuum Valves, Tapping Sleeve and Valve Assemblies, Hydrants, End Connections, Hydrant Extensions, Hydrant Restraints, Traffic Flanges, Saddles, Corporation Stops, Copper Tubing, Polyethylene Tubing, Service Fittings, Meter Setters, Bronze Nipples and Fittings, and Meter Boxes – Catalog Cut per Construction Manual Section 9-1.4G.
      iii. Valve Boxes, Valve Marker Posts, and Guard Posts – Visual Acceptance per Construction Manual Section 9-1.4C.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5. Check material delivered to the project for damage to the galvanized coatings caused by shipping and handling and conformance to the contract documents. See that damaged areas and field cut threads are protected with an approved galvanized repair paint formula, standard formula A-9-73.


6. Other Requirements
   a. Water distribution pipe requires testing after installation in conformance with the Standard Specifications Section 7-09.
b. For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.70 Elastomeric Bearing Pads

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance shall be by a Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D accompanied by a certified test report identifying the specific batch of material and demonstrating conformance to AASHTO M251.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Make certain that material to be used is from the certified batch.


6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.71 Bridge Bearings – Cylindrical, Disc, Fabric Pad, Pin, Spherical

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – As determined by the WSDOT Materials Fabrication Inspection Office, Bridge Bearings may be inspected at the point of manufacture prior to shipping or at the jobsite by the Materials Fabrication Inspector. Contract Provision
may provide for job site inspection of the Bridge Bearings by the engineer. Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

Bridge Bearings delivered to the job site without “APPROVED FOR SHIPMENT” stamps and/or tags require Materials Fabrication Inspection. Contact the WSDOT Materials Fabrication Inspection Office for inspection and required documentation needed prior to their physical inspection of the Bridge Bearing.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Contact WSDOT Materials Fabrication Inspection Office for inspection of Bridge Bearings delivered to the jobsite without “APPROVED FOR SHIPMENT” Tag and/or Stamp.

5. Specification Requirements – Bearings specifications are currently defined in General Special Provisions and Bridge Special Provisions. Review the contract documents to determine the specification requirements.

6. Other Requirements – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in Construction Manual Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.72 Precast Concrete Barrier

1. Approval of Material – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – Acceptance is based on “WSDOT INSPECTED” Stamp (Figure 9-3). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.
The “WSDOT INSPECTED” stamp on barrier will include the connecting pins, which will be inspected at the barrier fabricator’s facility.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “WSDOT INSPECTED” Stamp (Figure 9-3) and the “F” or “D” Stamp for foreign or domestic steel and document it.

5. **Specification Requirements** – See *Standard Specifications* Section 6-10. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

   For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.73 Vacant

### 9-4.74 Metal Bridge Rail

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Tag or Stamp and the “F” or “D” Stamp for foreign or domestic steel and document it.

5. **Specification Requirements** – See *Standard Specifications* Sections 6-06.3(2) and 9-06.18. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.
For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.75 Construction Geosynthetics

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   RAM Approval – Submittal requirements for geogrid and geotextile products proposed for use in permanent geosynthetic retaining walls or reinforced slopes, refer to Standard Specifications Section 9-33.4(1).

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance

   a. Underground Drainage

   i. Less than 100 SY – Acceptance shall be by the Manufacturer’s Certificate of Compliance per Construction Manual Section 9-1.4D.

   ii. 100 SY and greater – Materials shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory.

   b. Temporary or Permanent Geosynthetic Retaining Walls and Reinforced Slopes – Materials shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory.

   c. Soil Stabilization and Separation, Permanent Erosion Control, and Prefabricated Drainage Mat – Acceptance shall be by the Manufacturer’s Certificate of Compliance per Construction Manual Section 9-1.4D.

   d. Temporary Erosion Control Materials – Visual Acceptance per Construction Manual Section 9-1.4C.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5. Check each roll of geotextile fabric for proper identification as shown on either the Manufacturer’s Certificate of Compliance or on the State Materials Laboratory test report.


6. Other Requirements – If seams are sewn in the field, refer to 9-33.4(5) for sampling and testing requirements.
9-4.76 Concrete

1. **Approval of Material** – Approval of all materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   **Cement** – See *Construction Manual* Section 9-4.1.

   **Concrete Aggregate** – See *Construction Manual* Section 9-4.4.

   **Admixtures for Concrete** – See *Construction Manual* Section 9-4.58.

   **Water** – See *Construction Manual* Section 9-4.77.

Submittal and approval of the Concrete Mix Design shall be per *Standard Specifications* Sections 6-02.3(2) and 9-03.1(1) and *Construction Manual* Section 6-2.1A. Contractor must submit a concrete mix design on WSDOT Form 350-040. All concrete except commercial and Lean Concrete must come from a pre-qualified Batch Plant.

For mix designs proposed for cement concrete pavement the contractor is required to submit flexural and compressive strength test results in accordance with *Standard Specifications* Section 5-05 as part of the concrete mix design.

*Note:* If the Aggregate Source Approval (ASA) database Tracking System requires Alkali Silica Reactivity (ASR) mitigation, the concrete mix design submittal may include the use of either a low alkali cement (per *Standard Specifications* Section 9-01.3(3)) or fly ash (*Standard Specifications* Section 9-23.9) as approved by the engineer. The contractor shall provide test results for ASTM C 1567 showing the mitigating measures are effective (see *Standard Specifications* Section 9-03). Contact the State Materials Laboratory Construction Materials Engineer or the State Bridge Construction Engineer if the contractor is proposing to use other mitigating measures.

2. **Preliminary Samples** – Not required.

3. **Acceptance**

   a. **Prepackaged Concrete** – Visual Acceptance per *Construction Manual* Section 9-1.4C that all bags are labeled meeting the requirements of ASTM C387.

   b. **Controlled Density Fill (CDF)** – Check Concrete Delivery Ticket to verify the mix provide is in accordance with the approved Mix Design.

   c. **Commercial and Lean Concrete** – Is accepted based on a Certificate of Compliance to be provided by the supplier as described in *Standard Specifications* Section 6-02.3(5)B.

   d. **Cement Concrete Pavement** – Compressive Strength shall be accepted on receipt of “Satisfactory” test reports. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents,
and Construction Manual Sections 9-3 and 9-7. Air Content will be tested at the time of placement and documented on the Concrete Delivery Ticket. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents, and this chapter.

e. **Structural Concrete** – Compressive Strength shall be accepted on receipt of “Satisfactory” test reports. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents, and Construction Manual Sections 9-3 and 9-7. Slump, Air Content and Temperature will be tested at the time of placement and documented on the Concrete Delivery Ticket. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents, and this chapter.

4. **Field Inspection** – Field verify per Construction Manual Section 9-1.5. Check Concrete Delivery Ticket to verify the concrete provide conforms to the approved concrete Mix Design.

5. **Specification Requirements** – See Standard Specifications Section 2-09.3(1)E, 9-03.1, 5-05, and 6-02.

6. **Other Requirements** – None.

### 9-4.77 Water for Concrete

1. **Approval of Material** – Not required.

2. **Preliminary Samples** – Not required.

3. **Acceptance** – Acceptance is based on test results provided by the contractor. If the Contractor is using potable water that is clear and apparently clean, then no testing is required.

   a. **Physical Requirements** – Testing will be conducted on a weekly interval for the first four weeks and thereafter on monthly interval.

   b. **Chemical Requirements** – Testing will be conducted on a monthly interval.

4. **Field Inspection** – Field verify per Construction Manual Section 9-1.5.


6. **Other Requirements** – None.

### 9-4.78 Expansion Joints

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.
Chapter 9

9-4.79 Traffic Signal Controller Assembly

1. Approval of Material

Signal Controller Assembly – Approval of the Signal Controller Assembly Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.
**Signal Controller Assembly “Pluggable” Components** – The Project Engineer is responsible for obtaining the approval of traffic signal control equipment prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

**RAM Submittal** – Attach Catalog Cuts for components using the Catalog Cut Transmittal (WSDOT Form 350-072) and fully dimensioned Shop Drawings to assist in the approval process.

2. **Preliminary Samples** – A preliminary sample of the individual components will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**
   a. **Traffic Signal Controllers** – Shall be accepted on receipt of “Satisfactory” test reports. A “Satisfactory” test report is defined as acceptable performance in the following tests:
      - WSDOT Test Method 421, Traffic Controller Inspection and Test Procedure
      - WSDOT Test Method 422, Transient Voltage Test (Spike Test) Procedure (Optional)
      - WSDOT Test Method 423, Conflict Monitor Testing
      - WSDOT Test Method 424, Power Interruption Test Procedure (Only for Type 170 and NEMA Controllers)
      - WSDOT Test Method 425, Environmental Chamber Test
      - WSDOT SOP 429, Method for Determining the Acceptability of Traffic Signal Controller Assembly
      - WSDOT Test Method T427, Loop Amplifier Test (Optional)
      - WSDOT Test Method T428, Compliance Inspection and Test Procedure
   b. **Signal Controller Assembly “Pluggable” Components** – Visual Acceptance per Construction Manual Section 9-1.4C. Document functionality of the “pluggable” component at the start up by the Region Traffic Signal Inspector.

4. **Field Inspection** – Field verify per Construction Manual Section 9-1.5. Verify the controller cabinet assembly received on the job site, has satisfactory test report.


6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.80 Miscellaneous Temporary Erosion and Sediment Control Items

1. Approval of Material – Approval of materials prior to use is required for Geosynthetic for Silt Fence, Compost Socks, Coir Logs, PAM, erosion control blankets and wattles. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   RAM Submittal – Attach Catalog Cuts using the Catalog Cut Transmittal (WSDOT Form 350-072) to assist in the approval process for Compost Socks, Coir Logs, PAM, erosion control blankets and wattles.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – Acceptance for all temporary erosion and sediment control items shall be by Visual Acceptance per Construction Manual Section 9-1.4C.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5.


6. Other Requirements – None.

9-4.81 Concrete Patching Material, Grout and Mortar

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   RAM Submittal – If the product is not listed on the QPL, submit test data from an accredited independent laboratory confirming that the concrete patching material, grout or mortar meets Standard Specifications Section 9-20.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance

   a. Concrete Patching Materials – Concrete Patching materials shall be accepted on receipt of “Satisfactory” tests report for air content and compressive strength performed once per shift. The Contractor must submit a mix design meeting the requirements of Standard Specifications Section 9-20 for the concrete patching material.
b. **Grout**

i. **Grout Type 1** – Materials shall be accepted by Visual Acceptance per *Construction Manual* Section 9-1.4C to verify that the grout has achieved initial set, is less than 6 months old from date of manufacturer and that the water cement ratio is 0.45 or less. Initial set shall be determined by making 3 grout cubes per WSDOT TM 813 and documenting that the grout has set in a reasonable amount of time. Afterwards, the cubes may be discarded.

ii. **Grout Type 2** – Materials shall be accepted by receipt of “Satisfactory” test report for compressive strength, testing to be performed once per bridge pier or 1 per day. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents and *Construction Manual* Sections 9-3 and 9-7.

iii. **Grout Type 3** – Materials shall be accepted by receipt of “Satisfactory” test report for compressive strength, testing to be performed once per bridge pier or 1 per day, and shall be by the Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D to verify ASTM C 157 and ASTM C 882 requirements. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents and *Construction Manual* Sections 9-3 and 9-7.

iv. **Grout Type 4**

- **Structural Applications** – Materials shall be accepted by receipt of “Satisfactory” test report for compressive strength, testing to be performed once per day, and shall be by Visual Acceptance per *Construction Manual* Section 9-1.4C for conformance to the mix design. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents and *Construction Manual* Sections 9-3 and 9-7.

- **Soils Nails and Ground Anchors** – Acceptance shall be by Visual Acceptance per Section 9-1.4C of this manual for conformance to the mix design. Samples of the grout shall be obtained once per day in accordance with the contract documents and Section 9-7 of this manual. These samples shall be retained until all associated verification, performance, and proof testing of the soil nails or ground anchors has been successfully completed.

- **Nonstructural Applications** – Acceptance for column jacket pour back or bridge or retaining wall shaft CSL access tube pour back will be by Visual Acceptance per *Construction Manual* Section 9-1.4C for conformance to the mix design.
Materials

Chapter 9

9-4.82 Streambed Aggregates

1. Approval of Material – Approval of materials is required prior to use. Consult the Aggregate Source Approval (ASA) database for approval status of the material for each source.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071). If the ASA database indicated that the aggregate source has expired, or will expire before the end of the project, a source evaluation may be required. Contact the Regional materials office for further direction. If samples are required, the Regional materials office will coordinate with the ASA engineer to obtain the necessary samples according to SOP 128.

3. Acceptance
   a. Streambed Sediment – Materials shall be accepted on receipt of “Satisfactory” test report. Acceptance samples shall be obtained, tested, and recorded in accordance with the contract documents, and Construction Manual Sections 9-3 and 9-7.
b. **Streambed Cobbles, Streambed Boulders and Habitat Boulders** – Visual Acceptance per *Construction Manual* Section 9-1.4C. Approximate size can be determined per *Standard Specifications* Section 9-03.11.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Ensure that the gradation for streambed sediment remains constant.

5. **Specification Requirements** – See *Standard Specifications* Section 9-03.11. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – None.

### 9-4.83 Temporary Traffic Control Materials

1. **Approval of Materials and Systems** – Approval of materials prior to use is required for:

   a. **Truck and Trailer Mounted Attenuators** – Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   **RAM submittal** – The contractor shall provide certification that the unit complies with NCHRP 350 Test Level 3 requirements.

   b. **Portable Temporary Traffic Control Signal** – Material will be approved per *Standard Specifications* Section 1-10.3(3)K.

   c. **Pavement Markings** – Refer to *Construction Manual* Section 9-4.55.

   Prior approval is not required for:

   - Barricades
   - Barrier Drums
   - Construction Signs
   - Portable Changeable Message Signs
   - Sequential Arrow Signs
   - Sign Covering
   - Stop/Slow Paddles
   - Tall Channelizing Devices
   - Traffic Cones
   - Traffic Safety Drums
   - Tubular Markers
   - Warning Lights and Flashers
   - Wood Sign Posts

2. **Preliminary Samples** – No preliminary sample required.

3. **Acceptance**

   a. **Stop/Slow Paddles, Wood Sign Supports, Sign Covering** – Visual Acceptance per *Construction Manual* Section 9-1.4C to ensure good condition and conformance to the appropriate *Standard Specifications*. 

b. **Construction Signs, Sequential Arrow Signs, Portable Changeable Message Signs, Barricades, Traffic Safety Drums, Barrier Drums, Traffic Cones, Tubular Markers, Warning Lights and Flashers, Tall Channelizing Devices** – Visual Acceptance per *Construction Manual* Section 9-1.4C to ensure the signs and traffic control devices are acceptable or marginal as defined in *Quality Guidelines for Temporary Traffic Control Device* and conform to the appropriate *Standard Specifications*.

c. **Portable Temporary Traffic Control Signal** – Visual Acceptance per *Construction Manual* Section 9-1.4C. All Portable Temporary Traffic Control Signals must be accepted prior to use. Inspect all Portable Temporary Traffic Control Signals to ensure good condition, functionality and conformance to the appropriate *Standard Specifications*.

d. **Truck and Trailer Mounted Attenuator (TMA)** – Visual Acceptance per *Construction Manual* Section 9-1.4C. All Truck and Trailer Mounted Attenuators shall be selected from the approved manufacturers and models listed in the QPL and inspected for condition, reflectivity and conformance to the appropriate *Standard Specifications*.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Field verify all temporary traffic controls devices to ensure good working order, cleanliness, and appropriate reflectivity.

5. **Specification Requirements** – See *Standard Specifications* Sections 1-10, 8-21.3(3), and 9-35. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – None.

### 9-4.84 Modular Expansion Joint

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – Preliminary samples of the material will be required by the contract provisions or if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – As determined by the WSDOT Materials Fabrication Inspection Office, Modular Expansion Joints may be inspected at the point of manufacture prior to shipping or at the jobsite by the Materials Fabrication Inspector. Contract Provision may provide for job site inspection of the Modular Expansion Joints by
the engineer. Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

Modular Expansion Joints delivered to the job site without “APPROVED FOR SHIPMENT” stamps and/or tags require Materials Fabrication Inspection. Contact the WSDOT Materials Fabrication Inspection Office for inspection and required documentation needed prior to their physical inspection of the Modular Expansion Joints.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it.

5. **Specification Requirements** – Modular Expansion Joints specifications are currently specified in General Special Provisions. Review the contract documents to determine the specification requirements.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.85 Junction Boxes, Cable Vaults, and Pull Boxes

1. **Approval of Material**

   **Fabrication Inspection items** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

   **Note:** Approved design/shop drawings are available online at www.wsdot.wa.gov/design/traffic/shop-drawings.htm. Online drawings represent fabricators designs that have passed initial proof load testing for design approval. The Online drawings maintained by the WSDOT Traffic Design Office are used to inspect Junction Boxes, Cable Vaults and Pull Boxes.

   **Non-Fabrication Inspection Items** – Approval of the Surface/Barrier Mounted Junction Boxes are required prior to use. The Surface/Barrier Mounted Junction Boxes will be approved by the *Qualified Products List* or Request for Approval
of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

**RAM Submittal** – Attach Catalog Cuts using the Catalog Cut Transmittal (WSDOT Form 350-072) and/or Shop Drawing to the State Materials Laboratory to assist in the approval process.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance**
   a. **Type 1, 2, and 8 Junction Boxes**
      - **Concrete** – Acceptance is based on “WSDOT INSPECTED” Stamp (Figure 9-3). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.
      - **Non-Concrete** – Acceptance shall be by the Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D including an Independent Test Report from a Nationally Recognized Testing Laboratory.
   b. **Type 4, 5, and 6 Junction Boxes** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.
   c. **Cable Vaults and Pull Boxes** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.
   d. **Surface/Barrier Mounted Junction Boxes** – Visual Acceptance per *Construction Manual* Section 9-1.4C.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for appropriate “WSDOT INSPECTED (Figure 9-3) or “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it.

5. **Specification Requirements** – See *Standard Specifications* Section 9-29.2. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements**
   a. **Materials Fabrication Inspected CMO** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
b. **Non-Fabrication Inspected CMO** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

### 9-4.86 Precast Bridge Deck Panels, Floor Panels, Marine Pier Deck Panels, Noise Barrier Walls, Pier Caps, Retaining Walls, Roof Panels, Structural Earth Walls, Wall Panels, and Wall Stem Panels

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. **Field Inspection** – Field verify per Construction Manual Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.

5. **Specification Requirements** – See Standard Specifications Section 6-02.3(25), 6-02.3(28), 6-11, 6-12, and 6-13. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in Construction Manual Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.87 Precast Reinforced Concrete Three Sided Structures

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. **Field Inspection** – Field verify per Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.

5. **Specification Requirements** – Review the contract documents to determine the specification requirements.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in Construction Manual Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.88 Precast Concrete Vaults (Utility, Drainage, etc.) and Box Culverts

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.
2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.

5. **Specification Requirements** – Review the contract documents to determine the specification requirements.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

   For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

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### 9-4.89 Miscellaneous Metal Drainage Items (Frame and Grate for Grate Inlet and Drop Inlet, Flow Restrictors, Oil Separators, Safety Bars)

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.
5. **Specification Requirements** – See *Standard Specifications* Section 9-05.16. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

   For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

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### 9-4.90 Miscellaneous Steel Structures (Cattle Guards, Handrail, Retrofit Guardrail Posts With Welded Base Plate, Seismic Retrofit Earthquake Restrainers, Column Jackets)

1. **Approval of Material** – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.

5. **Specification Requirements** – See *Standard Specifications* Section 6-03. Review contract documents to determine if supplemental specifications apply.

6. **Other Requirements** – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

   For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.91 Miscellaneous Welded Structural Steel

1. Approval of Material – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.


6. Other Requirements – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in Construction Manual Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.92 Wood Bridges

1. Approval of Material – Approval of the Fabricator is required prior to the start of fabrication. The Fabricator will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification. Materials used within the fabricated item do not require approval through the Project Engineer office. Provide the WSDOT Materials Fabrication Inspection Office with a copy of the Qualified Products Page or Request for Approval of Material listing the Fabricator. Review of the Contract Special Provisions is necessary to determine if special qualifications or testing is required for approval of the fabricator.
2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance is based on “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5). An “F” or “D” will be stamped to indicate the steel or iron is of foreign or domestic origin.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Check for “APPROVED FOR SHIPMENT” Stamp and/or Tag (Figure 9-4 or 9-5) and the “F” or “D” Stamp for foreign or domestic steel and document it. Check for damage caused by shipping and handling.

5. **Specification Requirements** – Review contract documents to determine the specification requirements.

6. **Other Requirements** – Certificate of Material Origin for steel components will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

   For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

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**9-4.93 Electrical Service Cabinets**

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

   **RAM Submittal** – Attach Catalog Cuts for components using the Catalog Cut Transmittal (WSDOT Form 350-072) and fully dimensioned Shop Drawings to assist in the approval process.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance shall be by a Manufacture’s Quality Check List included with the cabinet and signed by the Region Electrical Inspector.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Verify the Electrical Service Cabinet assembly received on the job site, has a Manufacture’s Quality Check List.


6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.94 Monument Case, Cover, and Riser

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). An on-site inspection of the fabricating facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – Acceptance shall be by the Manufacturer’s Certificate of Compliance with supporting Mill Certification per Construction Manual Section 9-1.4D.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5.


6. Other Requirements – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.95 Steel Bollards

1. Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). An on-site inspection of the WSDOT Materials Fabrication Office of the fabricating facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance – Acceptance shall be by the Manufacturer’s Certificate of Compliance with supporting Mill Certification per Construction Manual Section 9-1.4D.

4. Field Inspection – Field verify per Construction Manual Section 9-1.5.

5. Specification Requirements – Review contract documents to determine the specification requirements.

6. Other Requirements – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.96 Metal Trash Racks and Debris Cages

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). An on-site inspection by the WSDOT Materials Fabrication Office of the fabricating facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance shall be by the Certificate of Compliance per *Construction Manual* Section 9-1.4E.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Field Verify that hardware included is per the Contract Specifications and Plan.

5. **Specification Requirements** – Review contract documents to determine the specification requirements.

6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.

9-4.97 Flow Restrictors and Oil Separators

1. **Approval of Material** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). An on-site inspection by the WSDOT Materials Fabrication Office of the fabricating facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. **Preliminary Samples** – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. **Acceptance** – Acceptance shall be by the Certificate of Compliance per *Construction Manual* Section 9-1.4E.

4. **Field Inspection** – Field verify per *Construction Manual* Section 9-1.5. Field Verify that hardware included is per the Contract Specifications and Plan.

5. **Specification Requirements** – Review contract documents to determine the specification requirements.

6. **Other Requirements** – For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.98 Concrete Blocks

1. Approval of Material

**Ecology Blocks** – Approval of materials is not required.

**Masonry Units** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

**Precast Concrete Block** – Approval of materials is required prior to use. Materials will be approved by the *Qualified Products List* or Request for Approval of Material (WSDOT Form 350-071). An on-site inspection by the WSDOT Materials Fabrication Office of the fabricating facilities prior to approval will be required only if a new manufacture is requested on the Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

2. Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

3. Acceptance

   a. **Ecology Block** – Visual Acceptance per *Construction Manual* Section 9-1.4C.

   b. **Masonry Units** – Acceptance shall be by the Certificate of Compliance per *Construction Manual* Section 9-1.4E.

   c. **Precast Concrete Block** – Acceptance shall be by the Manufacturer’s Certificate of Compliance per *Construction Manual* Section 9-1.4D. A cylinder test report is required for each lot of blocks delivered to the job site. The freeze/thaw report shall be acceptable for a period of two years from the date the block was manufactured.

4. Field Inspection – Field verify per *Construction Manual* Section 9-1.5. The field inspector is required to document in their IDR the “lot” number of the precast concrete block as it is delivered to the job site.


6. Other Requirements – Certificate of Material Origin will be the responsibility of the Materials Fabrication Inspector as defined in *Construction Manual* Section 9-2.1A.

For projects with the Buy America requirement, the Project Engineer office is required to obtain the Certificate of Materials Origin for all foreign steel or iron materials from the Contractor, track the quantity, and retain these documents in the project records.
9-4.99 Parting Compound for Concrete Forms

Approval of Material – Approval of materials is required prior to use. Materials will be approved by the Qualified Products List or Request for Approval of Material (WSDOT Form 350-071). Be certain to verify that the product is in fact qualified for its intended use and the product is listed under the appropriate specification.

Preliminary Samples – A preliminary sample of the material will be required only if coded on the Request for Approval of Material (WSDOT Form 350-071).

Acceptance – If the lot is listed on the QPL, it may be used without testing on current projects per Construction Manual Section 9-1.4A(1). If the lot is not on the QPL, submit a one-quart sample taken by, or in the presence of, an agency representative for each lot. Samples must be submitted for testing 10 days prior to use of parting compound. Samples submitted shall be accepted on receipt of “Satisfactory” test reports from the State Materials Laboratory.

Field Inspection – Field verify per Construction Manual Section 9-1.5.


Other Requirements – There may be special shipping requirements for parting compound. These samples shall be transported to the Region Materials Laboratory for proper shipping.

9-5 Quality Assurance Program

9-5.1 General

The purpose of the WSDOT Quality Assurance Program (QAP) is to ensure that materials incorporated into any highway construction project are in conformity with the approved plans and specifications, including any approved changes. This program also conforms to the criteria in FHWA regulation for Quality Assurance Procedures for Construction (23 CFR 637).

The QAP includes the following:

• Qualified Tester Program
• Equipment Calibration/Standardization/Check and Maintenance Program
• Qualified Laboratory Program
• Independent Assurance (IA) Program
### 9-5.2 Quality Assurance Program Structure and Responsibilities

Table 9-3 outlines the structure of the quality program for WSDOT.

#### State Materials Laboratory (SML) Requirements

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>State Materials Engineer</strong></td>
<td>Oversees</td>
</tr>
<tr>
<td></td>
<td>• WSDOT Quality System Program</td>
</tr>
<tr>
<td></td>
<td>• Accreditation of State Materials Laboratory</td>
</tr>
<tr>
<td></td>
<td>• Program compliance reports to FHWA</td>
</tr>
<tr>
<td><strong>Quality Systems Manager</strong></td>
<td>Management of WSDOT’s Quality System Program which includes:</td>
</tr>
<tr>
<td></td>
<td>• Qualified Testers</td>
</tr>
<tr>
<td></td>
<td>• Independent Assurance</td>
</tr>
<tr>
<td></td>
<td>• Qualified Laboratory</td>
</tr>
<tr>
<td></td>
<td>• Maintaining up-to-date Test Procedures in the Construction Manual and the Materials Manual</td>
</tr>
<tr>
<td></td>
<td>• Maintaining Calibration/Standardization/Check Equipment Procedures</td>
</tr>
<tr>
<td></td>
<td>• Auditing SML and regions compliance to the requirements of the QAP</td>
</tr>
<tr>
<td></td>
<td>• Supervising Laboratory Review Team</td>
</tr>
<tr>
<td></td>
<td>• Compiling yearly report for FHWA</td>
</tr>
<tr>
<td><strong>SML Laboratory Managers</strong></td>
<td>Management of their laboratory’s QAP which includes:</td>
</tr>
<tr>
<td></td>
<td>• Maintaining qualified testers</td>
</tr>
<tr>
<td></td>
<td>• Maintaining calibrated/standardized/checked equipment for their department</td>
</tr>
<tr>
<td></td>
<td>• Maintaining AMRL/CCRL Accreditation</td>
</tr>
</tbody>
</table>

#### Region Materials Laboratory Requirements

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Region Materials Engineer</strong></td>
<td>Oversees</td>
</tr>
<tr>
<td></td>
<td>• Region Quality System Program</td>
</tr>
<tr>
<td></td>
<td>• Qualification of Region Materials Laboratory</td>
</tr>
<tr>
<td><strong>Region Laboratory Supervisor</strong></td>
<td>Management of the Region Laboratory Quality System Program which includes:</td>
</tr>
<tr>
<td></td>
<td>• Maintaining qualified testers</td>
</tr>
<tr>
<td></td>
<td>• Maintaining calibrated/standardized/checked equipment for the Region Materials Laboratory</td>
</tr>
<tr>
<td></td>
<td>• Participating in biannual laboratory review</td>
</tr>
<tr>
<td><strong>Region Independent Assurance Inspector</strong></td>
<td>Management of the Region’s QAP which includes:</td>
</tr>
<tr>
<td></td>
<td>• Qualified tester</td>
</tr>
<tr>
<td></td>
<td>• Determining how the program will be implemented in the Region within the guidelines of this Section</td>
</tr>
<tr>
<td></td>
<td>• Proctoring written and proficiency examinations</td>
</tr>
<tr>
<td></td>
<td>• Maintaining documentation of tester qualification</td>
</tr>
<tr>
<td></td>
<td>• Independent Assurance</td>
</tr>
<tr>
<td></td>
<td>• Determining frequency of visits</td>
</tr>
<tr>
<td></td>
<td>• Witnessing IA process in the field</td>
</tr>
<tr>
<td></td>
<td>• Investigating excessive deviations on split samples and aiding in the review of reports of deviation from specified sampling and testing procedures</td>
</tr>
<tr>
<td></td>
<td>• Providing yearly report of IA to Quality Systems Manager</td>
</tr>
<tr>
<td></td>
<td>• Other functions (optional by Region)</td>
</tr>
<tr>
<td></td>
<td>• Conducting initial training for qualification.</td>
</tr>
<tr>
<td></td>
<td>• Mentoring new or newly qualified testers to enhance efficiency and confidence.</td>
</tr>
<tr>
<td></td>
<td>• Assisting in or conducting testing and inspection training in concert with the Regional Construction Trainer.</td>
</tr>
<tr>
<td></td>
<td>• Reviewing materials, test-related records, and forms.</td>
</tr>
<tr>
<td></td>
<td>• Radiation safety officer</td>
</tr>
</tbody>
</table>

**Table 9-3**
### Project Engineering Office Requirements

<table>
<thead>
<tr>
<th>Project Engineer</th>
<th>Management of the Project Office QAP which includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Training of qualifying testers</td>
</tr>
<tr>
<td></td>
<td>• Providing training opportunities</td>
</tr>
<tr>
<td></td>
<td>• Providing opportunity for experience in the field</td>
</tr>
<tr>
<td></td>
<td>• Maintaining qualified testers on projects</td>
</tr>
<tr>
<td></td>
<td>• Maintaining staff of qualified testers to perform the testing on all projects under the management of the Project Engineer</td>
</tr>
<tr>
<td>PE Office Contact (appointed by PE as the office contact to the IAI)</td>
<td>• Tracking qualification of testers</td>
</tr>
<tr>
<td></td>
<td>• Contacting IAI to schedule tester qualification or requalification</td>
</tr>
<tr>
<td></td>
<td>• Contacting IAI to schedule an IA visit</td>
</tr>
</tbody>
</table>

### Individual Tester Requirements

<table>
<thead>
<tr>
<th>Qualified Tester</th>
<th>Management of personal qualification which includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Preparing for requalification</td>
</tr>
<tr>
<td></td>
<td>• Notifying office contact of approaching expiration of qualification. Notification should be one month in advance of the expiration of qualification</td>
</tr>
<tr>
<td></td>
<td>• Notifying office contact to schedule an IA review</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unqualified Tester</th>
<th>Management of personal qualification which includes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Reading test procedure</td>
</tr>
<tr>
<td></td>
<td>• Hands-on practice of test procedure</td>
</tr>
<tr>
<td></td>
<td>• Notifying office contact when ready for written and proficiency examinations</td>
</tr>
</tbody>
</table>

### Table 9-3 (continued)

#### 9-5.3 Qualified Tester Program

This program provides uniform statewide procedures for sampling and testing personnel qualification to ensure that tests required by the specifications are performed according to the prescribed sampling and testing methods. This program is based on AASHTO R 25.

All personnel who perform acceptance testing on materials must be qualified in the test method they are performing or may work under the direct supervision of a tester qualified as a trainee. An individual may only work as a trainee for one year.

It is the responsibility of the Project Engineer to ensure that all personnel sampling or testing materials on a project or in a field laboratory are qualified.

#### 9-5.3A Types of Qualifications

The Qualified Tester Program has two types of qualifications; module qualified testers and method qualified testers.

##### 9-5.3A(1) Module Qualified Tester

A module qualified tester is an individual that has proficiency in one or more testing modules. There are five modules which represent the majority of the acceptance tests performed on highway projects. Each module contains a defined list of test procedures.

To qualify as a module qualified tester, an individual must pass a written and a proficiency examination for each method in the module. These modules are listed in Table 9-4.
### Aggregate Module

<table>
<thead>
<tr>
<th>Procedure Number</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO T-2</td>
<td>WSDOT FOP for AASHTO for the Sampling of Aggregates</td>
</tr>
<tr>
<td>AASHTO T-27/T11</td>
<td>FOP for WAQTC/AASHTO for the Sieve Analysis of Fine &amp; Coarse Aggregates</td>
</tr>
<tr>
<td>AASHTO T-176</td>
<td>WSDOT FOP for AASHTO for Determining the Plastic Fines in Graded Aggregate by Use of the Sand Equivalent Test</td>
</tr>
<tr>
<td>AASHTO T-248</td>
<td>WSDOT FOP for AASHTO for Reducing Field Samples of Aggregates to Testing Size</td>
</tr>
<tr>
<td>AASHTO T-255</td>
<td>WSDOT FOP for AASHTO for Determining the Total Moisture Content of Aggregate by Drying</td>
</tr>
<tr>
<td>AASHTO T-335</td>
<td>FOP for AASHTO for Determining the Percentage of Fracture in Coarse Aggregate</td>
</tr>
<tr>
<td>AASHTO T-304</td>
<td>WSDOT FOP for AASHTO Uncompacted Void Content of Fine Aggregates</td>
</tr>
</tbody>
</table>

### Hot Mix Asphalt Module

<table>
<thead>
<tr>
<th>Procedure Number</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO T-168</td>
<td>FOP for WAQTC/AASHTO for the Sampling Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>AASHTO T-209</td>
<td>WSDOT FOP for AASHTO for Determining the Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>AASHTO T-27/T11</td>
<td>FOP for WAQTC/AASHTO for the Sieve Analysis of Fine &amp; Coarse Aggregates</td>
</tr>
<tr>
<td>AASHTO T-40</td>
<td>FOP for WAQTC/AASHTO for Sampling Bituminous Materials</td>
</tr>
<tr>
<td>AASHTO- T 166</td>
<td>WSDOT FOP for AASHTO Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface Dry Specimens</td>
</tr>
<tr>
<td>AASHTO T-308</td>
<td>WSDOT FOP for AASHTO for Determining Asphalt Content of Hot Mix Asphalt (HMA) by the Ignition Method</td>
</tr>
<tr>
<td>AASHTO T-329</td>
<td>FOP for AASHTO Moisture Content of Hot Mix Asphalt (HMA) by Oven Method</td>
</tr>
<tr>
<td>WSDOT 712</td>
<td>Standard Method of Reducing Bituminous Paving Mixtures</td>
</tr>
<tr>
<td>WSDOT 716</td>
<td>Method of Random Sampling for Location of Testing and Sampling Sites</td>
</tr>
<tr>
<td>AASHTO T 312</td>
<td>FOP for AASHTO for Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor</td>
</tr>
</tbody>
</table>

### Concrete Module

<table>
<thead>
<tr>
<th>Procedure Number</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO T-23</td>
<td>WSDOT FOP for AASHTO for Making and Curing Concrete test Specimens in the Field</td>
</tr>
<tr>
<td>AASHTO T-119</td>
<td>WSDOT FOP for AASHTO for Determining the Slump of Hydraulic Cement Concrete</td>
</tr>
<tr>
<td>AASHTO T-152</td>
<td>FOP for WAQTC/AASHTO for Determining the Air Content of Freshly Mixed Concrete by the Pressure Method</td>
</tr>
<tr>
<td>WAQTC TM-2</td>
<td>Sampling Freshly Mixed Concrete</td>
</tr>
<tr>
<td>AASHTO T-309</td>
<td>WSDOT FOP for AASHTO for Determining the Temperature of Freshly Mixed Portland Cement Concrete</td>
</tr>
<tr>
<td>WSDOT 716</td>
<td>Method of Random Sampling for Location of Testing and Sampling Sites</td>
</tr>
</tbody>
</table>

### Embankment and Base Density Module

<table>
<thead>
<tr>
<th>Procedure Number</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO T-310</td>
<td>WSDOT FOP for AASHTO for In-Place Density and Moisture Content of Soil and Soil Aggregate by Nuclear Method</td>
</tr>
<tr>
<td>WSDOT SOP 615</td>
<td>Determination of the % Compaction for Embankment &amp; Untreated Surfacing Materials Using the Nuclear Moisture-Density Gauge</td>
</tr>
</tbody>
</table>

### Hot Mix Asphalt Density Module

<table>
<thead>
<tr>
<th>Procedure Number</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAQTC TM-8</td>
<td>FOP for WAQTC for In Place Density of Bituminous Mixtures Using the Nuclear Moisture Gauge</td>
</tr>
<tr>
<td>WSDOT 716</td>
<td>Method of Random Sampling for Location of Testing and Sampling Sites</td>
</tr>
</tbody>
</table>

### Testing Modules

*Table 9-4*
9-5.3A(2) **Method Qualified Tester**

A method qualified tester is an individual that has proficiency in one or more test procedures which may partially encompass methods in the qualification modules.

9-5.3B **Qualification Process**

All persons responsible for sampling of materials and performing acceptance testing on a project are required to be qualified. To become qualified an individual must pass a proficiency examination or a combination of a proficiency and written examination.

9-5.3B(1) **Frequency of Qualification**

A State Materials Laboratory (SML) qualification is good for one calendar year from the date of qualification. (Example: Qualification on January 2, 2009 expires on January 2, 2010)

A Region laboratory/field testing qualification is good from the date of qualification to December 31 of the year following qualification. (Example: Qualification on January 2, 2009 expires on December 31, 2010)

Qualification may not be granted or maintained by Grandfathering, the acceptance of a Professional Engineer or Engineer-in-Training Certificate, or lifetime qualification.

9-5.3B(2) **Preparation for Initial Qualification**

Prior to an individual taking either the written exam or the proficiency exam, it is the responsibility of the Project Engineer to make sure the following requirements have been met by the individual:

- Studied and understands the test method(s) for the method or module.
- Has watched the test performed by a qualified tester, attended classroom training or on-line training relevant to the test procedure.
- Has practiced the test procedure under the supervision of a qualified tester.
- Has successfully completed a hands-on demonstration of the test procedure which conforms to test method checklist(s) without coaching.
- Has worked in the field or laboratory under the close supervision of a qualified tester experienced in the test method(s).

These requirements may be waived for individuals with previous testing certification such as WAQTC or ACI.

9-5.3C **Initial Qualification Examination Requirements**

Qualification examinations will be either a proficiency examination or a combination of proficiency and written examination. Written and proficiency examinations are given to determine if the tester possesses the knowledge and skills necessary to satisfy the established qualification requirements.

Written and proficiency examinations for qualification of testers will be administered by the one or more of the following WSDOT personnel:
• Region independent assurance inspector (IAI)
• Assistant Regional IAI, Construction Trainer
• Qualified Region Materials Laboratory staff under the direction of the Region Materials Engineer
• Qualified SML laboratory staff under the direction of the State Materials Engineer

Written examinations and checklists for proficiency examinations will be reviewed and updated yearly, under the direction of the Quality Systems Manager. Updated examinations will be published to the Independent Assurance Inspectors share site each year no later than January 30.

The individual administering any proficiency examination shall document the examination using the appropriate test method checklist from the Construction Manual, Materials Manual, AMRL, or CCRL.

9-5.3C(1) Written Examinations

Written examinations are required for Module Qualification and are optional for Method Qualification. Written Module Qualification examinations will consist of a series of written examinations based on each test procedure within the modules listed in Table 9-4.

The written examinations will be closed book and will consist of five or more multiple choice questions.

To successfully pass a written examination the individual must have a score of 60 percent or more on any individual method examination and an overall module score of 70 percent or more.

9-5.3C(2) Proficiency Examinations

Using a test procedure checklist from the Construction Manual, Materials Manual, AMRL or CCRL the examiner will document the tester’s conformance to the test procedure. The tester is required to have a current copy of the test procedure available during the proficiency examination. Scoring of the proficiency exam will be on a Satisfactory/Unsatisfactory basis.

A satisfactory performance rating will be given for a performance that consists of the following:

1. Performing the key elements of the procedure correctly and in sequential order as established by the Test Method Checklist.

   Note: Incidences of single to several errors as isolated, first-time occurrences, which are acknowledged and corrected on the spot and discussed with the proficiency examination administer may constitute satisfactory performance.

2. Completing the test within the time limit of the test procedure or a reasonable time as defined by the administrator of the test.

3. Performing the calculations correctly.
An unsatisfactory performance rating will be given for a performance that consists of repeated infractions or incorrect performance of individual critical items on the checklist and/or the inability to complete the test method within the designated time limit.

The following items will result in immediate termination of the proficiency examination:

- Observed falsification of test reports.
- Violations of safety, hazardous materials.
- Violations of nuclear materials security standards.
- Failure to provide proper care of equipment.

9-5.3D Documentation of Initial Qualification

The IAI will be responsible for maintenance of the Region’s qualified tester information in the Tester Qualification Database and in hard copy files within the Region. Originals of each tester’s qualification examination (written examination and checklist) will be kept in the Region files for a minimum of seven years.

The State Materials Laboratory will be responsible for maintaining the Tester Qualification computer program.

9-5.3E Failure of Examination

An individual failing either the written or proficiency examination may request a reexamination. The waiting period for reexamination is as follows:

1. **First Failure** – A minimum of three days waiting period, unless this time limit is waived by the IAI.

2. **Second Failure** – A minimum of a one week waiting period or a minimum of three days waiting period and a letter from the Project Engineer documenting the steps taken to prepare the individual for reexamination.

3. **Three or more consecutive failures** – A minimum of a one month waiting period and a letter from the Project Engineer documenting the steps taken to prepare the individual for reexamination. When an individual fails the proficiency examination more than three times, consecutively, the IAI with the approval of the Regional Materials Engineer may determine that the individual is not eligible for qualification.

9-5.4 Requalification of Testing Personnel

Once a tester’s qualification expires he/she may no longer perform acceptance testing until a requalification visit has been satisfactorily completed. Therefore, to prevent a lapse in qualification the tester should notify the Project Office contact one month in advance of their qualification expiration. Upon notification of the pending qualification expiration the Office contact should get in touch with the IAI to schedule a requalification visit.
Requalification requires the tester to perform a proficiency examination in the presence of one or more of the following WSDOT personnel:

- Region independent assurance inspector (IAI)
- Assistant Regional IAI, Construction Trainer
- Qualified Region Materials Laboratory staff under the direction of the Region Materials Engineer or a Qualified SML laboratory staff under the direction of the State Materials Engineer.

If a tester’s qualification expires prior to their requalification, the Project Engineer may request a 30 day extension of qualification. The extension must be approved by the Region IAI and the tester must be requalified within the 30-day extension period.

### 9-5.4A Requalification Examination

The requalification examination will meet the requirement of *Construction Manual* Section 9-5.3C(2) Proficiency Examinations. Results of the requalification will be reported as either Satisfactory or Unsatisfactory as defined in *Construction Manual* Section 9-5.3C.

The proficiency examination may be performed on a project site or in a laboratory.

If the tester’s performance is satisfactory, the administrator of the proficiency examination shall document the examination using the appropriate test method checklist from the *Construction Manual, Materials Manual, AMRL, or CCRL*. If the requalification is performed in the field, the administrator of the proficiency exam may choose to obtain an Independent Assurance sample in accordance with the section.

If the performance is unsatisfactory the administrator may recommend corrective action.

Unsatisfactory performance constitutes repeated occurrences of previous on-the-spot corrections, incorrect performance of critical steps of the testing procedure. Administrator may also assign unsatisfactory performance based on observed falsification of test reports, violations of safety, hazardous materials or nuclear materials security standards, or failure to provide proper care of equipment.

### 9-5.5 Lapse in Qualification

A tester missing two consecutive yearly annual evaluations shall be required to qualify in accordance with *Construction Manual* Section 9-5.3C.

### 9-5.6 Suspension of Qualification

An IAI may recommend to the Regional Materials Engineer that a tester’s qualification be suspended for the following items:

1. Repeated failure of proficiency examinations for requalification.
2. Observed falsification of test reports.
3. Violations of safety that may result in injury or death to the individual or coworkers.
4. Violation of hazardous materials or nuclear materials security standards.

5. Failure to provide proper care of equipment.

If an IAI recommends suspension of a tester’s qualification, a letter documenting the reason(s) for suspension of qualification will be sent to the tester’s Project Engineer. Upon receipt of the letter the Project Engineer will remove the tester from performing the tests related to the suspension of qualification until all issues have been resolved to the satisfaction of the IAI.

In the case of a serious safety issue or a violation of nuclear material security standard, the IAI will notify the Project Engineer of the violation and may request the removal of the tester from the performance of that test procedure(s). The IAI will document the violation. The Region Materials Engineer, with recommendations from the IAI and the Project Engineer, will determine the duration of the suspension of qualification.

9-5.7 Report of Deviation from Specified Sampling and Testing Procedures

A report of a deviation from specified sampling and testing procedures requires following the procedure outlined in Standard Specifications Section 1-06.2(1). The Project Engineer should work with the Region IAI to review the test procedure and determine what, if any, deviation occurred during the sampling and testing. After determining if a deviation took place the Project Engineer can respond in writing to the report.

9-5.8 Calibration/Standardization/Check of Equipment

All laboratory equipment will be calibrated/standardized/checked as required by the test procedures, AASHTO R 18 or WSDOT Verification Procedures.

The State Materials Laboratory will calibrate/standardize/check all required equipment every 12 months unless otherwise stated in the test procedure, AASHTO R 18 or the WSDOT Verification Procedures.

Regional and field laboratories will calibrate/standardize/check all required equipment once a year unless otherwise specified by the WSDOT Verification Procedures. All calibration/standardization/checks will be completed by April 1st of each year. A tag bearing the year the calibrate/standardize/check expires will be affixed to all calibrated/standardized/checked equipment. The tags will be provided to the regions each year by the Quality Systems Manager.
9-5.9 Qualified Laboratories

All laboratories performing acceptance testing on state or Federal funded construction projects must be qualified.

Qualification of the State Materials Laboratory will be by accreditation through the AASHTO Accreditation Program (AAP).

9-5.9A Qualification of Region or Other Subordinate Laboratories

Qualification of Region or other subordinate laboratories requires the following:

1. Identification of all test methods performed on a regular basis. Methods must conform to those established by WSDOT for materials acceptance.

2. Annually, calibration/standardization/check equipment laboratory and field test equipment, using State Materials Laboratory equipment calibrated/standardized or checked equipment procedure. All calibrated/standardized or checked equipment must have a calibration tag stating the expiration date of the calibration/standardization/check.

3. Maintain staff qualification for all methods performed in the laboratory. Qualification shall be either by Module Qualified Tester or Individual Method Qualified tester.

4. Each Region laboratory will be reviewed biennially by a team from the State Materials Laboratory. The process of the review will be in accordance with QC3, which is modeled after the AASHTO Materials Reference Laboratory (AMRL) inspection program.

9-5.9B Qualification of Private Laboratories

Qualification of Private Laboratories requires the following:

1. Approval for use by the State Materials Engineer.

2. The private laboratory must have an up-to-date Laboratory Quality Systems Manual meeting the requirements of AASHTO R 18.

3. The private laboratory must have documentation of tester training and qualification meeting the requirements of AASHTO R 25.

4. The testing equipment must be labeled with a sticker showing the date of calibration/standardization/check and all equipment calibration/standardization/check documentation must meet the requirements of AASHTO R 18.

5. The State Materials Laboratory Review team may conduct a yearly on-site review of the laboratory facilities, tester performance and calibration/standardization/check of the testing equipment in accordance with QC 3.
9-5.10 Independent Assurance Program (IAP)

The IAP shall consist of a system based approach to Independent Assurance (IA). This approach bases the frequency of IA evaluations on time, regardless of the number of tests, quantities of materials, or numbers of projects tested by the active qualified tester. This program is based on AASHTO R 44.

The overall IAP for the Region will be managed by the Region’s IAI. Each active qualified tester will have an IA evaluation for each module or method they are qualified in once a year. An active qualified tester is defined as, any qualified tester performing at least one acceptance test per year. The Project Office is responsible for contacting the IAI and scheduling an IA visit when the following testing is occurring on a project:

- Concrete
- Aggregate
- HMA
- Density (HMA or Embankment)

The on-site evaluation of module qualified testers shall include evaluation of all test methods in the applicable qualification module. Method qualified testers will be evaluated in the performance of the individual test method.

IAP evaluations will be performed as follows:

- Concrete and Density test method evaluations will be by observation.
- Hot Mix Asphalt and Aggregate test methods shown in Table 9-5 will be evaluated by observation and split sample. All other Hot Mix Asphalt and Aggregate test methods will be evaluated by observation only.
- Hot Mix Asphalt and Aggregate test methods shown in Table 9-5 will be evaluated by observation and split sample. All other Hot Mix Asphalt and Aggregate test methods will be evaluated by observation only.
- The field split of HMA or Aggregate will be tested by the individual who sampled and reduced the material, under the observation of the IAI or a qualified Region laboratory staff member under the direction of the Region Materials Engineer.
- The laboratory split of the IA sample must remain in the custody of the IAI until the sample is logged into the Regional Materials Laboratory.
- A qualified tester from the Region Materials Laboratory will perform the testing on the laboratory portion of the split sample. The same tester may not perform both the field and the laboratory testing on an IA sample.
- The same equipment may not be used to test the laboratory and the field portions of the IA split sample.
- All equipment used for testing the split samples will be evaluated for condition and current calibration/standardization/check tags.
A record of the evaluation will be kept by the IAI in the Region Office and provided to the PE upon request. The record should contain the following:

- Name of qualified tester.
- Observations concerning the condition of the testing equipment.
- Observations concerning the performance of the qualified tester including, suggestions or on-the-spot corrections for improving the tester’s performance.

**9-5.10A Comparison Evaluation of the Independent Assurance Sample**

The IA split sample will be tested by the Region laboratory except, when the Region laboratory performs the acceptance testing. If the Region Materials Laboratory performs the acceptance testing then, the IA split sample will be tested by the State Materials Laboratory or another Region Materials Laboratory. The tester performing the comparison evaluation of the Independent Assurance sample must be qualified in the procedures being evaluated.

The calibrated/standardized/checked testing equipment used for the comparison must be different equipment than that used by the field during the split sample evaluation.

**9-5.10B Assurance and Acceptance Test Results**

Independent Assurance split samples will be compared using Table 9-5. Reports of the degree of conformance will be sent to the Project Engineer and the Region IAI by the Region Materials Engineer (RME).

Comments reflecting the degree of conformance will be entered in the remarks section of the report by the Regional Materials Engineer. The degree of conformance will be determined according to the deviation ranges noted below. Gradation test results will be compared only on specification screens.

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<tr>
<th>Test</th>
<th>Normal Range of Deviation</th>
<th>Maximum Range of Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Equivalent</td>
<td>± 8 points</td>
<td>± 15 points</td>
</tr>
<tr>
<td>Fracture</td>
<td>± 5 percent</td>
<td>± 10 percent</td>
</tr>
<tr>
<td>Asphalt Binder Content (HMA &amp; ATB)</td>
<td>± 0.3 percent</td>
<td>± 0.6 percent</td>
</tr>
<tr>
<td>Sieve Analysis – All Items:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 4 sieve and larger</td>
<td>± 5 percent</td>
<td>± 8 percent</td>
</tr>
<tr>
<td>No. 6 sieve to No. 80 sieve</td>
<td>± 3 percent</td>
<td>± 6 percent</td>
</tr>
<tr>
<td>No. 100 sieve to No. 200 sieve</td>
<td>± 2 percent</td>
<td>± 4 percent</td>
</tr>
</tbody>
</table>

*Table 9-5*

In the table above, “Normal Range” indicates an acceptable range of variation between test results and no action is required. Test results that fall in this category will be so indicated by the wording “normal deviation” on the IA reports.

Test results falling outside of the “Normal Range” but within the “Maximum Range,” will be indicated by the wording “questionable deviation” on the IA reports.
Deviations falling into the questionable category will be reviewed by the Region IAI. The review may include the following:

- Check for calculation errors.
- Review of sampling and splitting procedure.
- Review of test procedure.

Findings of the review will be documented and a copy of the report retained in the Region IAI’s file.

Test results exceeding the maximum range will be indicated by the wording “excessive deviation.” Deviations falling in the excessive category will require a review by the Region IAI. The review will include the items listed under questionable deviations and may require the field tester to pull another IA sample. The IAI will document the findings of the review. If further action is required the IAI will submit a report to the Region Materials Engineer and Project Engineer. If further action is not required a copy of the report will be retained in the IAI’s files.

9-5.10C Independent Assurance Report

WSDOT is required by 23 CFR Part 637 to provide an annual report to the FHWA summarizing the results of the IA program. These reports provide a tool for the Region and WSDOT to analyze trends, identify training needs, and make improvements.

Each Region IAI will submit an annual IA report to the Quality Systems Manager. The report will be submitted in January and will summarize the IA results of the previous year. The annual report will include the following:

1. Number or percent of testers evaluated.
2. How often the qualified testers were evaluated.
3. If applicable, include a general statement as to why all qualified testers were not evaluated.
4. What, if any, problems occurred and why.
5. A general statement as to how any problems that were reported were resolved.

The focus of Independent Assurance sampling is based on individual tester’s activity and is not intended to provide independent assurance sample reports on all projects or on all materials on any particular project.
9-6 Radioactive Testing Devices

9-6.1 Administration and Safety

This chapter provides guidance for personnel using, and administering the use of, nuclear density gauges. The instructions included in this chapter will be used throughout the Washington State Department of Transportation for the express purpose of regulating the use of nuclear density gauges containing radioactive materials.

Each Region shall have a Radiation Administration Officer (RAO) and a Radiation Safety Officer (RSO) whose duties are described in Construction Manual Sections 9-6.2 and 9-6.3 respectively. All Regional RAO and RSO personnel must have radiation safety training. Only personnel who have successfully completed the WSDOT “Nuclear Gauge Safety and Operations” course are authorized to use or transport the nuclear density gauge. Personnel transporting gauges through a common carrier are required to have training that satisfies USDOT training requirements of 49 CFR 172, subpart H (HAZMAT). Recurrent training is required every 3 years (every 2 years if gauges are to be shipped by air). Personnel - performing acceptance testing with the nuclear density gauge must become a qualified or interim tester in either TM-8, In-Place Density of Bituminous Mixtures Using the Nuclear Moisture Gauge, and or, T-310, In-Place Density and Moisture Content of Soils and Soil-Aggregate by Nuclear Method. The operator’s responsibilities for safety and security of the gauges are described in Construction Manual Section 9-6.4.

All personnel using or responsible for the nuclear density gauge shall be:

1. Thoroughly familiar with the safe handling techniques for using radioactive materials.

2. Fully informed of the hazards to health that exists near radioactive materials.

3. Completely familiar and in compliance with the following rules and regulations:
   a. Rules and Regulations for Radiation Protection by the State Department of Health, Division of Radiation Protection, Title 246, WAC.

Copies of the above publications will be kept by the Region Radiation Safety Officer and at the storage location of the gauge. A copy of the Radiation Emergency Handbook will also be supplied with each nuclear density gauge. Authorized Operator(s) will read this handbook before using the radioactive testing device for testing.

If an emergency as outlined in the Radiation Emergency Handbook occurs, the following people or agencies should be notified by the individual in charge of the nuclear density gauge:

- Radiation safety officer
- Radiation administration officer
The RSO or the RAO will notify the following people or agencies:

- Radiation Control Program, Health Services Division, State Department of Health, Olympia, WA (Phone 206/NUCLEAR).
- Washington State Patrol, if a public hazard exists.
- State Radiation Administration Officer or Radiation Safety Officer, at the Materials Laboratory.

The telephone numbers of these agencies or individuals will be posted at all storage sites and a copy of these numbers shall be kept with each nuclear density gauge.

It is paramount to the WSDOT that all employees work in a healthy and safe environment. To this end, each employee that works around or with nuclear gauges needs to know the potential hazards of working with nuclear gauges and their individual rights. Each office that uses or stores nuclear gauges shall have a copy of the latest “Sealed Source Edition Rules & Regulations for Radiation Protection” published by the Department of Health. Every employee that uses a nuclear gauge, or works near the storage location of the nuclear gauges, must review the applicable Chapters 246-220 Radiation – General Provisions; 246-221 Radiation Protection Standards; 246-222 Radiation Protection – Worker Rights and sign the “Acknowledgment of the Hazards of Working with Radiation Sources” form which is available through the Radiation Safety Officer.

Personal monitoring of radiation received from the nuclear density gauge is one of the major items in the Health Safety Program. Any individual using radioactive sources or receiving on the job training with radioactive sources must wear a radiation exposure badge which records exposure the body may receive. Radiation exposure badges are assigned to individuals they are not to be used by any other person. Any individual using radioactive sources or receiving on the job training with radioactive sources must be familiar with the conditions outlined in WAC 246-221-010 and WAC 246-221-055 regarding radiation exposure during pregnancy and dose limits to the embryo/fetus. Personnel with valid safety or health concerns may be released from the operation of nuclear gauges without prejudice to their career opportunities with the WSDOT.

The acquisition of radiation exposure badges, as needed by each Region, shall be the responsibility of the Regional Radiation Safety Officer or a designated individual with radiation safety training. These badges can be obtained from U.S. Dosimeter Technology Inc., 660-A George Washington Way, Richland, WA 99352, 509-946-8738, or from a firm recognized by the Department of Health to perform this service. Three-month TLD (Thermal Luminescent Dosimeter) badges indicating exposure to gamma, beta, x-ray, and neutron radiation will be used as a minimum.

Each nuclear density gauge will be supplied in the manufacture’s shipping container with an adequate latch. While transporting and when storing the nuclear density gauge, it must be secured with a minimum of three levels of security using locks:

1. Security level one is considered to be a combination of a lock on the handle of the nuclear density gauge, and a lock on the manufacture’s shipping container.
2. Security level two is considered to be the chain and lock combination, or other locking mechanism, used to secure the manufacturers shipping container to the vehicle if in transport or field use, or to a storage bench or locker in an approved storage facility.

*Note:* Security level two must prevent the manufacturers shipping container from being opened if the lock is removed.

3. Security level three is considered to be:
   a. If a passenger vehicle is used for transporting, the manufacturers shipping container containing the nuclear density gauge, which is secured and locked in the trunk.
   b. If a station wagon, van, or panel truck is used, the manufacturers shipping container containing the nuclear density gauge, which is secured and locked in the back of the vehicle in such a manner as to prevent it from moving during transport.

   *Note:* If the manufacture’s shipping container can be seen through a window or other opening it must be covered.

   c. If a truck with a utility box is used, the manufacturers shipping container containing the nuclear density gauge must be secured in the utility box with the storage lid locked. The nuclear density gauge shall not be transported in the cab of the truck.

   d. If a truck with a canopy is used, the manufacturer’s shipping container containing the nuclear density gauge must be secured to the bed of the truck and the canopy lid locked. The nuclear density gauge shall not be transported in the cab of the truck.

   e. If a licensed storage location, or temporary storage facility approved by the Regional RSO is used, the storage facility door must be locked.

At all times, the key(s) for the security locks will be in the possession of the individual responsible for the nuclear density gauge.

Every effort shall be made to store and transport nuclear density gauges in a manner that minimizes its view from the general public.

When the nuclear density gauges are not in use or in transit, they must be stored with three levels of security in licensed storage locations, or temporary storage facilities approved by the Regional RSO.

Performance audits shall be conducted randomly by the Region Radiation Safety Officer or designee to ensure that each gauge user:

1. Understands the security and transportation requirements described above.
2. Has the necessary means available to use three levels of security in each of their transport vehicles.
3. Is actively employing the three levels of security while gauges are out of a licensed storage area.

The Region Radiation Safety Officer shall retain records of performance audits.

### 9-6.2 Radiation Administration Officer (Region Materials Engineer)

The Radiation Administration Officer (RAO) will be responsible for administering the use of radioactive material within the Region.

The RAO will obtain, revise, and renew the Region’s Radioactive Material License issued by the Washington State Department of Health. A license indicates the strength and type of radioactive sources that a Region may possess.

Licenses are issued subject to all the requirements of the Washington Rules and Regulations for Radiation Protection and to the conditions specified in the license. Licenses are also subject to any additional requirements of the Department of Health as stated in letters issued by DOH. Where a letter containing a license condition requirement differs from the Regulations, the letter will supersede the regulations insofar as the license is concerned.

When a change occurs in the use, transport or operation of nuclear density gauge which would make a statement in the current Radioactive Material License untrue, the Licensee (RSO) will notify the Department of Health and request an appropriate amendment.

The Radiation Safety Officer must be listed on the license. Individual operators are not required to be listed on the license, but the Radiation Administration Officer or RSO must maintain a list of Authorized Operators. This list of Authorized Operators should include the operator’s name, type of training, final test score, and a copy of the training certificate. The RAO or RSO will be responsible for the storage of the nuclear density gauge when not in field use and the assignment of nuclear density gauges to the individual project offices. The RAO or RSO will be responsible for maintaining the following records:

1. List of qualified operators within the Region.
2. Radioactive testing device location records.
3. Radioactive testing device shipping records.

Prior to shipping or transferring a nuclear density gauge from one licensed organization to another, the shipper shall check, and be assured that, the receiver has a valid radioactive material license; and that the shipped or transferred sources do not exceed the limitations of the receiver’s license. Shipment to authorized personnel within the Region is covered by the Region’s license. The State Materials Laboratory shall be notified when repairs or calibration are needed for any of WSDOT’s nuclear density gauges. When a nuclear density gauge is not in use it shall be secured in a licensed storage location, or temporary storage facility approved by the Regional RSO. The following information shall be posted on the walls of the storage facility to notify personnel of the existence of radiation:
2. DOH Form RHF-3 “Notice to Employees.”
4. DOH Form “Notification of a Radiation Emergency.”

9-6.3 Radiation Safety Officer

The Radiation Safety Officer (RSO) will be responsible for maintaining the radioactive material license. The RSO will be responsible for maintaining the following records:

1. Leak test records.
2. Medical records.
5. The Acknowledgment of the Hazards of Working with Radiation Sources form.

Leak testing is required by law and is simply a swabbing of the sealed source to ascertain that no radioactive contamination has occurred from the nuclear source. The Regional RSO shall be responsible for having each source leak tested every twelve months. The analysis of leak tests shall be done by a commercial firm licensed to do this work.

The service contract will be obtained by individual regions. Records of leak test results shall be kept in units of micro-curies and maintained for inspection. Any leak test revealing the presence of 1850 Bq or more of removable radioactive material shall be reported to the Department of Health, Division of Radiation Protection, P.O. Box 47827, Olympia, WA 98504-7827, within five days of the test. This report should include a description of the defective source or device, the results of the test, and the corrective action taken.

Leak test kits can be obtained from Troxler Electronic Laboratory, Inc. When returning the sample for testing, place the sample in a plastic envelope. Place the plastic envelope(s) in another envelope and write your regions name, address, and other pertinent details on the outside. This envelope must be marked “RADIOACTIVE MATERIALS – NO LABEL REQUIRED.”

Place this envelope into another envelope addressed to the approved facility for processing. Prior to being mailed, the contents and packing must be checked with a survey instrument and the radiation at any point on the surface must not exceed a dose rate greater than 0.005 mSv per hour in order to comply with U.S. Postal Regulations.

The RSO will be responsible for radiation exposure reports for personnel in that Region. Exposure records shall be kept on Department of Health Form RFH-5, or in a manner which includes all information required on said form. Each entry shall be for a period of time not exceeding one calendar quarter.
9-6.4 Authorized Operators

The Authorized Operators will be directly responsible to the RAO for the use and storage of the nuclear density gauge in the field and to the RSO for all safety in regard to the nuclear density gauge.

The Authorized Operators shall be responsible for posting the following information at all field storage areas:


2. DOH Form RHF-3 “Notice to Employees.”


4. DOH Form Notification of a Radiation Emergency

The Authorized Operator must keep the RAO or RSO informed of the location of the nuclear density gauge at all times. (The State Radiation Control Unit inspectors will want the sources produced or the exact locations given during their periodic inspections.) If the exact location where the nuclear density gauge will be used is known in advance, it should be noted before leaving the Region office, and if unknown, shall be forwarded to the RAO or RSO as soon as it is known.

The operation of the shutter-operating device should be frequently checked, and any malfunction reported to the RAO or RSO immediately. When not in use, the source index handle will be locked and the nuclear density gauge locked in an adequate storage facility. When operating the nuclear gauge (i.e., when the handle is in the “USE” position), unauthorized persons are not to be within 15 feet (5 meters) of the gauge.
### 9-7 WSDOT Testing Methods and Field Operating Procedures Included In This Manual

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In-Place Density of Bituminous Mixes Using the Nuclear Moisture-Density Gauge

Scope

This test method describes a test procedure for determining the density of Hot Mix Asphalt (HMA) by means of a nuclear density gauge employing either direct transmission or backscatter (thin layer only) methods. Correlation with densities determined under SOP 730 is required.

Apparatus

- Nuclear density gauge with the factory matched standard reference block.
- Drive pin, guide, scraper plate, and hammer for testing in direct transmission mode.
- Transport case for properly shipping and housing the gauge and tools.
- Instruction manual for the specific make and model of gauge.
- Radioactive materials information and calibration packet containing:
  - Daily Standard Count Log
  - Factory and Laboratory Calibration Data Sheet
  - Leak Test Certificate
  - Shippers Declaration for Dangerous Goods
  - Procedure Memo for Storing, Transporting and Handling Nuclear Testing Equipment
  - Other radioactive materials documentation as required by local regulatory requirements.

Material

WSDOT does not use filler material

Radiation Safety

This method does not purport to address the safety concerns, if any, associated with its use. This test method involves potentially hazardous materials. The gauge utilizes radioactive materials that may be hazardous to the health of the user unless proper precautions are taken. Users of this gauge must become familiar with the applicable safety procedures and governmental regulations. All operators will be trained in radiation safety prior to operating nuclear density gauges. Some agencies require the use of personal monitoring devices such as a thermoluminescent dosimeter or film badge. Effective instructions together with routine safety procedures such as source leak tests, recording and evaluation of personal monitoring device data, etc., are a recommended part of the operation and storage of this gauge.

Calibration

WSDOT performs calibrations according to the manufacturer’s Operators Manual.
Standardization

1. Turn the gauge on and allow it to stabilize (approximately 10 to 20 minutes) prior to standardization. Leave the power on during the day’s testing.

2. Standardize the gauge at the construction site at the start of each day’s work and as often as deemed necessary by the operator or agency. Daily variations in standard count shall not exceed the daily variations established by the manufacturer of the gauge. If the daily variations are exceeded after repeating the standardization procedure, the gauge should be repaired and or recalibrated.

3. Record the standard count for both density and moisture in the Daily Standard Count Log. The exact procedure for standard count is listed in the manufacturer’s Operators Manual.

Test Site Location

1. Select a test location(s) randomly and in accordance with WSDOT Test Method T 716. Test sites should be relatively smooth and flat and meet the following conditions:
   a. At least 33 ft (10 m) away from other sources of radioactivity.
   b. At least 10 ft (3 m) away from large objects (i.e., vehicles).
   c. No closer than 24 in (600 mm) to any vertical mass, or less than 6 in (152.0 mm) from a vertical pavement edge.

Overview

There are two methods for determining in-place density of HMA.

- Direct Transmission – The standard for WSDOT when the depth of Hot Mix Asphalt is 0.15 foot or greater.
- Backscatter – Optional standard for WSDOT when the depth of Hot Mix Asphalt is 0.10 foot or greater. Only gauges with two sets of photon detectors operating in “Thin Layer Mode” will be allowed.

**Note:** When a density lot is started in thin layer mode it must remain in thin layer mode until the lot is completed. If a density lot is started in direct transmission the lot must be completed in direct transmission unless the pavement depth falls below 0.15 feet.

Procedure

**Direct Transmission**

1. Maintaining maximum contact between the base of the gauge and the surface of the material under test is critical.

2. Use the guide and scraper plate as a template and drill a hole to a depth of at least ¼ in (7 mm) deeper than the measurement depth required for the gauge.

3. Place the gauge on the prepared surface so the source rod can enter the hole. Insert the probe in the hole and lower the source rod to the desired test depth using the handle and trigger mechanism. Position the gauge with the long axis of the gauge parallel to the direction of paving. Pull the gauge so that the probe is firmly against the side of the hole.


**WSDOT Note:** For alignment purposes, the user may expose the source rod for a maximum of 10 seconds.

4. Take one 4-minute test and record the wet density (WD) reading.

**Thin Layer Gauge or Mode**

1. A thin layer gauge (i.e., Troxler 4640) or a moisture density & thin layer gauge that has a thin layer mode setting (i.e., Troxler 3450) is required to perform this testing.

2. Take tests in accordance with manufacturer’s recommendation.

3. Take one 4-minute test and record the wet density (WD) reading.

**Calculation of Percent of Compaction**

The percent compaction is determined by comparing the in-place wet density, as determined by this method, to the Average Theoretical Maximum Density of the HMA as determined by the WSDOT SOP 729.

The density gauge operator will receive a new average Theoretical Maximum Density from the tester at the HMA plant each day that production requires a mix test. The density gauge operator will continue to use the previous moving average until a new moving average is received from the tester at the HMA plant.

Each gauge shall be correlated in accordance with WSDOT SOP 730. A correlation factor will be provided to the density gauge operator for each gauge.

Use the following equations to calculate the percent of compaction:

1. Calculate the corrected gauge reading to the nearest tenth of a percent as follows:
   
   \[ \text{Corrected Gauge Reading} = WD \times CF \]

   - **WD** = moisture density gauge wet density reading
   - **CF** = gauge correlation factor (WSDOT SOP 730)

2. Calculate the percent compaction as follows.

   \[ \text{Percent Compaction} = \frac{\text{Corrected Gauge Reading}}{\text{Average Theoretical Maximum Density}} \times 100 \]

**Correlation With Cores**

WSDOT has deleted this section, refer to WSDOT SOP 730.

**Report**

Report the results using one of the following:

- Materials Testing System (MATS)
- WDOT Form 350-092 and 350-157
- Form approved in writing by the State Materials Engineer

Report the percent compaction to the nearest tenth of a percent (0.1 percent)
Tester Qualification Practical Exam Checklist

In-place Density of Hot Mix Asphalt (HMA) Using the Nuclear Moisture-Density Gauge

FOP for WAQTC TM 8

Participant Name ________________________________  Exam Date ____________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Gauge turned on?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Gauge standardized and standard count recorded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Test location selected appropriately?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Direct Transmission Mode:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Hole made a minimum of ¼ inch deeper than measurement depth?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Gauge placed parallel to direction of paving, probe extended, gauge pulled back so probe against hole?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. For alignment purposes did not expose the source rod for more than 10 seconds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. One four-minute test made?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Wet density recorded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Thin Layer Gauge or Gauge in Thin Layer Mode:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Gauge placed, probe extended to backscatter position?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. One four-minute test made; gauge placed as described in the manufacture recommendations?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Wet Densities recorded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. All calculations performed correctly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Nuclear Gauge secured in a manner consistent with current DOH requirements?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First Attempt:  Pass ☐   Fail ☐       Second Attempt:  Pass ☐   Fail ☐

Signature of Examiner

Comments:
WSDOT FOP for AASHTO T 23
Making and Curing Concrete Test Specimens in the Field

1. Scope

1.1 This method covers procedures for making and curing cylinder specimens from representative samples of fresh concrete for a construction project.

1.2 The concrete used to make the molded specimens shall be sampled after all on-site adjustments have been made to the mixture proportions, including the addition of mix water and admixtures, except as modified in Section 5.1. This practice is not satisfactory for making specimens from concrete not having measurable slump or requiring other sizes or shapes of specimens.

1.3 The values stated in English units are to be regarded as the standard.

1.4 This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. (Warning – Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to exposed skin and tissue upon prolonged exposure.)

2. Referenced Documents

2.1 AASHTO Standards

T 23 – Making and Curing Concrete Test Specimens in the Field

M 201 – Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

M 205 – Molds for Forming Concrete Test Cylinders Vertically

R 39 – Making and Curing Concrete Test Specimens in the Laboratory

T 231 – Capping Cylindrical Concrete Specimens

2.2 ASTM Standards

C 125 – Terminology Related to Concrete and Concrete Aggregates

2.3 ACI Standards

309 R – Guide for Consolidation of Concrete

2.4 WSDOT

FOP for WAQTC TM 2 Sampling Freshly Mixed Concrete

3. Terminology

For definitions of terms used in this practice, refer to Terminology ASTM C 125.

1 This FOP is based on AASHTO T 23-08
4. Significance and Use

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

4.2 If the specimens are made and standard cured, as stipulated herein, the resulting strength test data where the specimens are tested are able to be used for the following purposes:

4.2.1 Acceptance testing for specified strength,

4.2.2 Checking the adequacy of mixture proportions for strength,

4.2.3 Quality control.

4.3 If the specimens are made and field cured, as stipulated herein, the resulting strength test data when the specimens are tested are able to be used for the following purposes:

4.3.1 Determination of whether a structure is capable of being put in service.

4.3.2 Comparison with test results of standard cured specimens or with test results from various in-place test methods,

4.3.3 Adequacy of curing and protection of concrete in the structure.

4.3.5 Form or shoring removal time requirements.

5. Apparatus

5.1 Molds, General – Refer to AASHTO T 23.

5.2 Cylinder – Molds for casting concrete test specimens shall conform to the requirements of M 205, and shall come from an approved shipment as verified by the WSDOT Quality Systems Manual Verification Procedure No. 2.

5.3 Beam Molds – Refer to WSDOT Test Method T 808.

5.4 Tamping Rod – Two sizes are specified as indicated in Table 1. Each shall be a round, straight steel rod with at least the tamping end rounded to a hemispherical tip of the same diameter as the rod. Both ends may be rounded if preferred.

<table>
<thead>
<tr>
<th>Diameter of Cylinder, in (mm)</th>
<th>Rod Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diameter, in (mm)</td>
</tr>
<tr>
<td>4 (100)</td>
<td>⅜ (10)</td>
</tr>
<tr>
<td>6 (150)</td>
<td>⅝ (16)</td>
</tr>
</tbody>
</table>

a. Rod tolerances length ± 4 in (100 mm) and diameter ± ⅛ in (2 mm).

Tamping Rod Requirements

Table 1

5.5 Vibrators – Internal vibrators shall be used. The vibrator frequency shall be at least 7,000 vibrations per minute at 150 Hz while the vibrator is operating in the concrete. The diameter of a round vibrator shall be no more than one-fourth the diameter of the
cylinder mold or one-fourth the width of the beam mold. Other shaped vibrators shall have a perimeter equivalent to the circumference of an appropriate round vibrator. The combined length of the vibrator shaft and vibrating element shall exceed the depth of the section being vibrated by at least 3 in (75 mm). The vibrator frequency shall be checked periodically.

**Note 1:** For information on size and frequency of various vibrators and a method to periodically check vibrator frequency, see ACI 309R.

5.6 Mallet – A mallet with a rubber or rawhide head weighing 1.25 ± 0.50 lb (0.57 ± 0.23 kg) shall be used.

5.7 Small Tools – Tools and items that may be required are shovels, pails, trowels, wood float, metal float, blunted trowels, straightedge, feeler gauge, scoops, and rules.

5.8 Sampling and Mixing Receptacle – The receptacle shall be a suitable heavy gage metal pan, wheelbarrow, or flat, clean non-absorbent mixing board of sufficient capacity to allow easy remixing of the entire sample with a shovel or trowel.

5.9 Cure Box – The cure box shall be capable of maintaining temperatures between 60°F and 80°F. The box shall also be capable of maintaining an environment that does not allow moisture loss from the concrete cylinders.

5.10 Temperature Measuring Device – The temperature measuring device shall be capable of recording the minimum and maximum temperature within a 24 hr period. The thermometer shall be capable of reading from 32°F to 150°F (0°C to 65°C) with an accuracy of 1.8°F (1.0°C).

6. Testing Requirements

Testing for determining the compressive strength at 28 days shall require a set of two specimens made from the same sample.

6.1 Compressive Strength Specimens – Compressive strength specimens shall be cylinders cast and allowed to set in an upright position. The length shall be twice the diameter. The cylinder diameter shall be at least three times the nominal maximum size of the coarse aggregate. The standard specimen shall be the 4 by 8 in (100 by 200 mm) cylinder when the nominal maximum size of the coarse aggregate does not exceed 1 in (25 mm). When the nominal maximum size of the coarse aggregate exceeds 1 in (25 mm) the specimens shall be made with 6 by 12 in (150 by 300 mm) cylinders. Mixing of cylinder sizes for a particular concrete mix design is not permitted on a project. When the nominal maximum size of the coarse aggregate exceeds 2 in (50 mm), the concrete sample shall be treated by wet sieving through a 2 in (50 mm) sieve as described in FOP for WAQTC TM 2. Contact the Materials Laboratory for directions.

**Note 2:** The nominal maximum size is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

**Note 3:** When molds in SI units are required and not available, equivalent inch-pound unit size molds should be permitted.
6.2 Flexural Strength Specimens

Refer to WSDOT Test Method T 808.

7. Sampling Concrete

7.1 The samples used to fabricate test specimens under this standard shall be obtained in accordance with FOP for WAQTC TM 2 unless an alternative procedure has been approved.

7.2 Record the identification of the sample with respect to the location of the concrete represented and the time of casting.

7.3 Cylinders shall be made using fresh concrete from the same sample as the slump, air content and temperature tests. Material from the slump, air content, and unit weight tests cannot be reused to construct cylinders.

8. Slump, Air Content, and Temperature

As required, perform the following tests prior to making cylinders:

8.1 Slump – FOP for AASHTO T 119

8.2 Air Content – FOP for WAQTC T 152 or FOP for AASHTO T 196

8.3 Temperature – FOP for AASHTO T 309

8.4 Unit Weight – AASHTO T 121

9. Molding Cylinders

9.1 Place of Molding – Mold cylinders on a level, rigid horizontal surface, free of vibration and other disturbances, at a place as near as practicable to the location where they are to be stored.

9.2 Casting the Concrete – Place the concrete in the mold using a scoop, blunted trowel, or shovel. Select each scoopful, trowelful, or shovelful of concrete from the mixing pan to ensure that it is representative of the batch. Remix the concrete in the mixing pan with a shovel or trowel to prevent segregation during the molding of specimens. Move the scoop, trowel, or shovel around the perimeter of the mold opening when adding concrete so the concrete is uniformly distributed within each layer with a minimum of segregation. Further distribute the concrete by use of the tamping rod prior to the start of consolidation. In placing the final layer, the operator shall attempt to add an amount of concrete that will exactly fill the mold after consolidation. Underfilled molds shall be adjusted with representative concrete during consolidation of the top layer. Overfilled molds shall have excess concrete removed.
9.2.1 Number of Layers – Make specimens in layers as indicated in Table 2 or 3.

<table>
<thead>
<tr>
<th>Cylinders: Diameter, in (mm)</th>
<th>Number of Layers of Approximately Equal Depth</th>
<th>Number of Roddings per Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinders: Diameter, in (mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (100)</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>6 (150)</td>
<td>3</td>
<td>25</td>
</tr>
</tbody>
</table>

**Molding Requirements by Rodding**  
*Table 2*

<table>
<thead>
<tr>
<th>Cylinders: Diameter, in (mm)</th>
<th>Number of Layers</th>
<th>Number of Vibrator Insertions per Layer</th>
<th>Approximate Depth of Layer, in (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinders: Diameter, in (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (100)</td>
<td>2</td>
<td>1</td>
<td>one-half depth of specimen</td>
</tr>
<tr>
<td>6 (150)</td>
<td>2</td>
<td>2</td>
<td>one-half depth of specimen</td>
</tr>
</tbody>
</table>

**Molding Requirements by Vibration**  
*Table 3*

9.2.2 Select the proper tamping rod from 5.4 and Table 1 or the proper vibrator from 5.5. If the method of consolidation is rodding, determine molding requirements from Table 2. If the method of consolidation is vibration, determine molding requirements from Table 3.

9.3 Consolidation

9.3.1 Method of Consolidation – Preparation of satisfactory cylinders require different methods of consolidation. The methods of consolidation are rodding and vibration. Base the selection of the method of consolidation on slump, unless the method is stated in the specifications under which the work is being performed. Rod or vibrate concretes with slumps greater than 1 in (25 mm). Vibrate concretes with slumps less than or equal to 1 in (25 mm). Concretes of such low water content that they cannot be properly consolidated by the method herein, or requiring other sizes and shapes of specimens to represent the product or structure, are not covered by this method. Specimens for such concretes shall be made in accordance with the requirements of R 39 with regards to specimen size and shape and method of consolidation.

9.3.2 Rodding – Place the concrete in the mold, in the required number of layers of approximately equal volume. Rod each layer with the rounded end of the rod using the required number of roddings specified in Table 2. Rod the bottom layer throughout its depth. Distribute the strokes uniformly over the cross section of the mold. For each layer, allow the rod to penetrate through the layer being rodded and into the layer below approximately 1 in (25 mm). After each layer is rodded, tap the outsides of the mold lightly 10 to 15 times with the open hand, mallet, or rod, to close any holes left by rodding and to release any large air bubbles that may have been trapped.
9.3.3  Vibration – Maintain a uniform time period for duration of vibration for the particular kind of concrete, vibrator, and specimen mold involved. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually, sufficient vibration has been applied as soon as the surface of the concrete has become relatively flat and large air bubbles cease to break through the top surface. Continue vibration only long enough to achieve proper consolidation of the concrete. (See Note 4.) Fill the molds and vibrate in the required number of approximately equal layers. Place all the concrete for each layer in the mold before starting vibration of that layer. Compacting the specimen, insert the vibrator slowly and do not allow it to rest on the bottom or sides of the mold. Slowly withdraw the vibrator so that no large air pockets are left in the specimen. When placing the final layer, avoid overfilling by more than ¼ in (6 mm).

Note 4: Generally, no more than 5 s of vibration should be required for each insertion to adequately consolidate concrete with a slump greater than 3 in (75 mm). Longer times may be required for lower slump concrete, but the vibration time should rarely have to exceed 10 s per insertion.

9.3.3.1  Cylinders – The number of insertions of a vibrator per layer is given in Table 3. When more than one insertion per layer is required, distribute the insertion uniformly within each layer. Allow the vibration to penetrate through the layer being vibrated, and into the layer below, approximately 1 in (25 mm). After each layer is vibrated, tap the outsides of the mold lightly 10 to 15 times with the open hand, mallet, or rod, to close any holes left by rodding and to release any large air bubbles that may have been trapped.

9.3.3.2  Beam – Refer to WSDOT Test Method T 808.

9.4  Finishing – After consolidation, strike off excess concrete from the surface. Perform all finishing with the minimum manipulation necessary to produce a flat even surface that is level with the rim or edge of the mold and that has no depressions or projections larger than ⅛ in (3.2 mm). Place lid on cylinder.

10.  Curing

10.1  Standard Curing – Standard curing is the curing method used when the specimens are made and cured for the purposes stated in 4.2.

10.1.1  Storage – If specimens cannot be molded at the place where they will receive initial curing, immediately after finishing, move the specimens to an initial curing place for storage. The supporting surface on which specimens are stored shall be level to within ¼ in per ft (20 mm per m). If cylinders in the single-use molds are moved, lift and support the cylinders from the bottom of the molds with a large trowel or similar device. If the top surface is marred during movement to place of initial storage, immediately refinish.
10.1.2 Initial Curing – Immediately after molding and finishing, the specimens shall be stored in a cure box for a period 24 ± 8 hours, unless Contractor provides initial curing information for final set.

For concrete with a specified strength less than 6,000 psi the cure temperature shall be between 60°F and 80°F and for concrete with specified strengths of 6,000 psi and higher the cure temperature shall be between 68°F and 78°F.

A minimum/maximum thermometer shall be mounted on the cure box such that the thermometer reads the internal temperature of the box but is visible from the outside. Keep a record of the minimum and maximum temperatures at intervals of 24 hours during the initial curing time.

Do not exceed the capacity of the cure box. When concrete is placed at more than one location simultaneously, each location must have its own cure box.

Once concrete cylinders are placed in the cure box, the cure box shall not be moved until the cylinders are ready to be transported to the final cure location (See 10.1.3).

10.1.3 Transportation of Specimens to Final Cure Location – Prior to transporting, cure and protect specimens as required in Section 10. Specimens shall not be transported until at least 8 h after final set. (See Note 5) During transporting, protect the specimen with suitable cushioning material to prevent damage from jarring and transport in an upright position. During cold weather, protect the specimens from freezing by transporting in an insulated container. Prevent moisture loss during transportation by use of tight-fitting plastic caps on plastic molds. Transportation time shall not exceed 4 h.

Note 5: If a specimen does not attain final set within 32 hours, it is to remain in place until final set is reached. The time of final set shall be provided by the concrete producer. After final set is reached, it can then be transported.

10.1.4 Final Curing

10.1.4.1 Cylinders – Upon completion of initial curing and within 30 minutes after removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of 73 ± 3°F (23 ± 2°C) using water storage tanks or moist rooms complying with the requirements of Specification M 201, except when capping with sulfur mortar capping compound and immediately before testing. When capping with sulfur mortar capping compounds, the ends of the cylinder shall be dry enough to preclude the formation of steam or foam pockets under or in cap larger than ¼ in (6 mm) as described in T 231. For a period not to exceed 3 h immediately prior to test, standard curing temperature is not required provided free moisture is maintained on the cylinders and ambient temperature is between 68 to 80°F (20 and 30°C).

10.1.4.2 Beams – Refer to WSDOT Test Method T 808.
10.2 Field Curing – Field curing is the curing method used for the specimens made for the purposes stated in 4.3.

10.2.1 Cylinders – Store cylinders in or on the structure as near to the point of deposit of the concrete represented as possible. Protect all surfaces of the cylinders from the elements in as near as possible the same way as the formed work. Provide the cylinders with the same temperature and moisture environment as the structural work. Test the specimens in the moisture condition resulting from the specified curing treatment. To meet these conditions, specimens made for the purpose of determining when a structure is capable of being put in service shall be removed from the molds at the time of removal of form work.

10.2.2 Beams – Refer to WSDOT Test Method T 808.

11. Transportation of Specimens to Laboratory

See Section 10.1.3

12. Report

12.1 Report the following information to the laboratory that will test the specimens:

12.1.1 Identification number.

12.1.2 Location of concrete represented by the samples.

12.1.3 Date, time, and name of individual molding specimens.

12.1.4 Slump, air content, and concrete temperature, test results and results of any other tests on the fresh concrete and any deviations from referenced standard test methods.

12.1.5 Record all information required using the Materials Testing System (MATS) electronic Concrete Transmittal.

**Note:** Agencies that do not have access to MATS may use WSDOT Form 350-009 Concrete Cylinder Transmittal.
Performance Exam Checklist  
*Making and Curing Concrete Test Specimens in the Field*  
**FOP for AASHTO T 23**

Participant Name ________________________________  
Exam Date ____________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
</tr>
<tr>
<td>2. Molds placed on a level, rigid, horizontal surface free of vibration?</td>
</tr>
<tr>
<td>3. Making of specimens begun within 15 minutes of sampling?</td>
</tr>
<tr>
<td>4. Concrete placed in the mold, moving a scoop or trowel around the perimeter of the mold to evenly distribute the concrete as discharged?</td>
</tr>
<tr>
<td>5. Mold filled in correct number of layers, attempting to exactly fill the mold on the last layer?</td>
</tr>
<tr>
<td>6. Each layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
</tr>
<tr>
<td>7. Bottom layer rodded throughout its depth?</td>
</tr>
<tr>
<td>8. Middle and top layers rodded, each throughout their depths, and penetrate into the underlying layer?</td>
</tr>
<tr>
<td>9. Sides of the mold tapped 10-15 times after rodding each layer?</td>
</tr>
<tr>
<td>10. Strike off excess concrete, and finished the surface with a minimum of manipulation?</td>
</tr>
<tr>
<td>11. Specimens covered with non-absorbent, nonreactive cap or plate?</td>
</tr>
</tbody>
</table>

First Attempt: Pass ☐ Fail ☐  
Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ________________________________

This checklist is derived, in part, from copyrighted material printed in ACI CP-1, published by the American Concrete Institute.

Comments:
Sieve Analysis of Fine and Coarse Aggregates

Significance

Sieve analyses are performed on aggregates used in roadway bases and in portland cement and asphalt cement concretes. Sieve analyses reveal the size makeup of aggregate particles – from the largest to the smallest. A gradation curve or chart showing how evenly or unevenly the sizes are distributed between largest and smallest is created in this test. How an aggregate is graded has a major impact on the strength of the base or on the properties and performance of concrete. In portland cement concrete (PCC), for example, gradation influences shrinkage and shrinkage cracking, pumpability, finishability, permeability, and other characteristics.

Scope

This procedure covers sieve analysis in accordance with AASHTO T 27 and materials finer than No. 200 (75 µm) in accordance with AASHTO T 11. The procedure combines the two test methods.

Sieve analyses determines the gradation or distribution of aggregate particles within a given sample in order to determine compliance with design and production standards.

Accurate determination of material smaller than No. 200 (75 µm) cannot be made with AASHTO T 27 alone. If quantifying this material is required, it is recommended that AASHTO T 27 be used in conjunction with AASHTO T 11. Following AASHTO T 11, the sample is washed through a No. 200 (75 µm) sieve. The amount of material passing this sieve is determined by comparing dry sample masses before and after the washing process.

This procedure covers sieve analysis in accordance with AASHTO T 27 and materials finer than No. 200 (75 µm) in accordance with AASHTO T 11. The procedure includes two method choices, A and B.

Note: All Field Operating Procedures (FOPs) referred to in this procedure are WSDOT FOPs.

Apparatus

- Balance or scale – Capacity sufficient for the masses shown in Table 2, accurate to 0.1 percent of the sample mass or better and conform to the requirements of AASHTO M 231.
- Sieves – Meeting the requirements of AASHTO M 92.
- Mechanical sieve shaker – Meeting the requirements of AASHTO T 27.
- Suitable drying equipment (see FOP for AASHTO T 255).
- Containers and utensils – A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.
- Optional Mechanical washing device.

1This FOP is based on WAQTC FOP for AASHTO T 27/T 11 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5497.
Sample Sieving

In all procedures it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification. The sieves are nested in order of decreasing size from the top to the bottom and the sample, or a portion of the sample, is placed on the top sieve. The sample may also be sieved in increments.

Sieves are shaken in a mechanical shaker for the minimum time determined to provide complete separation for the sieve shaker being used.

Time Evaluation

WSDOT has deleted this section.

Overload Determination

Additional sieves may be necessary to provide other information, such as fineness modulus, or to keep from overloading sieves. The sample may also be sieved in increments.

For sieves with openings smaller than No. 4 (4.75 mm), the mass retained on any sieve shall not exceed 4 g/in² (7 kg/m²) of sieving surface. For sieves with openings No. 4 (4.75 mm) and larger, the mass, in grams shall not exceed the product of 2.5 × (sieve opening in mm) × (effective sieving area). See Table 1.

<table>
<thead>
<tr>
<th>Sieve Size US inches (mm)</th>
<th>8 φ (203)</th>
<th>12 φ (305)</th>
<th>12 × 12 (305 × 305)</th>
<th>14 × 14 (350 × 350)</th>
<th>16 × 24 (372 × 580)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3½ (90)</td>
<td>*</td>
<td>15.1</td>
<td>20.9</td>
<td>27.6</td>
<td>48.5</td>
</tr>
<tr>
<td>3 (75)</td>
<td>*</td>
<td>12.6</td>
<td>17.4</td>
<td>23.0</td>
<td>40.5</td>
</tr>
<tr>
<td>2½ (63)</td>
<td>*</td>
<td>10.6</td>
<td>14.6</td>
<td>19.3</td>
<td>34.0</td>
</tr>
<tr>
<td>2 (50)</td>
<td>3.6</td>
<td>8.4</td>
<td>11.6</td>
<td>15.3</td>
<td>27.0</td>
</tr>
<tr>
<td>1½ (37.5)</td>
<td>2.7</td>
<td>6.3</td>
<td>8.7</td>
<td>11.5</td>
<td>20.2</td>
</tr>
<tr>
<td>1 (25.0)</td>
<td>1.8</td>
<td>4.2</td>
<td>5.8</td>
<td>7.7</td>
<td>13.5</td>
</tr>
<tr>
<td>¾ (19.0)</td>
<td>1.4</td>
<td>3.2</td>
<td>4.4</td>
<td>5.8</td>
<td>10.2</td>
</tr>
<tr>
<td>¾ (16.0)</td>
<td>1.1</td>
<td>2.7</td>
<td>3.7</td>
<td>4.9</td>
<td>8.6</td>
</tr>
<tr>
<td>½ (12.5)</td>
<td>0.89</td>
<td>2.1</td>
<td>2.9</td>
<td>3.8</td>
<td>6.7</td>
</tr>
<tr>
<td>¾ (9.5)</td>
<td>0.67</td>
<td>1.6</td>
<td>2.2</td>
<td>2.9</td>
<td>5.1</td>
</tr>
<tr>
<td>¼ (6.3)</td>
<td>0.44</td>
<td>1.1</td>
<td>1.5</td>
<td>1.9</td>
<td>3.4</td>
</tr>
<tr>
<td>No. 4 (4.75)</td>
<td>0.33</td>
<td>0.80</td>
<td>1.1</td>
<td>1.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Less than (No. 4)</td>
<td>0.20</td>
<td>0.47</td>
<td>0.65</td>
<td>0.86</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Sample sizes above are in kilograms to convert: To grams multiple by 1,000. To convert to pounds multiple by 2.2.

Maximum Allowable Mass of Material Retained on a Sieve, kg

Table 1
Sample Preparation

Obtain samples in accordance with the FOP for AASHTO T 2 and reduce to the size shown in Table 2 in accordance with the FOP for AASHTO T 248.

If the gradation sample is obtained from FOP for AASHTO T-308, the Ignition Furnace, proceed to Procedure Method A, Step 2.

<table>
<thead>
<tr>
<th>Nominal Maximum</th>
<th>Minimum Dry Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size* in (mm)</td>
<td>lb</td>
</tr>
<tr>
<td>US No. 4 (4.75)</td>
<td>1</td>
</tr>
<tr>
<td>¼ (6.3)</td>
<td>2</td>
</tr>
<tr>
<td>⅜ (9.5)</td>
<td>2</td>
</tr>
<tr>
<td>½ (12.5)</td>
<td>5</td>
</tr>
<tr>
<td>% (16.0)</td>
<td>5</td>
</tr>
<tr>
<td>⅝ (19.0)</td>
<td>7</td>
</tr>
<tr>
<td>1 (25.0)</td>
<td>13</td>
</tr>
<tr>
<td>1¼ (31.5)</td>
<td>17</td>
</tr>
<tr>
<td>1½ (37.5)</td>
<td>20</td>
</tr>
<tr>
<td>2 (50)</td>
<td>22</td>
</tr>
<tr>
<td>2½ (63)</td>
<td>27</td>
</tr>
<tr>
<td>3 (75)</td>
<td>33</td>
</tr>
<tr>
<td>3½ (90)</td>
<td>44</td>
</tr>
</tbody>
</table>

*For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

Sample Sizes for Aggregate Gradation Test

Table 2

Note: For an aggregate specification having a generally unrestrictive gradation (i.e. wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

WSDOT Note 1: These sample sizes are standard for aggregate testing but, due to equipment restraints, samples may need to be partitioned into several “subsamples.” See Method A.

Overview

Method A – This method is the preferred method of sieve analysis for HMA aggregate.

- Determine dry mass of original sample
- Wash through a No. 200 (75 µm) sieve
- Determine dry mass of washed sample
- Sieve material

Method B

- Determine dry mass of original sample
- Wash through a No. 200 (75 µm) sieve
- Determine dry mass of washed sample
- Sieve coarse material
- Determine mass of fine material
- Reduce fine portion
- Determine mass of reduced portion
- Sieve fine portion
Procedure Method A

1. Dry the sample in accordance with the FOP for AASHTO T 255, and record to the nearest 0.1 percent of total mass or better.

2. When the specification requires that the amount of material finer than No. 200 (75 µm) be determined, do Step 3 through Step 9 – otherwise, skip to Step 10.

   **WSDOT Note 2:** If the applicable specification requires that the amount passing the No. 200 (75 µm) sieve be determined on a portion of the sample passing a sieve smaller than the nominal maximum size of the aggregate, separate the sample on the designated sieve and determine the mass of the material passing that sieve to 0.1 percent of the mass of this portion of the test sample. Use the mass as the original dry mass of the test sample.

3. Nest a sieve, any sieve ranging from a No. 8 (2.36 mm) to a No.16 (1.18 mm) may be used, above the No. 200 (75 µm) sieve.

4. Place the test sample in a container and add sufficient water to cover it.

   **WSDOT Note 3:** A detergent, dispensing agent, or other wetting solution may be added to the water to assure a thorough separation of the material finer than the No. 200 (75 µm) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

5. Agitate vigorously to ensure complete separation of the material finer than No. 200 (75 µm) from coarser particles and bring the fine material into suspension above the coarser material. When using a mechanical washing device, exercise caution to not degrade the sample.

6. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves, being careful not to pour out the coarser particles.

7. Add a second change of water to the sample remaining in the container, agitate, and repeat Step 6. Repeat the operation until the wash water is reasonably clear.

8. Return all material retained on the nested sieves to the container by flushing into the washed sample.

   **WSDOT Note 4:** A suction device may be used to extract excess water from the washed sample container. Caution will be used to avoid removing any material greater than the No. 200.

9. Dry the washed aggregate in accordance with the FOP for AASHTO T 255, and then cool prior to sieving. Record the cooled dry mass.

10. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom and place the sample, or a portion of the sample, on the top sieve.

11. Place sieves in mechanical shaker and shake for a minimum of 10 minutes, or the minimum time determined to provide complete separation if this time is greater than 10 minutes for the sieve shaker being used.
12. Determine the individual or cumulative mass retained on each sieve and the pan to the nearest 0.1 percent or 0.1 g.

**WSDOT Note 5:** Use coarse wire brushes to clean the No. 40 (425 μm) and larger sieves, and soft bristle brushes for smaller sieves.

**Calculations**

The total mass of material after sieving should be verified with the mass before sieving. If performing T 11 with T 27 this would be the dry mass after wash. If performing just T 27 this would be the original dry mass. When the masses before and after sieving differ by more than 0.3 percent do not use the results for acceptance purposes. When performing the gradation from HMA using T 308, the masses before and after sieving shall not differ by more than 0.2 percent.

Calculate the total percentages passing, individual or cumulative percentages retained, or percentages in various size fractions to the nearest 0.1 percent by dividing the masses for Method A, or adjusted masses for Methods B and C, on the individual sieves by the total mass of the initial dry sample. If the same test sample was first tested by T 11, use the total dry sample mass prior to washing in T 11 as the basis for calculating all percentages. Report percent passing as indicated in the “Report” section at the end of this FOP.

Percent Retained:

\[
IPR = \frac{IMR}{M} \times 100 \quad \text{or} \quad CPR = \frac{CMR}{M} \times 100
\]

Where:
- IPR = Individual Percent Retained
- CPR = Cumulative Percent Retained
- M = Total Dry Sample mass before washing
- IMR = Individual Mass Retained OR Adjusted Individual mass from Methods B or C
- CMR = Cumulative Mass Retained OR Adjusted Individual mass from Methods B or C

OR

Percent Passing (Calculated):

\[
PP = PPP - IPR \quad \text{or} \quad PP = 100 - CPR
\]

Where:
- PP = Percent Passing
- PPP = Previous Percent Passing

Calculate cumulative percent retained on and passing each sieve on the basis of the dry mass of total sample, before washing. This will include any material finer than No. 200 (75 μm) that was washed out.

Divide the cumulative masses, or the corrected masses, on the individual sieves by the total mass of the initial dry sample (prior to washing) to determine the percent retained on and passing each sieve. Calculate the percent retained on and passing each sieve. Report percent passing as indicated in the “Report” section at the end of this FOP.
Example

Dry mass of total sample, before washing: 3214.0 g
Dry mass of sample, after washing out the No. 200 (75 µm) minus: 3085.1 g

For the ½ sieve:

Cumulative Mass retained on ½" sieve = 161.0 g

Cumulative % retained = \(\frac{161.0}{3214.0} \times 100 = 5.0\%\) retained

% passing = 100-5.0 = 95% passing ½" sieve

<table>
<thead>
<tr>
<th>Sieve Size in (mm)</th>
<th>Cumulative Mass Retained g</th>
<th>Cumulative Percent Retained</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>⅜ (9.5)</td>
<td>642.0</td>
<td>20.0</td>
<td>80</td>
</tr>
<tr>
<td>No. 4 (4.75)</td>
<td>1118.3</td>
<td>34.8</td>
<td>65</td>
</tr>
<tr>
<td>**No. 6 (3.35)</td>
<td>1515.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 10 (2.0)</td>
<td>1914.7</td>
<td>59.6</td>
<td>40</td>
</tr>
<tr>
<td>No. 40 (0.425)</td>
<td>2631.6</td>
<td>81.9</td>
<td>18</td>
</tr>
<tr>
<td>No. 80 (0.210)</td>
<td>2862.7</td>
<td>89.1</td>
<td>11</td>
</tr>
<tr>
<td>No. 200 (0.075)</td>
<td>3051.1</td>
<td>94.9</td>
<td>5.1</td>
</tr>
<tr>
<td>Pan</td>
<td>3086.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Report No. 200 (75 µm) sieve to 0.1 percent. Report all others to 1 percent.
**Intermediate sieve used to prevent overloading the U. S. No. 10 sieve.

Gradation on All Screens

Test Validation: 3086.4 – 3085.1/3085.1 x 100 = 0.04 % which is within the 0.3 percent requirement and the results can be used for acceptance purposes.
Procedure Method B

1. Perform steps 1 thru 9 from the Procedure Method A then continue as follows:

2. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the No. 4 (4.75 mm) with a pan at the bottom to retain the minus No. 4 (4.75 mm). (See Table 1.)

3. Place sieves in mechanical shaker and shake for a minimum of 10 minutes, or the minimum time determined to provide complete separation if this time is greater than 10 minutes for the sieve shaker being used.

4. Determine the individual or cumulative mass retained on each sieve and the pan to the nearest 0.1 percent or 0.1 g. Ensure that all material trapped in the openings of the sieve are cleaned out and included in the mass retained. (See Note 5)

5. Determine the mass retained on each sieve to the nearest 0.1 percent of the total mass or better.

6. Determine the mass of the material in the pan (minus No. 4 (4.75 mm)).

7. Reduce the minus No. 4 (4.75 mm) using a mechanical splitter in accordance with the FOP for AASHTO T 248 to produce a sample with a mass of 500 g minimum. Determine and record the mass of the minus No. 4 (4.75 mm) split.

8. Select sieves to furnish information required by the specifications. Nest the sieves in order of decreasing size from top to bottom through the No. 200 (75 µm) with a pan at the bottom to retain the minus No. 200 (75 µm).

9. Place sieves in mechanical shaker and shake for a minimum of 10 minutes, or the minimum time determined to provide complete separation if this time is greater than 10 minutes for the sieve shaker being used.

10. Determine the individual or cumulative mass retained on each sieve and the pan to the nearest 0.1 percent or 0.1 g. Ensure that all material trapped in the openings of the sieve are cleaned out and included in the mass retained. (See Note 5)

Calculations

Compute the “Adjusted Cumulative Mass Retained” of the size increment of the original sample as follows when determining “Cumulative Mass Retained”:

Divide the cumulative masses, or the corrected masses, on the individual sieves by the total mass of the initial dry sample (prior to washing) to determine the percent retained on and passing each sieve. Calculate the percent retained on and passing each sieve. Report percent passing as indicated in the “Report” section at the end of this FOP.

When material passing the No. 4 (4.75 mm) sieve is split and only a portion of that is tested, the proportionate share of the amount passing the No. 200 (75 µm) sieve must be added to the sample mass to obtain a corrected test mass. This corrected test mass is used to calculate the gradation of the material passing the No. 4 (4.75 mm) sieve.
C = \left( \frac{M_1}{M_2} \times B \right) + D

Where:
- C = Total cumulative mass retained of the size increment based on a total sample
- M_1 = Mass of fraction finer than No. 4 (4.75 mm) sieve in total sample
- M_2 = Mass of reduced portion of material finer than No. 4 (4.75 mm) sieve actually sieved
- B = Cumulative mass of the size increment in the reduced portion sieved
- D = Cumulative mass of plus No. 4 (4.75 mm) portion of sample

Example:

Dry mass of total sample, before washing: 3214.0 g

Dry mass of sample, after washing out the No. 200 (75 µm) minus: 3085.1 g

Gradation on Coarse Screens

<table>
<thead>
<tr>
<th>Sieve Size in (mm)</th>
<th>Cumulative Mass Retained (g)</th>
<th>Cumulative Percent Retained</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ (19.0)</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>½ (12.5)</td>
<td>161.0</td>
<td>5.0</td>
<td>95</td>
</tr>
<tr>
<td>⅜ (9.50)</td>
<td>642.0</td>
<td>20.0</td>
<td>80</td>
</tr>
<tr>
<td>No. 4 (4.75)</td>
<td>1118.3</td>
<td>34.8</td>
<td>65</td>
</tr>
</tbody>
</table>

Pan = 1968.0

Test Validation: 1118.3 + 1968.0 - 3085.1/3085.1 x 100 = 0.04% which is within the 0.3 percent requirement and the results can be used for acceptance purposes.

The actual mass of material passing the No. 4 (4.75 mm) sieve and retained in the pan is 1968.0 g. This is M_1.

The pan (1968.0 grams) was reduced in accordance with the FOP for AASHTO T 248, so that at least 500 g are available. In this case, the mass determined was 512.8 g. This is M_2.

Gradation on Fine Screens

<table>
<thead>
<tr>
<th>Sieve Size in (mm)</th>
<th>Cumulative Mass Retained (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4 (4.75)</td>
<td>0</td>
</tr>
<tr>
<td>No. 10 (2.00)</td>
<td>207.5</td>
</tr>
<tr>
<td>No. 40 (0.425)</td>
<td>394.3</td>
</tr>
<tr>
<td>No. 80 (0.210)</td>
<td>454.5</td>
</tr>
<tr>
<td>No. 200 (0.075)</td>
<td>503.6</td>
</tr>
<tr>
<td>Pan</td>
<td>512.8</td>
</tr>
</tbody>
</table>

Test Validation: 512.8 - 512.8/512.8 = 0.0 % which is within the 0.3 percent requirement and the results can be used for acceptance purposes.
For the No. 10 sieve:
\[ M_1 = 1968.0 \text{g} \]
\[ M_2 = 512.8 \text{g} \]
\[ B = 207.5 \text{g} \]
\[ D = 1118.3 \text{g} \]

\[ C = \frac{M_1}{M_2} \times B + D = \frac{1968.0 \text{g}}{512.8 \text{g}} \times 207.5 \text{g} + 1118.3 \text{g} = 1914.7 \text{g} \]

\[ \% \text{ retained} = \frac{1914.7 \text{g}}{3214.0 \text{g}} = 59.6\% \]

\[ \% \text{ passing} = 100 - 59.6 = 40.4\%, \text{ reported as 40\%} \]

**Final Gradation on All Screens**

<table>
<thead>
<tr>
<th>Sieve Size in (mm)</th>
<th>Cumulative Mass Retained g</th>
<th>Adjusted Cumulative Mass Retained g</th>
<th>Cum. Percent Retained</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ (19.0)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>½ (12.5)</td>
<td>161.1</td>
<td>161.1</td>
<td>5.0</td>
<td>95</td>
</tr>
<tr>
<td>¼ (9.5)</td>
<td>642.5</td>
<td>642.5</td>
<td>20.0</td>
<td>80</td>
</tr>
<tr>
<td>No. 4 (4.75)</td>
<td>1118.3</td>
<td>1118.3</td>
<td>34.8</td>
<td>65</td>
</tr>
<tr>
<td>No. 10 (2.0)</td>
<td>207.5 \times 3.838 + 1118.3</td>
<td>1914.7</td>
<td>59.6</td>
<td>40</td>
</tr>
<tr>
<td>No. 40 (0.425)</td>
<td>394.3 \times 3.838 + 1118.3</td>
<td>2631.6</td>
<td>81.6</td>
<td>18</td>
</tr>
<tr>
<td>No. 80 (0.210)</td>
<td>454.5 \times 3.838 + 1118.3</td>
<td>2862.7</td>
<td>89.1</td>
<td>11</td>
</tr>
<tr>
<td>No. 200 (0.075)</td>
<td>503.6 \times 3.838 + 1118.3</td>
<td>3051.1</td>
<td>94.9</td>
<td>5.1</td>
</tr>
<tr>
<td>Pan</td>
<td>512.8 \times 3.838 + 1118.3</td>
<td>3086.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Report No. 200 (75 µm) sieve to 0.1 percent. Report all others to 1 percent.

**Alternative Method B**

As an alternate method to account for the fact that only a portion of the minus No. 4 (4.75 mm) material was sieved, multiply the fine screen “Percent Passing” values by the percent passing the No. 4 (4.75 mm) sieve obtained in the coarse screen procedure, 65 percent in this case.

The mass retained in the pan must be corrected to include the proper percent of No. 200 (.075 mm) minus material washed out.

Divide the cumulative masses, or the corrected masses, on the individual sieves by the corrected pan mass of the initial dry sample (prior to washing) to determine the percent retained on and passing each sieve. Calculate the percent retained on and passing each sieve. Report percent passing as indicated in the “Report” section at the end of this FOP.

Dry mass of total sample, before washing: 3214.0 g
Dry mass of sample, after washing out the No. 200 (75 µm) minus: 3085.1 g
Amount of No. 200 (75 µm) minus washed out: 3214.0 g − 3085.1 g = 128.9 g
### Sieve Analysis of Fine and Coarse Aggregates

#### Sieve Size in (mm) | Cumulative Mass Retained (g) | Cumulative Percent Retained | Reported Percent Passing*
---|---|---|---
¾ (19.0) | 0 | 0 | 100
½ (12.5) | 161.0 | 5.0 | 95
⅜ (9.50) | 642.0 | 20.0 | 80
No. 4 (4.75) | 1118.3 | 34.8 | 65

#### Gradation on Coarse Screens

Pan = 1968.0

Test validation: \( \frac{1118.3 + 1968.0 - 3085.1}{3085.1} \times 100 = 0.04\% \)

which is within the 0.3 percent requirement and the results can be used for acceptance purposes.

The actual mass of material passing the No. 4 (4.75 mm) sieve and retained in the pan is 1968.0 g. This is \( M_3 \).

The pan (1968.0 grams) was reduced in accordance with the FOP for AASHTO T 248, so that at least 500 g are available. In this case, the mass determined was 512.8 g. This is \( M_4 \).

\[
\text{Corrected pan mass} = M_4 + \frac{(M_4)(C_1)}{M_3}
\]

Where:
- \( M_4 \) = Mass retained in the pan from the split of the No. 4 (4.75 mm) minus
- \( M_3 \) = Mass of the No. 4 (4.75 mm) minus of entire sample, not including No. 200 (.075 mm) minus washed out
- \( C_1 \) = Mass of No. 200 (.075 mm) minus washed out

#### Sieve Size in (mm) | Cumulative Mass Retained (g) | Cumulative Percent Retained | Percent Passing
---|---|---|---
No. 4 (4.75) | 0 | 0 | 100.0
No. 10 (2.00) | 207.5 | 38.0 | 62.0
No. 40 (0.425) | 394.3 | 72.2 | 27.8
No. 80 (0.210) | 454.5 | 83.2 | 16.8
No. 200 (0.075) | 503.6 | 92.2 | 7.8
Pan | 512.8 | | |

The corrected pan mass is the mass used to calculate the percent retained for the fine grading.
Example:

\[ M_4 = 512.8g \]
\[ M_3 = 1968.0g \]
\[ C_1 = 128.9g \]

Corrected pan mass = \[ 512.8g + \frac{(512.8g)(128.9g)}{1968.0g} = 546.4g \]

For the No. 10 sieve:

Mass of No. 10 sieve = 207.5g

Corrected Pan Mass = 546.4g

Cumulative % retained = \[ \frac{207.5g}{546.4g} \times 100 = 38\% \]

% passing = 100 - 38.0 = 62.0%

Adjusted % passing No. 10 = % passing No. 10 × % No. 4 = 62.0 × 0.65 = 40%

| Sieve Size in (mm) | Adjustment | Reported Percent Passing*
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ (19.0)</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>½ (12.5)</td>
<td></td>
<td>95</td>
</tr>
<tr>
<td>⅜ (9.5)</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>No. 4 (4.75)</td>
<td>100 × .65 =</td>
<td>65</td>
</tr>
<tr>
<td>No. 10 (2.00)</td>
<td>62.0 × .65 =</td>
<td>40</td>
</tr>
<tr>
<td>No. 40 (0.425)</td>
<td>27.8 × .65 =</td>
<td>18</td>
</tr>
<tr>
<td>No. 80 (0.210)</td>
<td>16.8 × .65 =</td>
<td>11</td>
</tr>
<tr>
<td>No. 200 (0.075)</td>
<td>7.8 × .65 =</td>
<td>5.1</td>
</tr>
</tbody>
</table>

*Report No. 200 (75 µm) sieve to 0.1 percent. Report all others to 1 percent

**Final Gradation on All Screens**
Sample Calculation for Fineness Modulus

Fineness Modulus (FM) is used in determining the degree of uniformity of aggregate gradation in PCC mix designs. It is an empirical number relating to the fineness of the aggregate. The higher the FM, the coarser the aggregate. Values of 2.40 to 3.00 are common for FA in PCC.

The FM is the sum of the percentages retained on specified sieves, for PCC fine aggregate they are: No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (0.60 mm), No. 50 (0.30 mm), and No. 100 0.15 mm) divided by 100 gives the FM.

The following example is for WSDOT Class 2 Sand:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Size</th>
<th>% Passing</th>
<th>% Retained</th>
<th>% Retained on Specified Sieves</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4</td>
<td>4.75 mm</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No. 8</td>
<td>2.36 mm</td>
<td>87</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>No. 16</td>
<td>1.18 mm</td>
<td>69</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>No. 30</td>
<td>0.60 mm</td>
<td>44</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>No. 50</td>
<td>0.30 mm</td>
<td>18</td>
<td>82</td>
<td>82</td>
</tr>
<tr>
<td>No. 100</td>
<td>0.15 mm</td>
<td>4</td>
<td>96</td>
<td>96</td>
</tr>
</tbody>
</table>

\[ \text{FM} = \frac{278}{100} = 2.78 \]

Report

Results shall be reported on standard forms approved for use by the agency. Depending on the agency, this may include:

- Cumulative mass retained on each sieve.
- Cumulative percent retained on each sieve.
- Percent passing and retained on each sieve shall be reported to the nearest 1 percent except for the percent passing the U.S. No. 200 (75 µm) sieve, which shall be reported to the nearest 0.1 percent.
- FM to the nearest 0.01 percent for WSDOT Class 2 Sand.

Report the results using one or more of the following:

- Materials Testing System (MATS)
- WSDOT Form 422-020, 422-020A, or 422-020B
- Form approved in writing by the State Materials Engineer
### Performance Exam Checklist

**WAQTC FOP for AASHTO T 27/T 11**

**Sieve Analysis of Fine And Coarse Aggregates**

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Minimum sample mass meets requirement of Table 1 or from FOP for AASHTO T 308?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Test sample dried to a constant mass by FOP for AASHTO T 255?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Test sample cooled and mass determined to nearest 0.1 percent of mass?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Sample placed in container and covered with water? (If specification requires that the amount of material finer than the No. 200 sieve is to be determined.)</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Dispersing Agent used for HMA?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Contents of the container vigorously agitated?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Complete separation of coarse and fine particles achieved?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Wash water poured through required nested sieves?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. Operation continued until wash water is reasonably clear?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. Material retained on sieves returned to washed sample?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. Washed aggregate dried to a constant mass by FOP for AASHTO T 255?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14. Washed aggregate cooled and mass determined to nearest 0.1 percent of mass?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. Sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>16. Material sieved in verified mechanical shaker for minimum of 10 minutes or for the minimum verified time whichever is longer?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>17. Mass of residue on each sieve determined to 0.1 percent of mass?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>18. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent, or 0.2 percent for HMA (per FOP for AASHTO T 308)?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>19. Percentages calculated to the nearest 0.1 percent and reported to the nearest whole number, except No. 200 - reported to the nearest 0.1 percent?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>20. Percentage calculations based on original dry sample mass?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>21. Calculations performed properly? If material passing No. 4 sieve is split and only a portion is tested, calculation as noted in FOP performed properly?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

First Attempt: Pass ☐ Fail ☐  
Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ___________________________________________
AASHTO T 99

*Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop*

AASHTO T 99, Method A, has been adopted by WSDOT.
# Tester Qualification Practical Exam Checklist

**Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop**  
**FOP for AASHTO T 99**

Participant Name ________________________________  
Exam Date __________________

## Procedure Element

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.  The tester has a copy of the current procedure on hand?</td>
<td>❑</td>
</tr>
<tr>
<td>2.  All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>❑</td>
</tr>
</tbody>
</table>

## Sample Preparation

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.  If damp, sample dried in air or drying apparatus, not exceeding 140°F (60°C)?</td>
<td>❑</td>
</tr>
<tr>
<td>2.  Sample pulverized and adequate amount sieved over the No. 4 (4.75 mm) sieve?</td>
<td>❑</td>
</tr>
<tr>
<td>3.  Material retained on the sieve discarded?</td>
<td>❑</td>
</tr>
<tr>
<td>4.  Sample passing the sieve has appropriate mass?</td>
<td>❑</td>
</tr>
</tbody>
</table>

## Procedure

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.  Sample mixed with water to approximately 4 percent below expected optimum moisture content?</td>
<td>❑</td>
</tr>
<tr>
<td>2.  Layer of soil placed in mold with collar attached?</td>
<td>❑</td>
</tr>
<tr>
<td>3.  Mold placed on rigid and stable foundation?</td>
<td>❑</td>
</tr>
<tr>
<td>4.  Lightly tamp soil in mold?</td>
<td>❑</td>
</tr>
<tr>
<td>5.  Soil compacted with 25 blows?</td>
<td>❑</td>
</tr>
<tr>
<td>6.  Scrape sides of mold and evenly distributed on top of the layer?</td>
<td>❑</td>
</tr>
<tr>
<td>7.  Soil placed and compacted in three equal layers?</td>
<td>❑</td>
</tr>
<tr>
<td>8.  No more than ½ inch of soil above the top of the bottom portion of the mold?</td>
<td>❑</td>
</tr>
<tr>
<td>9.  Collar removed and soil trimmed to top of mold with straightedge?</td>
<td>❑</td>
</tr>
<tr>
<td>10.  Mass of mold and contents determined to appropriate precision?</td>
<td>❑</td>
</tr>
<tr>
<td>11.  Wet mass of specimen multiplied by mold factor to obtain wet density?</td>
<td>❑</td>
</tr>
<tr>
<td>12.  Soil removed from mold using sample extruder when applicable?</td>
<td>❑</td>
</tr>
<tr>
<td>13.  Soil sliced vertically through center?</td>
<td>❑</td>
</tr>
<tr>
<td>14.  Moisture sample removed from the entire face of one of the cut faces?</td>
<td>❑</td>
</tr>
<tr>
<td>15.  Sample weighed immediately and mass recorded?</td>
<td>❑</td>
</tr>
</tbody>
</table>
16. Moisture sample mass per Table 1?
17. Sample dried and water content determined according to AASHTO T 255 or T 265?
18. Remainder of material from mold broken up to about passing sieve size and added to remainder of original test sample?
19. Water added to increase moisture content in approximately 2 percent increments?
20. Steps 2 through 15 repeated for each increment of water added?
21. If soil is plastic (clay types):
   a. Sample mixed with water varying moisture content by approximately 2 percent, bracketing the optimum moisture content?
   b. Samples placed in covered containers and allowed to stand for at least 12 hours
22. Process continued until wet density either decreases or stabilizes?
23. Water content and dry density calculated for each sample?
24. All calculations performed correctly?

First Attempt: Pass ☐  Fail ☐  Second Attempt: Pass ☐  Fail ☐

Signature of Examiner  ________________________________

Comments:
Air Content of Freshly Mixed Concrete by the Pressure Method

Significance

Concrete is not a solid, but rather a solid with void spaces. The voids may contain gas such as air, or liquid, such as water. All concrete contains air voids, and the amount can be increased by the addition of an air entraining agent to the mix. When such an agent is used, the size of the voids drastically decreases and the number of voids greatly increases, providing a much greater dispersal of voids.

Air entrainment is necessary in concrete that will be saturated and exposed to cycles of freezing and thawing, and to deicing chemicals. The microscopic entrained air voids provide a site for relief of internal pressure that develops as water freezes and thaws inside the concrete. Without the proper entrained-air content, normal concrete that is saturated and is exposed to cycles of freezing and thawing can fail prematurely by scaling, spalling, or cracking.

Care must be taken, however, not to have too much entrained air. As the air content increases, there will be a corresponding reduction in the strength and other desirable properties of the concrete. Typically, this strength reduction will be on the order of 3 to 5 percent for each 1 percent of air content. A concrete mix design proportioned for 5 percent air, for example, will be approximately 15 to 25 percent lower in strength if the air content were to double.

Scope

This procedure covers determination of the air content in freshly mixed portland cement concrete containing dense aggregates in accordance with AASHTO T 152 (Type B meter). It is not for use with lightweight or highly porous aggregates. This procedure includes calibration of the "Type B" air meter gauge, and two methods for calibrating the gauge are presented. Concrete containing aggregate that would be retained on the 1½ in (37.5 mm) sieve must be wet sieved. Sieve a sufficient amount of the sample over the 1½ in (37.5 mm) sieve in accordance with the FOP for WAQTC TM 2.

Apparatus

- Air meter – Type B, as described in AASHTO T 152.
- Balance or scale – Accurate to 0.3 percent of the test load at any point within the range of use (for Method 1 calibration only).
- Verified external or internal calibration vessel of known volume (usually 5% ± of the volume of the meter base).
- Tamping rod – ⅝ in (16 mm) diameter and approximately 24 in (600 mm) long, having a hemispherical tip. (Hemispherical means half a sphere; the tip is rounded like half of a ball.)
- Vibrator – 7000 vibrations per minute, 0.75 to 1.50 in (19 to 38 mm) in diameter, at least 3 in (75 mm) longer than the section being vibrated for use with low slump concrete.
- Scoop.
- Container for water – rubber syringe (may also be a squeeze bottle).

---

1This FOP is based on WAQTC T 152 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
• Strike-off bar – Approximately 12 in × ¾ in × ⅛ in (300 mm × 22 mm × 3 mm).

• Strike-off Plate – A flat rectangular metal plate at least ¼ in (6 mm) thick or a glass or acrylic plate at least ½ in (12 mm) thick, with a length and width at least 2 in (50 mm) greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within tolerance of ¼ in (1.5 mm).

  Note 1: Use either the strike-off bar or strike-off plate; both are not required. Unit weight requires the use of a strike off plate.

• Mallet – With a rubber or rawhide head having a mass of 1.25 ±0.5 lb (0.57 ± 0.23 kg).

Calibration of Air Meter Gauge

  Note 2: There are two methods for calibrating the air meter, mass or volume.

1. Screw the short piece of straight tubing into the threaded petcock hole on the underside of the cover. Determine the mass of the dry, empty air meter base and cover assembly (Mass Method only).

2. Fill the base nearly full with water.

3. Clamp the cover on the base with the tube extending down into the water. Mark the petcock with the tube attached for future reference.

4. Add water through the petcock having the pipe extension below until all air is forced out the other petcock. Rock the meter slightly until all air is expelled through the petcock.

5. Wipe off the air meter base and cover assembly, and determine the mass of the filled unit (Mass Method only).

6. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

7. Close both petcocks and immediately open the main air valve exhausting air into the base. Wait a few seconds until the meter needle stabilizes. The gauge should now read 0 percent. If two or more tests show a consistent variation from 0 percent in the result, change the initial pressure line to compensate for the variation, and use the newly established initial pressure line for subsequent tests.

8. Determine which petcock has the straight tube attached to it. Attach the curved tube to external portion of the same petcock.

9. Pump air into the air chamber. Open the petcock with the curved tube attached to it. Open the main air valve for short periods of time until 5 percent of water by mass or volume has been removed from the air meter. Remember to open both petcocks to release the pressure in the base and drain the water in the curved tube back into the base. To determine the mass of the water to be removed, subtract the mass found in Step 1 from the mass found in Step 5. Multiply this value by 0.05. This is the mass of the water that must be removed. To remove 5 percent by volume, remove water until the external calibrating vessel is level full.
Note 3: Many air meters are supplied with a calibration vessel(s) of known volume that are used for this purpose. Calibration vessels must be protected from damage that would change their volume.

If an external or internal calibration vessel is used, confirm what percentage volume it represents for the air meter being used. Vessels commonly represent 5 percent volume, but they are for specific size meters. This should be confirmed by mass.

10. Remove the curved tube. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

11. Close both petcocks and immediately open the main air valve exhausting air into the base. Wait a few seconds until the meter needle is stabilized. The gauge should now read 5.0 ± 0.2 percent. If the gauge is outside that range, the meter needs adjustment. (Consult the Region Materials Lab) The adjustment could involve adjusting the starting point so that the gauge reads 5.0 ± 0.2 percent when this calibration is run, or could involve moving the gauge needle to read 5.0 percent. Any adjustment should comply with the manufacturer’s recommendations.

Note 4: Calibration shall be performed per agency standards, prior to field use, and weekly during construction use. Record the date of the calibration, the calibration results, and the name of the technician performing the calibration in the log book kept with each air meter.

WSDOT Note: Air meter calibration standard for WSDOT:

Region Laboratory – Required to calibrate air meter yearly

Project Office – Required to calibrate air meter as follows:

1. First Time Use Calibration: Calibrate air meter prior to first time use in the field each construction season or when the air meter has not been used for more than a month during the construction season.

2. Construction Use Calibration: After “First Time Use Calibration,” calibrate the air meter once a week when used during construction.

12. When the gauge hand reads correctly at 5.0 percent, additional water may be withdrawn in the same manner to check the results at other values such as 10 percent or 15 percent.

Note 5: Remove the extension tubing from threaded petcock hole in the underside of the cover before starting the test procedure.

An internal calibration vessel of known volume, usually 5% of the volume of the bucket, may be employed as a quick method to verify the calibration of the air meter during construction use. To employ this vessel proceed as follows:

13. Fill the base nearly full with water and place the internal calibration vessel into the base. Place the cover back on the base and gently add water through the petcock until all the air has been expelled. Do not disturb the meter to such an extent as to knock the calibration vessel from an upright position. Do not install either of the threaded tubes into the petcock when using the calibration vessels.
14. Pump up the air pressure to a little beyond the predetermined initial pressure indicated in the calibration record log book. Wait a few seconds for the compressed air to cool and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

15. Close both petcocks and immediately open the main air valve exhausting air into the base. Wait a few seconds and gently tap the back of the gauge until the meter needle stabilizes. The gauge should now read $5.0 \pm 0.2$ percent or $\pm 0.2$ percent of the volume indicated in the calibration vessel. If the gauge is outside of that range follow step 1 through step 12 of the calibration procedure to re-calibrate the air meter. If further adjustment is required consult the Region Materials Lab.

16. If necessary, additional vessels may be placed into the base to verify the calibration of the air meter at 10 percent volume and 15 percent volume or the sum of the volumes indicated on the individual calibration vessels.

17. Record the date that the calibration of the air meter was verified in the calibration log book.

18. Gently release the air pressure in the base by opening one of the petcocks then remove and drain any water from within the calibration vessel and store it in a safe location. The air meter is now ready for use.

**Procedure Selection**

There are two methods of consolidating the concrete – rodding and vibration. If the slump is greater than 3 in (75 mm), consolidation is by rodding. When the slump is 1 to 3 in (25 to 75 mm), internal vibration or rodding can be used to consolidate the sample, but the method used must be that required by the agency in order to obtain consistent, comparable results. For slumps less than 1 in (25 mm), consolidate the sample by internal vibration.

**Procedure – Rodding**

1. Obtain the sample in accordance with the FOP for WAQTC TM 2. If any aggregate larger than 1½ in (37.5 mm) is present, the larger aggregate must be removed. Sieve a sufficient amount of the sample over the 1½ in (37.5 mm) sieve in accordance with the Wet Sieving portion of the FOP for WAQTC TM 2. Contact the Materials Laboratory for directions.

   **Note 7:** Testing shall begin within five minutes of obtaining the sample.

2. Dampen the inside of the air meter base and place on a firm, level surface.

3. Fill the base approximately ⅓ full with concrete.

4. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. Rod throughout its depth without hitting the bottom too hard.

5. Tap the sides of the base smartly 10 to 15 times with the mallet to close voids and release trapped air.

6. Add the second layer, filling the base about ⅔ full.

7. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 1 in (25 mm) into the bottom layer.
8. Tap the sides of the base 10 to 15 times with the mallet.
9. Add the final layer, slightly overfilling the base.
10. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 1 in (25 mm) into the second layer.
11. Tap the sides of the base smartly 10 to 15 times with the mallet.

*Note 8:* The base should be slightly over full, about 1/8 in (3 mm) above the rim. If there is a great excess of concrete, remove a portion with the trowel or scoop. If the base is under full, add a small quantity. This adjustment may be done only after consolidating the final layer and before striking off the surface of the concrete.

12. Strike off the surface of the concrete and finish it smoothly with a sawing action of the strike-off bar or plate, using great care to leave the base just full. The surface should be smooth and free of voids, as much as possible.
13. Clean the top flange of the base to ensure a proper seal.
14. Moisten the inside of the cover and check to see that both petcocks are open and the main air valve is closed.
15. Clamp the cover on the base.
16. Inject water into one petcock until water emerges from the second petcock. (*Note:* Water is injected into only one petcock during the entire procedure)
17. Rock the air meter gently until no air bubbles appear to be coming out of the second petcock. The petcock expelling water should be higher than the petcock where water is being injected. Return the air meter to a level position and verify that water is present in both petcocks.
18. Close the air bleeder valve and pump air into the air chamber until the needle goes past the initial pressure line. Allow a few seconds for the compressed air to cool.
19. Tap the gauge gently with one hand while slowly opening the air bleeder valve until the needle rests on the initial pressure line. Close the air bleeder valve.
20. Close both petcocks.
21. Open the main air chamber valve.
22. Tap the sides of the base smartly with the mallet.
23. With the main air chamber valve open, lightly tap the gauge to settle the needle, and then read the air content to the nearest 0.1 percent, while the air chamber valve is open.
24. Release or close the main air chamber valve.
25. Open both petcocks to release pressure, remove the concrete, and thoroughly clean the cover and base with clean water.
26. Open the main air valve to relieve the pressure in the air chamber.
Procedure – Internal Vibration

1. Obtain the sample in accordance with the FOP for WAQTC TM 2. If any aggregate larger than 1½ in (37.5 mm) is present, the larger aggregate must be removed. Sieve a sufficient amount of the sample over the 1½ in (37.5 mm) sieve in accordance with the Wet Sieving portion of the FOP for WAQTC TM 2. Contact the Materials Laboratory for directions.

2. Dampen the inside of the air meter bowl and place on a firm level surface.

3. Fill the base approximately half full.

4. Insert the vibrator at three different points. Do not let the vibrator touch the bottom or sides of the base.

   Note 9: Remove the vibrator slowly, so that no air pockets are left in the material.

   Note 10: Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

5. Fill the base a bit over full.

6. Insert the vibrator as in Step 3. Do not let the vibrator touch the sides of the base, and penetrate the first layer approximately 1 in (25 mm).

7. Return to Step 12 of the rodding procedure and continue.

Report

Results shall be reported on standard forms approved for use by the agency. Record the percent of air to the nearest 0.1 percent.

Report results on concrete delivery ticket, (i.e. Certificate of Compliance).

The name of the tester who performed the field acceptance test is required on concrete delivery tickets containing test results.
Performance Exam Checklist

WSDOT FOP for WAQTC T 152
Air Content of Freshly Mixed Concrete by the Pressure Method

Participant Name ________________________________  Exam Date __________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Container filled in three equal layers, slightly overfilling the last layer?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Each layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Bottom layer rodded throughout its depth, without forcibly striking the bottom of the container?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Middle and top layers rodded, each throughout their depths and penetrating 1 in (25 mm) into the underlying layer?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Sides of the container tapped 10 to 15 times with the mallet after rodding each layer?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Concrete struck off level with top of container using the bar and rim cleaned off?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Using a Type B Meter

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Both petcocks open?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Air valve closed between air chamber and the bowl?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. Inside of cover cleaned and moistened before clamping to base?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. Water injected through petcock until it flows out the other petcock?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. Water injection into the petcock continued while tipping the meter to insure all air is expelled?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14. Air pumped up to initial pressure line?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. A few seconds allowed for the compressed air to stabilize?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>16. Gauge adjusted to the initial pressure?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>17. Both petcocks closed?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>18. Air valve opened between chamber and bowl?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>19. Sides of bowl tapped with the mallet?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Using a Type B Meter

20. With air valve open, Air percentage read after lightly tapping the gauge to stabilize the hand? Yes No

21. Air valve closed and then petcocks opened to release pressure before removing the cover? Yes No

22. Air content recorded to 0.1 percent? Yes No

23. All calculations performed correctly? Yes No

First Attempt:  Pass ☐ Fail ☐ Second Attempt:  Pass ☐ Fail ☐

Signature of Examiner  ________________________________

Comments:
1. Scope

1.1 This method of test covers the determination of bulk specific gravity of specimens of compacted hot mix asphalt.

1.2 Definition:

1.3 Bulk specific gravity (of solids) – The ratio of the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. The form of the expression shall be:

\[
\frac{x}{y} \text{ °C}
\]

where:

\[x = \text{temperature of the material, and}\]

\[y = \text{temperature of the water}\]

1.4 The bulk specific gravity of the compacted hot mix asphalt may be used in calculating the unit mass of the mixture.

1.5 The values stated in English units are to be regarded as the standard.

*Note:* Method A shall be used for laboratory compacted specimens, and field specimens compacted using gyratory compactor.

Method C shall be used for asphalt pavement cores.

2. Referenced Documents

2.1 AASHTO Standards

M 231 – Weighing Devices Used in the Testing of Materials

T 275 – Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens

3. Test Specimens

3.1 Test specimens may be either laboratory-molded HMA mixtures or from HMA pavements. The mixtures may be surface, wearing, leveling or base course materials.

3.2 Size of Specimens – It is recommended that: (1) the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens, be at least equal to four times the maximum size of the aggregate; and (2) the thickness of specimens be at least one-and-one-half times the maximum size of the aggregate.

This Test Method is based on AASHTO T 166-10.
3.3 Specimens shall be taken from pavements with core drill, diamond or carborundum saw, or by other suitable means.

3.4 Care shall be taken to avoid distortion, bending, or cracking of specimens during and after the removal from pavement or mold. Specimens shall be stored in a safe, cool place.

3.5 Specimens shall be free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

3.6 If desired, specimens may be separated from other pavement layers by sawing or other suitable means. Care should be exercised to ensure sawing does not damage the specimens.

**Method A**

4. Apparatus

4.1 Weighing Device – The weighing device shall have sufficient capacity, be readable to 0.1 percent of the specimen mass, or better, and conform to the requirements of AASHTO M 231. The weighing device shall be equipped with suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of scale pan of the weighing device.

4.2 Suspension Apparatus – The wire suspending the container shall be the smallest practical size to minimize any possible effects of a variable immersed length. The suspension apparatus shall be constructed to enable the container to be immersed to a depth sufficient to cover it and the specimen during weighing. Care should be exercised to ensure no trapped air bubbles exist under the specimen.

4.3 Water Bath – For immersing the specimen in water while suspended under the weighing device, equipped with an overflow outlet for maintaining a constant water level.

4.4 Thermometric Device – Liquid-in-glass thermometers or other suitable thermometric device, accurate to 1°F (0.5°C).

5. Procedure

5.1 Dry the specimen to a constant mass (Note 1). Cool the specimen to room temperature for a minimum of 15 hours and a maximum of 24 hours at 77 ± 9°F (25 ± 5°C) per SOP 731 and record the dry mass as A. Immerse each specimen in water at 77 ± 1.8°F (25 ± 1°C) for 4 ± 1 minute and record the immersed mass as C. Remove the specimen from the water, damp dry the specimen by blotting with a damp towel as quickly as possible (blotting not to exceed 10s), and determine the surface-dry mass as, B. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen (Note 1). Each specimen shall be immersed and weighed individually.

**Note 1:** Constant mass shall be defined as the mass at which further drying at 125 ± 5°F (52 ± 3°C) does not alter the mass by more than 0.05 percent. Specimen saturated with water shall initially be dried overnight at 125 ± 5°F (52 ± 3°C) and then weighed at 2-hour drying intervals. Recently molded laboratory specimens which have not been exposed to moisture do not require drying.
Note 2: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass (C) can be taken, then the surface-dry mass (B), and finally the dry mass (A).

Note 3: Terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from towel.

6. Transportation of Warm Specimens

It is not recommended that specimens be transported before they have cooled to room temperature. If however, a specimen must be transported prior to reaching room temperature the following guidelines should be used to transport the specimen:

a. Place the specimen in a container that has a flat bottom surface to prevent deformation of the bottom of the specimen.

   Note: A flat piece of wood, rigid aluminum or reinforced cardboard may be used to create a flat surface in an HMA sample box.

b. Make sure the specimen is not deformed in handling.

c. Do not stack anything on top of the specimen container.

d. Transport the container in the cab of the vehicle or secure it in the vehicle bed to prevent movement during transit.

7. Calculation

7.1 Calculate the bulk specific gravity of the specimens as follows (round and report the value to the nearest three decimal places):

   \[
   \text{Bulk Specific Gravity} = \frac{A}{B - C}
   \]

   Where:
   \[
   \begin{align*}
   A &= \text{Mass in grams of specimen in air} \\
   B &= \text{Mass in grams of surface-dry specimen in air} \\
   C &= \text{Mass in grams of specimen in water.}
   \end{align*}
   \]

7.2 Calculate the percent water absorbed by the specimen (on volume basis) as follows:

   \[
   \text{Percent Water Absorbed by Volume} = \frac{B - A}{B - C} \times 100
   \]

7.3 If the percent water absorbed by the specimen in Section 5.1 exceeds 2 percent, use T 275 (Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens) to determine the bulk specific gravity.
Method B

WSDOT does not use Method B and has removed this section from the procedure.

Method C (Rapid Test)

8. Procedure

8.1 This procedure can be used for testing specimens which are not required to be saved and which contain substantial amount of moisture. Specimens obtained by coring or sawing can be tested the same day by this method.

8.2 The testing procedure shall be the same as given in Sections 5 except for the sequence of operations. The dry mass (A) of the specimen is determined last as follows.

*Note 4:* A microwave oven can be used to speed up the process by initially heating the sample so that it can be broken into small pieces prior to placing it into the drying oven.

8.3 Place the specimen in a large flat bottom drying pan of known mass. Place the pan and specimen in a 325 ± 25º F (164 ± 14ºC) oven. Leave the specimen in the oven until it can be easily separated to the point where the particles of the fine aggregate-asphalt portion are not larger than ¼ in (6.4 mm). Place the separated specimen in the 325º F (164ºC) oven and dry to a constant mass. The test sample shall be initially dried for a minimum of 90 minutes, and it's mass determined. Then, at 30 minute intervals until constant mass is achieved.

*Note:* If samples are placed in the oven overnight for a minimum of 6 hours at 230°F, then the 90 minute weighting is not necessary.

8.4 Cool the pan and specimen to room temperature at 77 ± 9ºF (25 ± 5ºC). Determine the mass of the pan and specimen, subtract the mass of the pan and record the dry mass of the pan and record the dry mass, A.

9. Calculations

9.1 Calculate the bulk specific gravity per Sections 7.1.

10. Report

10.1 The report shall include the following:

10.1.1 Bulk Specific Gravity reported to the nearest thousandth (0.001).

10.1.2 Absorption reported to the nearest hundredth (0.01).

11. Precision

11.1 See AASHTO T 166 for precision statement.
Performance Exam Checklist
WSDOT FOP for AASHTO T 166
Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface Dry Specimens

Participant Name ________________________________  Exam Date ___________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Method A** (For use with laboratory compacted specimens.)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Compacted specimen cooled to room temperature (refer to WSDOT SOP 731, Procedure #5g), 77 ± 9º F, and record the dry mass.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2.</td>
<td>Immerse each specimen in water at 77 ± 1.8°F for 3 to 5 minutes and record the immersed mass to the nearest 0.1 gram?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3.</td>
<td>Remove sample from water, surface dry with damp towel and weigh the specimen in air at 77 ± 9º F to the nearest 0.1 gram?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4.</td>
<td>Calculated the bulk specific gravity of the specimens per Section 7.1?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Method C** (For use with pavement cores and chunks.)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Immerse specimen in water at 77 ± 1.8º F for 3 to 5 minutes and record the immersed weight to the nearest 0.1 gram?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2.</td>
<td>Remove sample from water, surface dry by blotting with damp towel and immediately weigh specimen in air at 77 ± 9º F to the nearest 0.1 gram?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3.</td>
<td>Place specimen in container (noting the empty container weight), then into an oven set at 325 ± 25º F until sample can be broken into small pieces?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4.</td>
<td>Return container to oven until it has reached a constant weight?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5.</td>
<td>Remove container and sample from oven and allow to cool to room temperature, 77 ± 9º F?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6.</td>
<td>Weigh pan with sample and record to nearest 0.1 gram, deducting known weight of pan to arrive at oven-dried sample weight?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7.</td>
<td>Calculated the bulk specific gravity of the specimen per Section 6.1?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

First Attempt:   Pass ☐   Fail ☐   Second Attempt:   Pass ☐   Fail ☐

Signature of Examiner  ________________________________
Comments:
1. **Scope**
   
   1.1 This test is intended to serve as a rapid field test to show the relative proportions of fine dust or claylike material in soils or graded aggregates.
   
   1.2 The following applies to all specified limits in this standard: For the purpose of determining conformance with these specifications, an observed value or a calculated value shall be rounded off “to the nearest unit” in the last right-hand place of figures used in expressing the limiting value, in accordance with E 29, Using Significant Digits in Test Data to Determine Conformance with Specifications.
   
   1.3 The values stated in English units are to be regarded as the standard.
   
   1.4 Refer to R 16 for regulatory information for chemicals.

2. **Reference Document**

   2.1 AASHTO Standards
   - M 92 – Wire-Cloth Sieves for Testing Purposes
   - M 231 – Weighing Devices Used in the Testing of Materials
   
   2.2 ASTM Standards
   - E 29 – Using Significant Digits in Test Data to Determine Conformance With Specifications
   
   2.3 WSDOT Standards
   - T2 – FOP for Sampling of Aggregates
   - T 248 – FOP for Reducing Samples of Aggregate to Testing Size

3. **Significance and Use**

   3.1 This test method is used to determine the proportion of detrimental fines in the portion passing the 4.75-mm (No. 4) sieve of soils or graded aggregates.

4. **Apparatus**

   4.1 A graduated plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly, and siphon assembly, all conforming to their respective specifications and dimensions shown in Figure 1. Fit the siphon assembly to a 1 gal (4L) bottle of working calcium chloride solution (see Section 4.9) placed on a shelf 36 ± 1 in (915 ± 25 mm) above the work surface. In lieu of the specified 1 gal (4L) bottle, a glass or plastic vat having a larger capacity may be used provided the liquid level of the working solution is maintained between 36 and 46 inches (915 and 1170 mm) above the work surface.

---

1This FOP is based on AASHTO T 176-08 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
FIGURE 1  Sand Equivalent Apparatus

Note: all dimensions are shown in mm unless otherwise indicated.
<table>
<thead>
<tr>
<th>Assembly</th>
<th>No. Reg.</th>
<th>Description</th>
<th>Stock size</th>
<th>Material</th>
<th>Heat Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Siphon Tube</td>
<td>6.4 dia. × 400</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Siphon Hose</td>
<td>4.6 I.D. × 1220</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Blow Hose</td>
<td>4.8 I.D. × 50.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Blow Tube</td>
<td>6.4 dia × 50.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Two-Hole Stopper</td>
<td>No. 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Irrigator Tube</td>
<td>6.4 O.D. 0.89 Wall × 500 Stainless Steel tube, Type 316</td>
<td>Pinchcock, Day, BKH No. 21730 or Equiv.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Clamp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>Tube</td>
<td>38.1 Od. × 430</td>
<td>Trans. Acrylic Plastic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Base</td>
<td>12.7 × 102 × 102</td>
<td>Trans. Acrylic Plastic</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>10</td>
<td>Sand Reading Indicator</td>
<td>6.4 dia. × 14.9</td>
<td>Nylon 101 type 66 Annealed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Rod</td>
<td>6.4 dia. × 438.2</td>
<td>Brass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Weight</td>
<td>50.8 dia. × 52.78</td>
<td>C.R. SH.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Roll Pin</td>
<td>0.16 dia. × 12.7</td>
<td>Steel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Foot</td>
<td>0.16 dia. × 13.7</td>
<td>Brass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Solid Stopper</td>
<td>No. 7</td>
<td>Rubber</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. “C” Mounted Foot Assembly to weigh 1000 ± 5 g.
2. Graduations of graduate to be 2.54 mm apart and every tenth mark to be numerically designated as shown. Every fifth line should be approximately 9.5 mm long. All other lines should be approximately 5.5 mm long. Depth to be 0.4 mm. Width to be 0.8 mm across the top.
3. Accuracy of scale to be ± 0.25 mm. Error at any point on scale to be ± 0.75 mm of true distance to zero.
4. Glass or stainless steel may be substituted as a material type for the copper siphon and blow tubing.

Sand Equivalent Apparatus

Figure 1

Note 1: An older model of weighted foot assembly has a guide cap that fits over the upper end of the graduated cylinder and centers the rod in the cylinder, and the foot of the assembly has a conical upper surface and three centering screws to center it loosely in the cylinder. The older model does not have the same reading indicator affixed to the rod (Figure 1), but a slot in the centering screws of the weighted foot is used to indicate the sand reading. Apparatus with the sand reading indicator (Figure 2) is preferred for testing clayey materials.
4.2 A tinned measure, having a capacity of 3 oz (85 ± 5 mL), approximately 2.25 in (57 mm) in diameter.

4.3 A balance with sufficient capacity, readable to 0.1 percent of the sample mass, or better, and conforming to the requirements of M 231.

4.4 A wide-mouth funnel approximately 4 in (100 mm) in diameter at the mouth.

4.5 A clock or watch reading in minutes and seconds.

4.6 A mechanical shaker having a throw of 8.00 ± 0.04 in (203.2 ± 1.0 mm) and operating at 175 ± 2 cycles per minute (2.92 ± 0.03 Hz) (Note 2). Prior to use, fasten the mechanical sand equivalent shaker securely to a firm and level mount.

Note 2: The mechanical shaker shall be used when performing referee sand equivalent determinations.

4.7 A manually operated shaker capable of producing an oscillating motion at the rate of 100 complete cycles in 45 ± 5 seconds, with a hand-assisted half stroke length of 5.0 ± 0.2 in (127 ± 5 mm). The shaker shall be fastened securely to a firm and level mount by bolts or clamps.

4.8 Stock Solution – Shall meet the requirements of AASHTO T 176.

4.9 Working calcium chloride solution: Prepare the working calcium chloride by diluting one measuring tin full 3 oz. (85 ± 5 mL), or from a graduated cylinder of the stock calcium chloride solution to 1 gal (3.8 L) with water (finished product will equal 1 gallon). Use distilled or demineralized water for the normal preparation of the working solution. Record the date made on the gallon bottle. Working solutions more than 30 days old shall be discarded.

4.10 A straightedge or spatula, suitable for striking off the excess soil from the tin measure.

4.11 A thermostatically controlled drying oven.

4.12 Quartering or splitting cloth, approximately 2 ft square, nonabsorbent material such as plastic or oil cloth.

4.13 A No. 4 (4.75-mm) sieve conforming to the requirements of M 92.

4.14 Optional Handle for Irrigation Tube – A 25 mm diameter wooden dowel to aid in pushing the irrigation tube into firm materials. See Figure 1, Assembly B.
5. Temperature Control

5.1 The temperature of the working solution should be maintained at 67-77°F (22 ± 3°C) during the performance of this test. If field conditions preclude the maintenance of the temperature range, frequent reference samples should be submitted to a laboratory where proper temperature control is possible. It is also possible to establish temperature correction curves for each material being tested where proper temperature control is not possible. However, no general correction curve should be utilized for several materials even within a narrow range of sand equivalent values. Samples which meet the minimums and equivalent requirement at a working solution temperature below the recommended range need not be subject to reference testing.

6. Sampling

6.1 Obtain a sample of the material to be tested in accordance with WSDOT FOP for AASHTO T 2.

6.2 Reduce the sample in accordance with WSDOT FOP for AASHTO T 248.

6.3 Sieve the sample over No. 4 (4.75 mm) sieve using a mechanical shaker. (Make sure all large clumps of material are broken up before placing sieves in the mechanical shaker)

6.3.1 Shake the sample in the mechanical shaker for a minimum of 10 minutes or for the minimum verified shaking time whichever is greater.

6.3.2 The material shall be at Saturated Surface Dry (Saturated Surface Dry is defined herein as no visible free moisture, but material may still appear damp) or drier prior to sieving.

6.3.2.1 If the “as received” sample requires drying to achieve the required SSD or dryer condition prior to initial sieving, either air dry it or dry it in a thermostatically controlled oven at a temperature not to exceed 350°F.

6.3.3 Sieves may be nested above the No. 4 (4.75 mm) to prevent overloading, as defined in Table 1 of WSDOT FOP for WAQTC/AASHTO T 27/T 11, or the sample may be sieved in increments.

6.3.4 Break up any remaining clumps of fine-grained material and clean the fines from particles retained above the No. 4 (4.75 mm) sieve. Pass this material over the No. 4 (4.75 mm) sieve and include the material that passes in the total material passing the No. 4 (4.75 mm) sieve.

6.4 Split or quarter the material passing the No. 4 (4.75 mm), in accordance with WSDOT FOP for AASHTO T 248, to yield approximately 1,000 g to 1,500 g of material. Use extreme care to obtain a truly representative portion of the original sample (Note 3).

Note 3: Experiments show that as the amount of material being reduced by splitting or quartering is decreased, the accuracy of providing representative portions is decreased. It is imperative that the sample be split or quartered carefully. When it appears necessary, dampen the material before splitting or quartering, to avoid segregation or loss of fines.
7. Sample Preparation

7.1 Prepare two test samples by the following method:

7.1.1 The sample must be in the proper moisture condition to achieve reliable results. Condition is determined by tightly squeezing a small portion of the thoroughly mixed sample in the palm of the hand. If the cast that is formed permits careful handling without breaking, the correct moisture range has been obtained. If the material is too dry, the cast will crumble and it will be necessary to add water and remix and retest until the material forms a cast. If the material shows any free water it is too wet to test and must be drained and air-dried, mixing it frequently to insure uniformity. This overly wet material will form a good cast when checked initially, so the drying process should continue until a squeeze check on the drying material gives a cast which is more fragile and delicate to handle than the original.

Place the sample on the splitting cloth and mix by alternately lifting each corner of the cloth and pulling it over the sample toward the diagonally opposite corner, causing the material to be rolled. When the material appears homogeneous, finish the mixing with the sample in a pile near the center of the cloth.

7.1.2 Fill the 3 oz (85 mL) tin measure by pushing it through the base of the pile while exerting pressure with the hand against the pile on the side opposite the measure. As the tin is moved though the pile, hold enough pressure with the hand to cause the material to fill the tin to overflowing. Press firmly with the palm of the hand, compacting the material and allowing the maximum amount to be placed in the tin. Strike off the tin measure level full with a spatula or straightedge. For the second determination, remix the sample and fill the tin again.

Dry the test sample in an oven to constant mass in accordance with FOP for AASHTO T 255. The oven temperature shall not exceed 350°F (177°C). Cool to room temperature before testing. It is acceptable to place the test sample in a larger container to aid drying.

8. Procedure

8.1 Start the siphon by forcing air into the top of the solution bottle through the bent copper, glass, or stainless steel blow tube while the pinch clamp is open. The apparatus is now ready for use.

8.2 Siphon 4.0 ± 0.1 in (101.6 ± 2.5 mm) of working calcium chloride solution into the plastic cylinder. Pour the prepared test sample into the plastic cylinder using the funnel to avoid spillage (see Figure 3). Tap the bottom of the cylinder sharply on the heel of the hand several times to release air bubbles and to promote thorough wetting of the sample.
8.3 Allow the wetted sample to stand undisturbed for 10 ± 1 minute. At the end of the 10-minute soaking period, stopper the cylinder, then loosen the material from the bottom by partially inverting the cylinder and shaking it simultaneously.

8.4 After loosening the material from the bottom of the cylinder, shake the cylinder and contents by any one of the following methods:

8.4.1 Mechanical Shaker Method – Place the stoppered cylinder in the mechanical sand equivalent shaker, set the timer, and allow the machine to shake the cylinder and contents for 45 ± 1 second.

8.4.2 Manual Shaker Method – Secure the stoppered cylinder in the three spring clamps on the carriage of the hand-operated sand equivalent shaker and reset the stroke counter to zero. Stand directly in front of the shaker and force the pointer to the stroke limit marker painted on the backboard by applying an abrupt horizontal thrust to the upper portion of the right hand spring steel strap. Then remove the hand from the strap and allow the spring action of the straps to move the carriage and cylinder in the opposite direction without assistance or hindrance. Apply enough force to the right hand spring steel strap during the thrust portion of each stroke to move the pointer to the stroke limit marker by pushing against the strap with the ends of the fingers to maintain a smooth oscillating motion. The center of the stroke limit marker is positioned to provide the proper stroke length and its width provides the maximum allowable limits of variation. The proper shaking action is accomplished only when the tip of the point reverses direction within the marker limits. Proper shaking action can best be maintained by using only the forearm and wrist action to propel the shaker. Continue the shaking action for 100 strokes.
8.5 Following the shaking operation, set the cylinder upright on the work table and remove the stopper.

8.6 Irrigation Procedure – Insert the irrigator tube in the cylinder and rinse material from the cylinder walls as the irrigator is lowered. Force the irrigator through the material to the bottom of the cylinder by applying a gentle stabbing and twisting action while the working solution flows from the irrigator tip. This flushes the fine material into suspension above the coarser sand particles. (See Figure 5.) Continue to apply the stabbing and twisting action while flushing the fines upward until the cylinder is filled to the 15 in (381 mm) mark. Then raise the irrigator slowly without shutting off the flow so that the liquid level is maintained at about 15 in (381 mm) while the irrigator is being withdrawn. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 15 in (381 mm). Final level as judged by the bottom of the meniscus shall be between the top two gradations on the tube but shall not be above the 15 in (381 mm) level.

![Image of irrigation procedure](image)

*Figure 5*

**Note 4:** For certain soils, particularly on crushed materials, the stabbing action may not be possible. For these materials, the irrigation technique is as follows: Continue to apply a twisting action as the irrigation tube is slowly withdrawn. As the tube is withdrawn, it is essential that as many fines as possible flushed upward until the cylinder is filled to the 15 in (381 mm) mark.

8.7 Allow the cylinder and contents to stand undisturbed for 20 minutes ± 15 seconds. Start the timing immediately after withdrawing the irrigator tube.

8.8 At the end of the 20 minute sedimentation period, read and record the level of the top of the clay suspension. This is referred to as the “clay reading.” If no clear line of demarcation has formed at the end of the specified 20 minute sedimentation period, allow the sample to stand undisturbed until a clear reading can be obtained, then immediately read and record the level of the top of the clay suspension and the total sedimentation time. If the total sedimentation time exceeds 30 minutes, it will be rejected.

8.9 After the clay reading has been taken, the “sand reading” shall be obtained by one of the following methods:

8.9.1 When using the weighted foot assembly having the sand indicator on the rod of the assembly, place the assembly over the cylinder and gently lower the assembly toward the sand. Do not allow the indicator to hit the mouth of the cylinder as the assembly is being lowered. As the weighted foot comes to rest on the sand,
tip the assembly toward the graduations on the cylinder until the indicator touches the inside of the cylinder. Subtract 10 in (254 mm) from the level indicated by the extreme top edge of the indicator and record this value as the “sand reading.” (See Figure 6.)

8.9.2 If an older model weighted foot assembly having centering screws is used, keep one of the centering screws in contact with the cylinder wall near the graduations so that it can be seen at all times while the assembly is being lowered. When the weighted foot has come to rest on the sand, read the level of the centering screw and record this value as the “sand reading.”

8.10 If clay or sand readings fall between 0.1 in (2.5 mm) graduations, record the level of the higher graduation as the reading. For example, a clay reading of 7.95 would be recorded as 8.0, and a sand reading of 3.22 would be recorded as 3.3.

9. Calculations

9.1 Calculate the sand equivalent (SE) to the nearest 0.1 using the following formula:

\[ SE = \frac{\text{Sand Reading} \times 100}{\text{Clay Reading}} \]

9.2 If the calculated sand equivalent is not a whole number, report it as the next higher whole number, as in the following example:

\[ SE = \frac{3.3 \times 100}{8} = 41.25 \]

which is reported as 42.

9.3 Average the whole number values determined as described above. If the average of these values is not a whole number, raise it to the next higher whole number, as in the following example:

Calculated SE values: 41.2, 40.9

After raising each to the next higher whole number, they become: 42, 41.
The average of these values is then determined:

\[
\frac{42 + 41}{2} = 41.5
\]

which is reported as 42.

If the two results from the same SE sample vary by more than 8 points, the test shall be invalid and a new test completed.

9.3.1 Since the average value is not a whole number, it is raised to the next higher whole number and the reported averages and equivalent value is reported as 42.

10. Report

10.1 Report the results using one or more of the following:

- Materials Testing System (MATS)
- WSDOT Form 350-161, 422-022, 422-022A, or 422-022B
- Form approved in writing by the State Materials Engineer
Performance Exam Checklist

**Plastic Fines in Graded Aggregates and Soils by the Use of the Sand Equivalent Test FOP for AASHTO T 176**

Participant Name ________________________________  Exam Date __________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Sample passed through No. 4 (4.75 mm) sieve?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Material in clods broken up and re-screened?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. No fines lost?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Temperature of working solution 72 ± 5°F (22 ± 3°C)?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Working calcium chloride solution 36 ± 1 in (915 mm ± 25 mm) above the work surface?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. 4 ± 0.1 in (101.6 ± 2.5 mm) working calcium chloride solution siphoned into cylinder?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Working solution dated?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample Preparation</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If necessary, sample sprayed with water to prevent loss of fines?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. Material checked for moisture condition by tightly squeezing small portion in palm of hand and forming a cast?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Sample at proper water content?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>a. If too dry, (cast crumbles easily), water added and re-mixed?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. If too wet (shows free water), sample drained, air dried and mixed frequently?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Sample placed on splitting cloth and mixed by alternately lifting each corner of the cloth and pulling it over the sample toward diagonally opposite corner, causing material to be rolled?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Is material thoroughly mixed?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. When material appears to be homogeneous, mixing finished with sample in a pile near center of cloth?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Fill the 85 mL tin by pushing through base of pile with other hand on opposite side of pile?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Material fills tin to overflowing?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Material compacted into tin with palm of hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Tin struck off level full with spatula or straightedge?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. Test sample dried to a constant mass?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. Sample cooled to room temperature</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Procedure

1. Prepared sample funneled into cylinder with no loss of fines? ☐ ☐
2. Bottom of cylinder tapped sharply on heel of hand several times to release air bubbles? ☐ ☐
3. Wetted sample allowed to stand undisturbed for 10 min ± 1 min? ☐ ☐
4. Cylinder stoppered and material loosened from bottom by shaking? ☐ ☐
5. Properly performed shaking method?
   - Mechanical Shaker Method ☐ ☐
   - Manual Shaker Method ☐ ☐
6. Following shaking, cylinder set vertical on work surface and stopper removed? ☐ ☐
7. Irrigator tube inserted in cylinder and material rinsed from cylinder walls as irrigator is lowered? ☐ ☐
8. Irrigator tube forced through material to bottom of cylinder by gently stabbing and twisting action? ☐ ☐
9. Stabbing and twisting motion applied until cylinder filled to 15 in (381 mm) mark? ☐ ☐
10. Liquid raised and maintained at 15 in (381 mm) mark while irrigator is being withdrawn? ☐ ☐
11. No clear solution at top of column? ☐ ☐
12. Contents let stand 20 minutes ± 15 seconds? ☐ ☐
13. Timing started immediately after withdrawal of irrigator? ☐ ☐
14. No vibration or disturbance of the sample? ☐ ☐
15. Readings taken at 20 minutes or up to 30 minutes, when a definite line appears? ☐ ☐
16. Weighted foot assembly lowered into cylinder without hitting mouth of cylinder? ☐ ☐
17. Calculations made to 0.1 and reported to the next higher whole number? ☐ ☐
18. SE is based on the average results of two samples? ☐ ☐
19. If the two SE values vary by more than 8 points additional tests run? ☐ ☐
20. All calculations performed correctly? ☐ ☐

First Attempt: Pass ☐ Fail ☐
Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ________________________________

Comments:
WSDOT FOP for AASHTO T 209¹
Theoretical Maximum Specific Gravity and Density of Hot-Mix Asphalt Paving Mixtures

1. Scope

1.1 This test method covers the determination of the theoretical maximum specific gravity and density of uncompacted hot-mix asphalt paving mixtures at 77°F (25°C).

1.2 The values stated in English units are to be regarded as the standard.

1.3 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 AASHTO Standards
   - M 231, Weighing Devices Used in the Testing of Materials
   - PP 57, Establishing Requirements for and Performing Equipment Standardizations and Checks

2.2 ASTM Standards
   - D 4311 – Practice for Determining Asphalt Volume Correction to a Base Temperature
   - C 670 – Preparing Precision and Bias Statements for Test Methods for Construction Materials

2.3 Other Standards
   - T 168 – WAQTC FOP for AASHTO for Sampling Bituminous Paving Mixtures
   - T 712 – WSDOT Standard Method of Reducing Hot Mix Asphalt Paving Mixtures

3. Terminology

3.1 Definitions

3.1.1 Density, as determined by this test method. The mass of a cubic meter of the material at 77°F (25°C) in English units, or the mass of a cubic foot of the material at 77°F (25°C) in inch-pound units.

3.1.2 Residual pressure, as employed by this test method. The pressure in a vacuum vessel when vacuum is applied.

3.1.3 Specific gravity, as determined by this test method. The ratio of a given mass of material at 77°F (25°C) to the mass of an equal volume of water at the same temperature.

¹This FOP is based on AASHTO T 209 (2011) and has been modified per WSDOT standards. To view the redline modifications, contact WSDOT Quality Systems Manager at 360-709-5412.
4. Summary of Test Method

4.1 A weighed sample of HMA paving mixture in the loose condition is placed in a tared vacuum vessel. Sufficient water is added to completely submerge the sample. Vacuum is applied for 15 ± 2 min to gradually reduce the residual pressure in the vacuum vessel. At the end of the vacuum period, the vacuum is gradually released. The volume of the sample of paving mixture is obtained by (Section 9.5.2) filling the vacuum container level full of water and weighing in air. At the time of weighing the temperature is measured as well as the mass. From the mass and volume measurements, the specific gravity or density at 77°F (25°C) is calculated. If the temperature employed is different from 77°F (25°C), an appropriate correction is applied.

5. Significance and Use

5.1 The theoretical maximum specific gravities and densities of hot-mix asphalt paving mixtures are intrinsic properties whose values are influenced by the composition of the mixtures in terms of types and amounts of aggregates and asphalt binder materials.

5.1.1 These properties are used to calculate percent air voids in compacted HMA.

5.1.2 These properties provide target values for the compaction of HMA.

5.1.3 These properties are essential when calculating the amount of asphalt binder absorbed by the internal porosity of the individual aggregate particles in HMA.

6. Apparatus

6.1 Follow the procedures for performing equipment standardizations, standardization, and checks found in PP 57.

6.2 Vacuum Container:

6.2.1 The vacuum containers described must be capable of withstanding the full vacuum applied, and each must be equipped with the fittings and other accessories required by the test procedure being employed. The opening in the container leading to the vacuum pump shall be covered by a piece of No. 200 (75-μm) mesh to minimize the loss of fine material.

6.2.2 The capacity of the vacuum container should be between 2000 and 10,000-mL and depends on the minimum sample size requirements given in Section 7.2. Avoid using a small sample in a large container.

6.2.3 Vacuum Bowl – Either a metal or plastic bowl with a diameter of approximately 7.1 to 10.2 in (180 to 260 mm) and a bowl height of at least 6.3 in (160 mm) equipped with a transparent cover fitted with a rubber gasket and a connection for the vacuum line.

6.2.4 Vacuum Flask for Weighing in Air Only – A thick-walled volumetric glass flask and a rubber stopper with a connection for the vacuum line.

6.2.5 Pycnometer for Weighing in Air Only – A glass, metal or plastic pycnometer.
6.3 Balance, conforming to the requirements of AASHTO M 231, Class G 2. The balance shall be standardized at least every 12 months.

6.3.1 For the mass determination-in-water method (Section 9.5.1), the balance shall be equipped with a suitable apparatus and holder to permit determining the mass of the sample while suspended below the balance. The wire suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length.

6.4 Vacuum pump or water aspirator, capable of evacuating air from the vacuum container to a residual pressure of 30 mm Hg (4.0 kPa) or less.

6.4.1 When a vacuum pump is used, a suitable trap of one or more filter flasks, or equivalent, shall be installed between the vacuum vessel and vacuum source to reduce the amount of water vapor entering the vacuum pump.

6.5 Absolute pressure gauge or vacuum gauge, used for annual standardization and traceable to NIST (mandatory) to be connected directly to the vacuum vessel and to be capable of measuring residual pressure down to 30 mm Hg (4.0 kPa), or less (preferably to zero). It is to be connected at the end of the vacuum line using an appropriate tube and either a “T” connector on the top of the vessel or by using a separate opening (from the vacuum line) in the top of the vessel to attach the hose.

\textbf{Note 2:} A residual pressure of 30 mm Hg (4.0 kPa) absolute pressure is approximately equivalent to 730 mm Hg (97 kPa) reading on vacuum gauge at sea level.

6.6 Bleeder Valve, attached to the vacuum train to facilitate adjustment of the vacuum being applied to the vacuum vessel.

6.7 Thermometric Device (Mass Determination in Air), liquid-in-glass thermometers or other suitable thermometric device, accurate to 1ºF (0.5ºC). The thermometric device shall be standardized at the test temperature at least every 12 months.

6.8 Water Bath, a water bath that can be maintained at a constant temperature between 73 and 82.9ºF (22.8 and 28.3°C).

6.9 Protective Gloves, used when handling glass equipment under vacuum.

6.10 Mallet, with a rubber or rawhide head.

7. Sampling

7.1 Obtain the sample in accordance with WAQTC FOP for AASHTO T 168 and WSDOT T 712.

7.2 The size of the sample shall conform to the requirements in Table 1. Samples larger than the capacity of the container may be tested a portion at a time.
8. Standardization of Flasks, Bowls, and Pycnometers

This section has been deleted by WSDOT and replaced with the following:

The volumetric flask or metal vacuum pycnometer will be standardized periodically in conformance with established verification procedures or per AASHTO T 209. Standardization shall be done at 77°F.

9. Sample Preparation

9.1 Separate the particles of the HMA sample by hand, taking care to avoid fracturing the aggregate, so that the particles of the fine aggregate portion are not larger than ¼ in (6.3 mm). If an HMA sample is not sufficiently soft to be separated manually, place it in a flat pan, and warm it in an oven until it can be separated as described.

9.2 WSDOT has deleted this section

9.3 Cool the sample to room temperature, and place it in a tared and standardized flask, bowl, or pycnometer. Weigh and designate the net mass of the sample as A. Add sufficient water at a temperature of approximately 25°C (77°F) to cover the sample completely.

Test Method A – Mechanical Agitation

10. Apparatus

10.1 In addition to the apparatus listed in Section 6, the following apparatus is required for Method A.

10.1.1 Mechanical Shaker-Shaker for removing air from asphalt mix.

11. Procedure

11.1 Remove air trapped in the sample by applying gradually increased vacuum until the absolute pressure gauge or vacuum gauge reads 30 mm HG or less (4.0 kPa or less). Maintain this residual pressure for 15 ± 2 min. Agitate the container and contents using the mechanical device during the vacuum period. Glass vessels should be shaken on a resilient surface such as a rubber or plastic mat, and not on a hard surface, so as to avoid excessive impact while under vacuum. To aid in releasing the trapped air from the metal vacuum pycnometer, tap the sides of the metal vacuum pycnometer 3 to 5 times with the mallet at approximately two minutes intervals.

Note: The release of entrapped air may be facilitated by the addition of a few drops of suitable wetting agent.
11.2 At the end of the vacuum period, release the vacuum within 10 to 15 seconds. Start the 9 to 11 minute time, as described in 13.2, immediately upon starting the release of vacuum. Proceed to 13.2.

**Test Method B – Manual Agitation**

12. Procedure

12.1 Remove air trapped in the sample by applying gradually increased vacuum until the absolute pressure gauge or vacuum gauge reads 30 mm HG or less (4.0 kPa or less). Maintain this residual pressure for 15 ± 2 min. Agitate the container and contents during the vacuum period by vigorous shaking at intervals of about 2 minutes. Glass vessels should be shaken on a resilient surface such as a rubber or plastic mat, and not on a hard surface, so as to avoid excessive impact while under vacuum.

12.2 At the end of the vacuum period, release the vacuum within 10 to 15 seconds. Start the 9 to 11 minute time, as described in 13.2 immediately upon starting the release of vacuum. Proceed to 13.2.

13. Mass Determination

13.1 WSDOT has deleted this section.

13.2 Mass Determination in Air – Fill the flask or any one of the pycnometers with water and adjust the contents to a temperature of 77 ± 2°F (25 ± 1°C) in a constant temperature water bath. Determine the mass of the container (and contents), completely filled, 9 to 11 minutes after starting Section 11.2 or 12.1. Designate this mass as E. Accurate filling may be ensured by the use of a glass cover plate.

In lieu of a constant temperature water bath described in 13.2, determine the temperature of the water within the flask or metal vacuum pycnometer and determine the appropriate density correction factor “R” using Table 2.

14. Calculation

14.1 Calculate the theoretical maximum specific gravity of the sample at 77°F (25°C) as follows:

14.1.1 WSDOT has deleted this section

14.1.2 Weighing Mass Determination in Air:

\[
\text{Theoretical Maximum Specific Gravity} = \frac{A}{A + D - E}
\]

Where:

- \( A \) = Mass of oven-dry sample in air, g
- \( D \) = Mass of container filled with water at 77°F (25°C), g
- \( E \) = Mass of container filled with sample and water at 77°F (25°C), g
14.1.3 If the test temperature differs significantly from 77°F (25°C), correct for thermal effects as follows:

WSDOT has removed the AASHTO calculation and replaced it with the following calculations:

a. Determination using temperature correction:

Theoretical Maximum Gravity = \[
\frac{A}{A + D - E} \times R
\]

Where:
- \( A \) = Mass of oven-dry sample in air, g;
- \( D \) = Mass of container filled with water at 77°F (25°C), g; and
- \( E \) = Mass of container filled with sample and water at 77°F (25°C), g.
- \( R \) = Factor from Table 2 to correct density of water from the test temperature to 77°F (25°C).

Note: The flask standardization is done at 77 ± 0.4°F (25 ± 0.2°C).

<table>
<thead>
<tr>
<th>C°</th>
<th>F°</th>
<th>&quot;R&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.8</td>
<td>73.0</td>
<td>1.00054</td>
</tr>
<tr>
<td>23.0</td>
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<th>&quot;R&quot;</th>
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<td>82.9</td>
<td>0.99910</td>
</tr>
</tbody>
</table>

Density Correction Factor “R”

Table 2

b. Determination using weighted average:

Weighted Average Maximum Specific Gravity = \[
\frac{(\text{Sp.G}_1 \times A_1) + (\text{Sp.G}_2 \times A_2)}{(A_1 + A_2)}
\]

Where:
- \( \text{Sp.G}_1 \) = Specific gravity of first test segment
- \( \text{Sp.G}_2 \) = Specific gravity of second test segment
- \( A_1 \) and \( A_2 \) = Mass of dry sample in air of respective test segments
14.2 Theoretical Maximum Density (Rice) at 77°F (25°C):

14.2.1 Calculate the corresponding theoretical maximum density at 77°F (25°C) as follows:

Theoretical maximum density at 77°F (25°C) = theoretical maximum specific gravity × 62.245 lb/ft³ in inch-pound units (or 997.1 kg/m³ in SI units).

Where:
The specific gravity of water at 77°F (25°C) = 62.245 in inch-pound units (or 997.1 in SI units).

15. Supplemental Procedure for Mixtures Containing Porous Aggregate

WSDOT has removed this section.

16. Report

16.1 Report the results using one of the following:

- Materials Testing System (MATS)
- WSDOT Form 350-092 and 350-157
- Form approved in writing by the State Materials Engineer

16.2 Report the Theoretical Maximum Specific Gravity ($G_{mm}$) to three decimal places. Report the Theoretical Maximum Density to 0.1 lb/ft³.

17. Precision

See AASHTO T 209 for Precision.
Appendix

(Nonmandatory Information)

A1. Theoretical Maximum Specific Gravity for a Loose-Paving Mixture

WSDOT has removed this section.
Performance Exam Checklist

Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
FOP for AASHTO T 209

Participant Name ________________________________  Exam Date ____________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current standardization/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Particles of sample separated?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Care used not to fracture mineral fragments?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. After separation, fine HMA particles not larger than ¼ inch?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Sample at room temperature?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Mass of bowl or flask determined?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Mass of sample and bowl or flask determined?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Mass of sample determined?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Water at approximately 77°F (25°C) added to cover sample?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. Entrapped air removed using partial vacuum for 15 ± 2 min?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. Container and contents agitated continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. For metal pycnometer, strike 3 to 5 times with a mallet?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14. Release of pycnometer, strike 3 to 5 times with a mallet?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. Flask determination:</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>a. Flask filled with water?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>1. Flask then placed in constant temperature water bath (optional) or?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. Temperature of water in flask determined upon completion of 15d.?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. Contents at 77 ± 2°F or density of water corrected using Table 2 in FOP?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>c. Mass of filled flask determined 9 to 11 minutes after removal of entrapped air completed?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>16. All calculations performed correctly?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

First Attempt:  Pass ☐  Fail ☐  Second Attempt:  Pass ☐  Fail ☐

Signature of Examiner
Comments:
Reducing Samples of Aggregate to Testing Size

1. **Scope**
   
   1.1 This method covers for the reduction of large samples of aggregate to the appropriate size for testing employing techniques that are intended to minimize variations in measured characteristics between the test samples so selected and the large sample.

   1.2 The values stated in English units are to be regarded as the standard.

   1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. **Referenced Documents**

   2.1 AASHTO Standards
      
      T 2 – Sampling of Aggregate
      T 84 – Specific Gravity and Absorption of Coarse Aggregate

   2.2 ASTM Standards
      
      C 125 – Terminology Relating to Concrete and Concrete Aggregates

3. **Terminology**

   3.1 Definitions – The terms used in this practice are defined in ASTM C 125.

4. **Significance and Use**

   4.1 Specifications for aggregates require sampling portions of the material for testing. Other factors being equal, larger samples will tend to be more representative of the total supply. These methods provide for reducing the large sample obtained in the field or produced in the laboratory to a convenient size for conducting a number of tests to describe the material and measure its quality in a manner that the smaller test sample portion is most likely to be a representation of the larger sample, and thus of the total supply. The individual test methods provide for minimum amount of material to be tested.

   4.2 Under certain circumstances, reduction in size of the large sample prior to testing is not recommended. Substantial differences between the selected test samples sometimes cannot be avoided, as for example, in the case of an aggregate having relatively few large size particles in the sample. The laws of chance dictate that these few particles may be unequally distributed among the reduced size test samples. Similarly, if the test sample is being examined for certain contaminants occurring as a few discrete fragments in only small percentages, caution should be used in interpreting results from the reduced size test sample. Chance inclusion or exclusion of only one or two particles in the selected test sample may importantly influence interpretation of the characteristics of the original sample. In these cases, the entire original sample should be tested.

---

1This FOP is based on AASHTO T 248-11.
4.3 Failure to carefully follow the procedures in this practice could result in providing a nonrepresentative sample to be used in subsequent testing.

5. Selection of Method

5.1 Fine Aggregate – Samples of fine aggregate that are at saturated-surface-dry condition or drier (Note 1) may be reduced using a mechanical splitter according to Method A. Samples having free moisture on the particle surfaces may be reduced in size by quartering according to Method B, or by treating as a miniature stockpile as described in Method C.

5.1.1 If the use of Method B or Method C is desired, and the sample does not have free moisture on the particle surfaces, the sample may be moistened to achieve this condition, thoroughly mixed, and then the sample reduction performed.

Note 1: The method of determining the saturated-surface-dry condition is described in Test Method T84. As a quick approximation, if the fine aggregate will retain its shape when molded in the hand, it may be considered to be wetter than saturated-surface-dry.

5.1.2 If use of Method A is desired and the sample has free moisture on the particle surfaces, the entire sample may be dried to at least the saturated-surface-dry condition, using temperatures that do not exceed those specified for any of the tests contemplated, and then the sample reduction performed. Alternatively, if the moist sample is very large, a preliminary split may be made using a mechanical splitter having wide chute openings of 1½ in (38 mm) or more to reduce the sample to not less than 5000 g. The portion so obtained is then dried, and reduction to test sample size is completed using Method A.

5.2 Mixtures of Coarse and Fine Aggregates

5.2.1 If the sample does not exceed a saturated surface dry condition (there is no visible free water, sample may still appear damp) then the sample may be reduced using Method A.

5.2.2 If the sample exceeds a saturated surface dry condition the sample may be reduced using Method B or dried to a constant mass per WSDOT FOP for T255 and then reduced using Method A.

5.3 Coarse Aggregates – Reduce the sample using a mechanical splitter in accordance with Method A (preferred method) or by quartering in accordance with Method B. The miniature stockpile Method C is not permitted for coarse aggregates.

5.4 Untreated materials shall be prepared for testing using this procedure. Treated materials (i.e., Hot Mix Asphalt or Asphalt Treated Base) shall be prepared for testing using WSDOT Test Method No. T712 for reduction of size of samples of Asphalt treated materials.

6. Sampling

6.1 The samples of aggregate obtained in the field shall be taken in accordance with T2, or as required by individual test methods. When tests for sieve analysis only are contemplated, the size of field sample listed in T2 is usually adequate. When additional tests are to be
Reducing Samples of Aggregate to Testing Size

conducted, the user shall determine that the initial size of the field sample is adequate to accomplish all intended tests. Similar procedures shall be used for aggregate production in the laboratory.

Sample Dividers (Riffles)

*Figure 1*

*(a) Large Riffle Samplers for Coarse Aggregate.*

*(b) Small Riffle Sampler for Fine Aggregate.*
Method A – Mechanical Splitter

7. Apparatus

7.1 Sample Splitter – Sample splitters shall have an even number of equal width chutes, but not less than a total of eight for coarse aggregate, or 12 for fine aggregate, which discharge alternately to each side of the splitter. For coarse aggregate and mixed aggregate, the minimum width of the individual chutes shall be approximately 50 percent larger than the largest particles in the sample to be split (Note 2). For dry fine aggregate in which the entire sample will pass the ⅜ in (9.5 mm) sieve, the minimum width of the individual chutes shall be at least 50 percent larger than the largest particles in the sample and the maximum width shall be ⅜ in (19 mm). The splitter shall be equipped with two receptacles to hold the two-halves of the sample following splitting. It shall also be equipped with a hopper or straight edge pan which has a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material (Figure 1).

8. Procedure

8.1 Place the original sample in the hopper or pan and uniformly distribute it from edge to edge, so that when it is introduced into the chutes, approximately equal amounts will flow through each chute. The rate at which the sample is introduced shall be such as to allow free flowing through the chutes into the receptacles below. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test. The portion of the material collected in the other receptacle may be reserved for reduction in size for other tests.

Method B – Quartering

9. Apparatus

9.1 Apparatus shall consist of a straightedge, scoop, shovel, or trowel; a broom or brush; and a canvas blanket or tear-resistant tarp approximately 6 by 8 ft (2 by 2.5 m).

10. Procedure

10.1 Use either the procedure described in 10.1.1 or 10.1.2 or a combination of both.

10.1.1 Place the original sample on a hard clean, level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. The diameter should be approximately four to eight times the thickness. Divide the flattened mass into four equal quarters with a shovel or trowel and remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. The two unused quarters may be set aside for later use or testing, if desired. Successively mix and quarter the remaining material until the sample is reduced to the desired size (Figure 2).
10.1.2 As an alternative to the procedure in 10.1.1 when the floor surface is uneven, the field sample may be placed on a canvas blanket or tear-resistant tarp and mixed with a shovel or trowel as described in 10.1.1, leaving the sample in a conical pile. As an alternative to mixing with a shovel or trowel, lift each corner of the blanket or tarp and pulling it over the sample toward the diagonally opposite corner causing the material to be rolled. After the material has been rolled a sufficient number of times so that it is thoroughly mixed, pull each corner of the blanket or tarp toward the center of the pile so the material will be left in a conical pile. Flatten the pile as described in 10.1.1. Divide the sample as described in 10.1.1 or insert a stick or pipe beneath the blanket or tarp and under the center of the pile, then lift both ends of the stick, dividing the sample into two equal parts. Remove the stick leaving a fold of the blanket between the divided portions. Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into four equal parts. Remove two diagonally opposite quarters, being careful to clean the fines from the blanket or tarp. Successively mix and quarter the remaining material until the sample is reduced to the desired size (Figure 3).
Reducing Samples of Aggregate to Testing Size

Method C – Miniature Stockpile Sampling (Damp Fine Aggregate Only)

11. Apparatus

11.1 Apparatus shall consist of a straight-edged scoop, shovel, or trowel for mixing the aggregate, and either a small sampling thief, small scoop, or spoon for sampling.

12. Procedure

12.1 Place the original sample of damp fine aggregate on a hard clean, level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lifts. If desired, the conical pile may be flattened to a uniform thickness and diameter by pressing the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. Obtain a sample for each test by selecting at least five increments of material at random locations from the miniature stockpile, using any of the sampling devices described in 11.1.
Performance Exam Checklist
*Reducing Samples of Aggregates to Testing Size*
*FOP for AASHTO T 248*

<table>
<thead>
<tr>
<th>Participant Name _______________________________</th>
<th>Exam Date ____________________</th>
</tr>
</thead>
</table>

### Procedure Element

#### Preparation

1. The tester has a copy of the current procedure on hand?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
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</tbody>
</table>

#### Selection of Method

1. Fine Aggregate or Mixture of Fine and Coarse Aggregates
   a. Saturated surface dry or drier: Method A (Splitter) used?  
   b. Free moisture present: Method B (Quartering) used?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>☐</td>
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</tbody>
</table>

2. Coarse Aggregate
   a. Method A used (preferred)?  
   b. Method B used?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>☐</td>
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</tbody>
</table>

#### Method A – Splitting

1. Material spread uniformly on feeder?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>☐</td>
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</table>

2. Rate of feed slow enough so that sample flows freely through chutes?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>☐</td>
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</table>

3. Material in one pan re-split until desired mass is obtained?  

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<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
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</table>

4. Chutes are set correctly for material being split?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>☐</td>
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</tbody>
</table>

#### Method B – Quartering

1. Sample placed on clean, hard, and level surface?  

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<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
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</table>

2. Mixed by turning over three times with shovel or by raising canvas and pulling over pile?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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</thead>
<tbody>
<tr>
<td>☐</td>
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</tbody>
</table>

3. Conical pile formed?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

4. Diameter equal to about 4 to 8 times thickness?  

<table>
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<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

5. Pile flattened to uniform thickness and diameter?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
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</tr>
</tbody>
</table>

6. Divided into 4 equal portions with shovel or trowel?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
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</table>

7. Two diagonally opposite quarters, including all fine material, removed?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
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<tbody>
<tr>
<td>☐</td>
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</tbody>
</table>

8. Cleared space between quarters brushed clean?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>☐</td>
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</tbody>
</table>

9. Process continued until desired sample size is obtained when two opposite quarters combined?  

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
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</tbody>
</table>

*The sample may be placed upon a blanket and a stick or pipe may be placed under the blanket to divide the pile into quarters.*

First Attempt:  Pass ☐  Fail ☐  
Second Attempt: Pass ☐  Fail ☐

Signature of Examiner
Comments:
1. Scope

1.1 This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying, both surface moisture and moisture in the pores of the aggregate. Some aggregate may contain water that is chemically combined with the minerals in the aggregate. Such water is not evaporable and is not included in the percentage determined by this test method.

1.2 The values stated in English units are to be regarded as the standard. The values stated in parentheses are provided for information only.

1.3 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements, see 5.3.1, 7.2.1, and 7.3.1.

2. Referenced Documents

2.1 AASHTO Standards

M 92 – Wire-Cloth Sieves for Testing Purposes
M 231 – Weighing Devices Used in Testing Materials
R 16 – Regulatory Information for Chemicals Used in AASHTO Tests
T 2 – Sampling of Aggregate
T 19/T 19M – Bulk Density (“Unit Weight”) and Voids in Aggregate
T 84 – Specific Gravity and Absorption of Coarse Aggregate
T 85 – Specific Gravity and Absorption of Fine Aggregate

2.2 ASTM Standards

C 125 – Terminology Relating to Concrete and Concrete Aggregates
C 670 – Practice for Preparing Precision Statements for Test Methods for Construction Materials

3. Terminology

3.1 Definitions

3.1.1 For definitions of terms used in this test method, refer to ASTM C 125.

\(^1\)This FOP is based on AASHTO T 255-00.
4. Significance and Use

4.1 This test method is sufficiently accurate for usual purposes, such as adjusting batch quantities of ingredients for concrete. It will generally measure the moisture in the test sample more reliably than the sample can be made to represent the aggregate supply. In rare cases where the aggregate itself is altered by heat, or where more refined measurement is required, the test should be conducted using a ventilated, controlled temperature oven.

4.2 Large particles of coarse aggregate, especially those larger than 2 in (50 mm), will require greater time for the moisture to travel from the interior of the particle to the surface. The user of this test method should determine by trial if rapid drying methods provide sufficient accuracy for the intended use when drying large size particles.

5. Apparatus

5.1 Balance – The balances shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of M 231.

5.2 Source of Heat – A ventilated oven capable of maintaining the temperature surrounding the sample at 110 ± 5°C (230 ± 9°F). Where close control of the temperature is not required (see Section 4.1), other suitable sources of heat may be used, such as an electric or gas hot plate, electric heat lamps, or a ventilated microwave oven.

5.3 Sample Container – A container not affected by the heat, and of sufficient volume to contain the sample without danger of spilling, and of such shape that the depth of sample will not exceed one fifth of the least lateral dimension.

5.3.1 Precaution – When a microwave oven is used, the container shall be nonmetallic.

*Note 1:* Except for testing large samples, an ordinary frying pan is suitable for use with a hot plate, or any shallow flat-bottomed metal pan is suitable with heat lamps or oven. Note Precaution in Section 5.3.1.

5.4 Stirrer – A metal spoon or spatula of convenient size.

6. Sampling

6.1 Sampling shall generally be accomplished in accordance with FOP for AASHTO T 2, except for the sample size may be as stated in Table 1.

6.2 Secure a sample of the aggregate representative of the moisture content in the supply being tested and having a mass not less than the amount listed in Table 1. Protect the sample against loss of moisture prior to determining the mass.
Nominal Maximum \(^{A}\) | Minimum Mass \(^{B}\)  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td><strong>In</strong></td>
<td><strong>(mm)</strong></td>
<td><strong>lb</strong></td>
<td><strong>kg</strong></td>
</tr>
<tr>
<td>US No. 4</td>
<td>(4.75)</td>
<td>1</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>¼</td>
<td>(6.3)</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>½</td>
<td>(9.5)</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>⅜</td>
<td>(12.5)</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>⅝</td>
<td>(16.0)</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>¾</td>
<td>(19.0)</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>(25.0)</td>
<td>13</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>1¼</td>
<td>(31.5)</td>
<td>17</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>1½</td>
<td>(37.5)</td>
<td>20</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>(50)</td>
<td>22</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2½</td>
<td>(63)</td>
<td>27</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>(75)</td>
<td>33</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>3½</td>
<td>(90)</td>
<td>44</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>(100)</td>
<td>55</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>(150)</td>
<td>110</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

\(^{A}\)For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

**Note:** For an aggregate specification having a generally unrestrictive gradation (i.e. wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

**Note:** When determining moisture content for T 99 samples, use approximately 100 grams, and approximately 500 grams for T 180 samples.

\(^{B}\)Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry-loose unit mass of the aggregate in kg/m³ (determined using T 19M/T 19) and dividing by 1600.

**Sample Size for Aggregate**

*Table 1*

7.  **Procedure**

7.1  Determine the mass of the sample to the nearest 0.1 percent or better of the total sample mass.

7.2  Dry the sample thoroughly in the sample container by means of the selected source of heat, exercising care to avoid loss of any particles. Very rapid heating may cause some particles to explode, resulting in loss of particles. Use a controlled temperature oven when excessive heat may alter the character of the aggregate, or where more precise measurement is required. If a source of heat other than the controlled temperature oven is used, stir the sample during drying to accelerate the operation and avoid localized overheating. When using a microwave oven, stirring of the sample is optional.

7.2.1  Caution – When using a microwave oven, occasionally minerals are present in aggregates that may cause the material to overheat and explode. If this occurs, it can damage the microwave oven.
7.3 When a hot plate is used, drying can be expedited by the following procedure. Add sufficient anhydrous denatured alcohol to cover the moist sample. Stir and allow suspended material to settle. Decant as much of the alcohol as possible without losing any of the sample. Ignite the remaining alcohol and allow it to burn off during drying over the hot plate.

7.3.1 Warning – Exercise care to control the ignition operation to prevent injury or damage from the burning alcohol.

7.4 The sample is thoroughly dry when further heating causes, or would cause, less than 0.1 percent additional loss in mass.

WSDOT Note: When weighing hot samples, use a heat sink to protect the balance.

7.5 Determine the mass of the dried sample to the nearest 0.1 percent or better of the total sample mass after it has to room temperature.

8. Calculation

8.1 Calculate total evaporable moisture content as follows:

\[ p = \frac{100 (W - D)}{D} \]

where:

\[ p = \text{total evaporable moisture content of sample, percent;} \]
\[ W = \text{mass of original sample, g; and} \]
\[ D = \text{mass of dried sample, g} \]

8.2 Surface moisture content is equal to the difference between the total evaporated moisture content and the absorption, with all values based on the mass of a dry sample. Absorption may be determined in accordance with T 85, Test for Specific Gravity and Absorption of Coarse Aggregates, or T 84, Test for Specific Gravity and Absorption of Fine Aggregates.

9. Precision and Bias

See AASHTO T 255 for Precision and Bias.

10. Report

Report the results using one or more of the following:

- Materials Testing System (MATS)
- WSDOT Form 422-020, 422-020A, or 422-020B
- Form approved in writing by the State Materials Engineer
Performance Exam Checklist

Total Moisture Content of Aggregate by Drying
FOP for AASHTO T 255

Participant Name ________________________________ Exam Date ____________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Representative sample of appropriate mass obtained?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Mass of clean, dry container determined?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Sample placed in container and mass determined?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Test sample mass conforms to the required mass?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Sample mass determined to 0.1 percent?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Loss of moisture avoided prior to mass determination?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Sample dried by a suitable heat source?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Sample cooled prior to mass determination?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. If aggregate heated by means other than a controlled oven, is sample stirred to avoid localized overheating?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. Mass determined and compared to previous mass – showing less than 0.1 percent loss?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. Calculations performed properly and results reported to the nearest 0.1 percent?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ___________________________________________

Comments:
AASHTO T 272
Standard Method of Test for Family of Curves—One Point Method

AASHTO T 272 has been adopted by WSDOT.
## Performance Exam Checklist

**Family of Curves — One-Point Method**  
**FOP for AASHTO T 272**

<table>
<thead>
<tr>
<th>Participant Name ________________________________</th>
<th>Exam Date ____________________</th>
</tr>
</thead>
</table>

**Procedure Element**

1. The tester has a copy of the current procedure on hand?  
   - Yes ☐  No ☐

2. One-point determination of dry density and corresponding moisture content made in accordance with the FOP for AASHTO T 99, or AASHTO T 180?  
   - Yes ☐  No ☐

   a. Correct size mold used?  
      - Yes ☐  No ☐

   b. Correct number of blows per layer used (25 or 56)?  
      - Yes ☐  No ☐

   c. Correct number of layers used (3, 4, or 5)?  
      - Yes ☐  No ☐

   d. Moisture content determined in accordance with FOP for AASHTO T 255/T 265 or AASHTO T 217?  
      - Yes ☐  No ☐

3. One-point plotted on family of curves supplied?  
   - Yes ☐  No ☐

4. One-point falls within 80 to 100 percent of optimum moisture content in order to be valid?  
   - Yes ☐  No ☐

5. If one-point does not fall within 80 to 100 percent of optimum moisture content, another one-point determination with an adjusted water content is made?  
   - Yes ☐  No ☐

6. Maximum dry density and corresponding optimum moisture content correctly estimated?  
   - Yes ☐  No ☐

First Attempt:  Pass ☐  Fail ☐  
Second Attempt: Pass ☐  Fail ☐

Signature of Examiner  ________________________________

Comments:

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WSDOT Test Method FOP for AASHTO T 304¹
Uncompacted Void Content of Fine Aggregate

1. Scope

1.1 This method describes the determination of the loose uncompacted void content of a sample of fine aggregate. When measured on any aggregate of a known grading, void content provides an indication of that aggregate’s angularity, sphericity, and surface texture compared with other fine aggregates tested in the same grading. When void content is measured on an as-received fine aggregate grading, it can be an indicator of the effect of the fine aggregate on the workability of a mixture in which it may be used.

1.2 Three procedures are included for the measurement of void content. Two use graded fine aggregate (standard grading or as-received grading), and the other uses several individual size fractions for void content determinations:

1.2.1 Standard Graded Sample (Method A) – This method uses a standard fine aggregate grading that is obtained by combining individual sieve fractions from a typical fine aggregate sieve analysis. See the section on Preparation of Test Samples for the Grading.

Note: WSDOT Specifications require Method A.

1.2.2 See the section on Significance and Use for guidance on the method to be used.

1.3 The values stated in English units shall be regarded as the standard.

1.4 This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. References Documents

2.1 AASHTO Standards

T 84 Specific Gravity and Absorption of Fine Aggregate

2.1 WSDOT Standards

T 2 – FOP for AASHTO for the Sampling of Aggregates

T 248 – FOP for AASHTO for Reducing Field Samples of Aggregates to Testing Size

T 27/11 – FOP for WAQTC for the Sieve Analysis of Fine and Coarse Aggregates

¹This FOP is based on AASHTO T 304-11 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
2.1  ASTM Standards
   B 88 – Specification for Seamless Copper Water Tube
   B 88M – Specification for Seamless Copper Water Tube (Metric)
   C 29/29M – Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate
   C 117 – Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
   C 125 – Terminology Relating to Concrete and Concrete Aggregates
   C 128 – Test Method for Specific Gravity and Absorption of Fine Aggregate
   C 136 – Test Method for Sieve Analysis of Fine and Coarse Aggregates
   C 702 – Practice for Reducing Samples of Aggregate to Testing Size
   C 778 – Specification for Standard Sand
   D 75 – Practice for Sampling Aggregates

2.2  ACI Document
   ACI 116R – Cement and Concrete Terminology

3.  Terminology
   3.1  Terms used in this standard are defined in ASTM C 125 or ACI 116R.

4.  Summary of Test Method
   4.1  A nominal 100-mL calibrated cylindrical measure is filled with fine aggregate of prescribed grading by allowing the sample to flow through a funnel from a fixed height into the measure. The fine aggregate is struck off, and its mass is determined by weighing. Uncompacted void content is calculated as the difference between the volume of the cylindrical measure and the absolute volume of the fine aggregate collected in the measure. Uncompacted void content is calculated using the bulk dry specific gravity of the fine aggregate. Two runs are made on each sample and the results are averaged.

   4.1.1  For a graded sample the percent void content is determined directly, and the average value from two runs is reported.

5.  Significance and Use
   5.1  Methods A provide percent void content determined under standardized conditions which depend on the particle shape and texture of a fine aggregate. An increase in void content by these procedures indicates greater angularity, less sphericity, or rougher surface texture, or some combination of the three factors. A decrease in void content results is associated with more rounded, spherical, smooth surfaced fine aggregate, or a combination of these factors.

   5.1.1  The standard graded sample (Method A) is most useful as a quick test which indicates the particle shape properties of a graded fine aggregate. Typically, the material used to make up the standard graded sample can be obtained from the remaining size fractions after performing a single sieve analysis of the fine aggregate.
Uncompacted Void Content of Fine Aggregate

Nominal 100-ml Cylindrical Measure

*Figure 1*

Suitable Funnel Stand Apparatus With Cylindrical Measure in Place

*Figure 2*
5.3.4 The bulk dry specific gravity of the fine aggregate is used in calculating the void content. The effectiveness of these methods of determining void content and its relationship to particle shape and texture depends on the bulk specific gravity of the various size fractions being equal, or nearly so. The void content is actually a function of the volume of each size fraction. If the type of rock or minerals, or its porosity, in any of the size fractions varies markedly it may be necessary to determine the specific gravity of the size fractions used in the test.

5.4 Void content information from Method A, will be useful as an indicator of properties such as in bituminous concrete, the effect of the fine aggregate on stability and voids in the mineral aggregate; or the stability of the fine aggregate portion of a base course aggregate.

6. Apparatus

6.1 Cylindrical Measure – A right cylinder of approximately 100 mL capacity having an inside diameter of approximately 39 mm and an inside height of approximately 86 mm made of drawn copper water tube meeting ASTM Specification B 88 Type M, or B 88 M Type C. The bottom of the measure shall be metal at least 6 mm thick, shall be firmly sealed to the tubing, and shall be provided with means for aligning the axis of the cylinder with that of the funnel. (See Figure 1.)

6.2 Funnel – The lateral surface of the right frustum of a cone sloped 60 ± 4º from the horizontal with an opening of 12.7 ± 0.6 mm diameter. The funnel section shall be a piece of metal, smooth on the inside and at least 38 mm high. It shall have a volume of at least 200 mL or shall be provided with a supplemental glass or metal container to provide the required volume. (See Figure 2.)

**Note 1:** Pycnometer top C9455 sold by Hogentogler and Co., Inc., 9515 Gerwig, Columbia, MD 21045, 410-381-2390 is satisfactory for the funnel section, except that the size of the opening has to be enlarged and any burrs or lips that are apparent should be removed by light filing or sanding before use. This pycnometer top must be used with suitable glass jar with the bottom removed (Figure 2).

6.3 Funnel Stand – A three or four legged support capable of holding the funnel firmly in position with the axis of the funnel colinear (within a 4º angle and a displacement of 2 mm) with the axis of the cylindrical measure. The funnel opening shall be 115 ± 2 mm above the top of the cylinder. A suitable arrangement is shown in Figure 2.

6.4 Glass Plate – A square glass plate approximately 60 mm by 60 mm with a minimum 4 mm thickness used to calibrate the cylindrical measure.

6.5 Pan – A metal or plastic pan of sufficient size to contain the funnel stand and to prevent loss of material. The purpose of the pan is to catch and retain fine aggregate particles that overflow the measure during filling and strike off. The pan shall not be warped so as to prevent rocking of the apparatus during testing.
6.6 Metal spatula with a blade approximately 100 mm long, and at least 20 mm wide, with straight edges. The end shall be cut at a right angle to the edges. The straight edges. The straight edge of the spatula blade is used to strike off the fine aggregate.

6.7 Scale or balance accurate and readable to ±0.1 g within the range of use, capable of weighing the cylindrical measure and its contents.

7. Sampling

7.1 The sample(s) used for this test shall be obtained using FOP for AASHTO T 2 and FOP for AASHTO T 248, or from sieve analysis samples used for FOP for WAQTC/AASHTO T 27/11, or from aggregate extracted from a bituminous concrete specimen. For Method A, the sample is washed over a 150-um (No. 100) or 75-um (No. 200) sieve in accordance with FOP for WAQTC/AASHTO T 27/11 and then dried and sieved into separate size fractions according to FOP for WAQTC/AASHTO T 27/11 procedures. Maintain the necessary size fractions obtained from one (or more) sieve analysis in a dry condition in separate containers for each size.

8. Calibration of Cylindrical Measure

8.1 Apply a light coat of grease to the top edge of the dry, empty cylindrical measure. Weigh the measure, grease, and glass plate. Fill the measure freshly boiled, deionized water at a temperature of 18 to 24°C. Record the temperature of the water. Place the glass plate on the measure, being sure that no air bubbles remain Dry the outer surfaces of the measure and determine the combined mass of measure, glass plate, grease, and water by weighing. Following the final weighing, remove the grease, and determine the mass of the clean, dry, empty measure for subsequent test.

8.2 Calculate the volume of the measure as follows:

\[
V = 1000 \frac{M}{D}
\]

where:

- \(V\) = volume of cylinder, mL,
- \(M\) = net mass of water, g, and
- \(D\) = density of water (see table in ASTM C 29/C 29M for density at the temperature used), Kg/m³.

Determine the volume to the nearest 0.1 mL.

Note 2: If the volume of the measure is greater than 100.0 mL, it may be desirable to grind the upper edge of the cylinder until the volume is exactly 100.0 mL, to simplify subsequent calculations.
9. Preparation of Test Samples

9.1 Method A – Standard Graded Sample – Weigh out and combine the following quantities of fine aggregate which has been dried and sieved in accordance with FOP for AASHTO T 27/11.

<table>
<thead>
<tr>
<th>Individual Size Fraction</th>
<th>Mass, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing</td>
<td>Retained on</td>
</tr>
<tr>
<td>No. 8 (2.36mm)</td>
<td>No. 16 (1.18 mm)</td>
</tr>
<tr>
<td>No. 16 (1.18 mm)</td>
<td>No. 30 (600 um)</td>
</tr>
<tr>
<td>No. 30 (600 um)</td>
<td>No. 50 (300 um)</td>
</tr>
<tr>
<td>No. 50 (300 um)</td>
<td>No. 100 (150 um)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

The tolerance on each of these amounts is ±0.2 g.

9.2 **Method B – Individual Size Fractions** – WSDOT has deleted this section they use Method A.

9.3 Method C – As Received Grading – WSDOT has deleted this section they use Method A.

9.4 Specific Gravity of Fine Aggregate – If the bulk dry specific gravity of fine aggregate from the source is unknown, determine it on the minus No. 4 (4.75 mm) material according to AASHTO T 84. Use this value in subsequent calculations unless some size fractions differ by more than 0.05 from the specific gravity typical of the complete sample, in which case the specific gravity of the fraction (or fractions) being tested must be determined. An indicator of differences in specific gravity of various particle sizes is a comparison of specific gravities run on the fine aggregate in different gradings. Specific gravity can be run on gradings with and without specific size fractions of interest. If specific gravity differences exceed 0.05, determine the specific gravity of the individual 2.36 mm (No. 8) to 150 um (No. 100) sizes for use with Method A or the individual size fractions for use with Method B either by direct measurement or by calculation using the specific gravity data on gradings with and without the size fraction of interest. A difference in specific gravity of 0.05 will change the calculated void content about 1 percent.

10. Procedure

10.1 Mix each test sample with the spatula until it appears to be homogeneous. Position the jar and funnel section in the stand and center the cylindrical measure as shown in Figure 2. Use a finger to block the opening of the funnel. Pour the test sample into the funnel. Level the material in the funnel with the spatula. Remove the finger and allow the sample to fall freely into the cylindrical measure.
10.2 After the funnel empties, strike-off excess heaped fine aggregate from the cylindrical measure by a single pass of the spatula with the width of the blade vertical using the straight part of its edge in light contact with the top of the measure. Until this operation is complete, exercise care to avoid vibration or any disturbance that could cause compaction of the fine aggregate in the cylindrical measure (Note 3). Brush adhering grains from the outside of the container and determine the mass of the cylindrical measure and contents to the nearest 0.1 g. Retain all fine aggregate particles for a second test run.

Note 3: After strike-off, the cylindrical measure may be tapped lightly to compact the sample to make it easier to transfer the container to scale or balance without spilling any of the sample.

10.3 Recombine the sample from the retaining pan and cylindrical measure and repeat the procedure. The results of two runs are averaged. See the Calculation section.

10.4 Record the mass of the empty measure. Also, for each run, record the mass of the measure and fine aggregate.

11. Calculation

11.1 Calculate the uncompacted voids for each determination as follows:

\[ U \] = \frac{V - (F/G)}{V} \times 100

\[ V \] = volume of cylindrical measure, mL;

\[ F \] = net mass, g, of fine aggregate in measure (gross mass minus the mass of the empty measure);

\[ G \] = Bulk dry specific gravity of fine aggregate; and

\[ U \] = uncompacted voids, percent, in the material.

11.2 For the standard Graded Sample (Method A), calculate the average uncompacted voids for the two determinations and report the result as \( U_s \).

12. Report

12.1 For the Standard Graded Sample (Method A) report:

12.1.1 The Uncompacted Voids \( (U_s) \) in percent to the nearest 1 percent.

12.1.2 The specific gravity value used in the calculations.

12.2 Report the results using one or more of the following:

- Materials Testing System (MATS)
- WSDOT Form 350-161
- Form approved in writing by the State Materials Engineer

13. Precision and Bias

See AASHTO T 304 for Precision and bias.
Performance Exam Checklist

Uncompacted Void Content of Fine Aggregate
FOP AASHTO T 304

Participant Name ________________________________ Exam Date ____________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>

Sample Preparation (Method A)

*Note:* If Bulk Dry Specific Gravity is unknown, determine it on the minus No. 4 (4.75 mm) material according to AASHTO T-84

1. Field sample obtained per FOP for AASHTO T-2? ☐ ☑
2. Sample reduced to testing size per FOP for AASHTO T-248? ☐ ☑
3. Sample washed over No. 100 or No. 200 sieve in accordance with FOP for WAQTC/AASHTO T 27/11? ☐ ☑
4. Sample dried to constant weight? ☐ ☑
5. Standard Graded sample achieved per FOP for WAQTC/AASHTO T 27/11? ☐ ☑
6. Necessary size fractions obtained, maintained in a dry condition in separate containers for each size? ☐ ☑
7. Standard Graded sample-weighed out and combined per Section 9.1, FOP for AASHTO T 304? ☐ ☑
Procedure Element

PROCEDURE (Method A)

Note: If Bulk Dry Specific Gravity is unknown, determine it on the minus No. 4 (4.75 mm) material according to AASHTO T-84.

1. Test sample mixed until it appears to be homogeneous? Yes No
2. Jar and funnel section positioned in stand and cylindrical measure centered on stand? Yes No
3. Finger used to block the opening of the funnel? Yes No
4. Test sample poured into the funnel and leveled? Yes No
5. Finger removed and sample allowed to fall freely into cylindrical measure? Yes No
6. After funnel empties, is excess material struck off with single pass of upright spatula? Yes No
7. Was care taken to avoid any vibration or disturbance that could cause compaction of material? Yes No
8. All adhering grains brushed off before weighing the cylindrical measure? Yes No
9. Mass of the cylindrical measure and contents weighed to nearest 0.1 gram? Yes No
10. All fine aggregate particles retained and re-homogenized for a second test run? Yes No
11. Percent (%) of Uncompacted Voids calculated for each run, as per FOP for AASHTO T-304, Method A? Yes No
12. Were the results for each run averaged for a final result? Yes No
13. Was the (%) percent of Uncompacted voids reported to the nearest one percent (1%)? Yes No
14. All calculations performed correctly? Yes No

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ________________________________

Comments:
WSDOT FOP for AASHTO T 308

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

1. Scope
   1.1 This test method covers the determination of asphalt binder content of HMA mixtures by ignition at temperatures that reach the flashpoint of the binder in a furnace. The means of specimen heating may be the convection method or the direct infrared (IR) irradiation method. The aggregate remaining after burning can be used for sieve analysis using FOP for AASHTO T 27/T11.
   1.2 The values in English units are to be regarded as the standard.
   1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents
   2.1 AASHTO Standards
      M 231 – Weighing Devices Used in the Testing of Materials
   2.2 Other Standards
      Manufacturer’s Instruction Manual
   2.3 WSDOT Standards
      T 329 – FOP for AASHTO Moisture Content of Asphalt (HMA) by Oven Method
      T27/11 – FOP for WAQTC Sieve Analysis of Fine and Coarse Aggregates
      T 168 – FOP for WAQTC Sampling Bituminous Paving Materials
      T 712 – Reducing Samples of Hot Mix Asphalt to Testing Size
      SOP 728 – Method for Determining Ignition Furnace Calibration Factor

3. Summary of Test Method
   3.1 The asphalt binder in the paving mixture is ignited using the furnace equipment applicable to the particular method.
   3.2 The asphalt binder content is calculated as the difference between the initial mass of the asphalt mixture and the mass of the HMA residual aggregate, with adjustments for the calibration factor, and the moisture content. The asphalt content is expressed as mass percent of moisture-free mixture.

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1This FOP is based on AASHTO T 308-08 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
4. Significance and Use

4.1 This method can be used for quantitative determinations of asphalt binder content and gradation in HMA mixtures and pavement specimens for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Aggregate obtained by this test method may be used for gradation analysis according to T 27/11.

5. Apparatus

5.1 Ignition Furnace – A forced-air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection-type furnace must be capable of maintaining the temperature at 578°C (1072°F). The furnace chamber dimensions shall be adequate to accommodate a specimen size of 3500 g. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and, when set up properly, shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with the capability to pull air through the furnace to expedite the test and reduce the escape of smoke into the laboratory.

5.1.1 For Method A, the furnace shall also have an internal balance thermally isolated from the furnace chamber and accurate to 0.1 g. The balance shall be capable of weighing a 3500-g specimen in addition to the specimen baskets. A data collection system will be included so that the mass can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate the change in mass of the specimen baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content (percent), test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the specimen mass loss does not exceed 0.01 percent of the total specimen mass for three consecutive minutes. The furnace shall also allow the operator to change the ending mass loss percentage to 0.02 percent.

5.2 Specimen Basket Assembly – Consisting of specimen basket(s), catch pan, and an assembly guard to secure the specimen basket(s) to the catch pan.

5.2.1 Specimen basket(s) – Of appropriate size that allows the specimens to be thinly spread and allows air to flow through and around the specimen particles. Sets with two or more baskets shall be nested. The specimen shall be completely enclosed with screen mesh, perforated stainless steel plate, or other suitable material.

Note 1: Screen mesh or other suitable material with maximum and minimum openings of 2.36 mm (No. 8) and 0.600 mm (No. 30), respectively, has been found to perform well.

5.2.2 Catch Pan – Of sufficient size to hold the specimen basket(s) so that aggregate particles and melting asphalt binder falling through the screen are caught.
5.3 Oven – Capable of maintaining 110 ± 5°C (230 ± 9°F).

5.4 Balance – Of sufficient capacity and conforming to the requirements of M 231, Class G 2.

5.5 Safety Equipment – Safety glasses or face shield, dust mask, high temperature gloves, long sleeve jacket, a heat-resistant surface capable of withstanding 650°C (1202°F) and a protective cage capable of surrounding the specimen baskets during the cooling period.

5.6 Miscellaneous Equipment – A pan larger than the specimen basket(s) for transferring the specimen after ignition, spatulas, bowls, and wire brushes.

6. Sampling

6.1 Obtain specimens of freshly produced hot-mix asphalt in accordance with FOP for WAQTC T 168.

6.2 The test specimen for asphalt content determination shall be the end result of a larger specimen taken in accordance with FOP for WAQTC T 168.

6.3 If the mixture is not sufficiently soft to separate for testing, carefully heat the mixture in an oven until sufficiently soft, not to exceed 350°F or the recommended mixing temperature from the mix design verification report. Do not leave the specimen in the oven for an extended period of time.

6.4 The size of the test specimen shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1. Specimen sizes shall not be more than 500 g greater than the minimum recommended specimen mass. The maximum specimen size including basket shall not exceed the capacity of the balance.

Note 2: Large specimens of fine mixes tend to result in incomplete ignition of asphalt binder.

<table>
<thead>
<tr>
<th>Nominal Max. Agg. * Size</th>
<th>Class</th>
<th>Minimum Mass of Specimen, g</th>
<th>Maximum Mass of Specimen, g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HMA</td>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>US No. 4</td>
<td>1200</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td>⅜ in</td>
<td>1200</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td>⅝ in</td>
<td>1500</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>¾ in</td>
<td>2000</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td>1 in</td>
<td>3000</td>
<td>3500</td>
<td></td>
</tr>
<tr>
<td>1½ in</td>
<td>4000</td>
<td>4500</td>
<td></td>
</tr>
</tbody>
</table>

*For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

Note: For an aggregate specification having a generally unrestrictive gradation (i.e. wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.


Test Method A

7. Test Procedures

7.1 Test Initiation

7.1.1 Preheat the ignition furnace to 1000°F (538°C). Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

7.2 Determine the moisture content of the specimens according to FOP for AASHTO T 329 Moisture Content of Asphalt (HMA) by Oven Method.

7.3 Enter the calibration factor for the specific mix to be tested.

7.4 Weigh and record the mass of the specimen basket(s) and catch pan (with guards in place) to the nearest 0.1g.

7.5 Prepare the specimen as described in Section 6. Evenly distribute this specimen in the specimen basket(s) that have been placed in the catch pan, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

7.6 Determine and record the total mass of the specimen, basket(s), catch pan, and basket guards to the nearest 0.1g. Calculate and record the initial mass of the specimen (total mass minus the mass of the specimen basket assembly).

7.7 Input the initial mass of the specimen in whole grams into the ignition furnace controller. Verify that the correct mass has been entered.

7.8 Tare or zero furnace balance, open the chamber door, and gently set the specimen baskets in the furnace. Close the chamber door, and verify that the specimen mass (including the basket(s)) displayed on the furnace scale equals the total mass recorded in Section 7.6 within ± 6 g. Differences greater than 6 g or failure of the furnace scale to stabilize may indicate that the sample basket(s) are contacting the furnace wall.

Note 3: Due to the extreme heat of the furnace, the operator should wear safety equipment high temperature gloves, face shield, fire-retardant shop coat—when opening the door to load or unload the specimen.

7.9 Initiate the test by pressing the start/stop button. This will lock the specimen chamber and start the combustion blower.

Note 4: The furnace temperature will drop below the setpoint when the door is opened, but will recover with the door closed and when ignition occurs. Specimen ignition typically increases the temperature well above the setpoint, depending on specimen size and asphalt content.

WSDOT Safety Note: Do not attempt to open the furnace door until the binder has been completely burned off.
7.10 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete (the change in mass does not exceed 0.01 percent for three consecutive minutes). Press the start/stop button. This operation will unlock the specimen chamber and cause the printer to print out the test results.

7.11 Open the chamber door, remove the specimen basket assembly and place it on a heat resistance surface. Place the protective cage over the specimen basket assembly, and allow specimen to cool to room temperature (approximately 30 minutes).

7.12 Use the corrected asphalt binder content (0.01 percent) from the printed ticket. If a moisture content (0.01 percent) has been determined, subtract the percent moisture from the printed ticket corrected asphalt content, and report the resultant value as the corrected asphalt binder content to 0.1 percent.

**Test Method B**

8. Test Procedure

WSDOT does not use Method B and has deleted it from the procedure.

9. Gradation

9.1 Allow the specimen to cool to room temperature in the sample baskets.

9.2 Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets. Determine and record the total mass of the specimen to the nearest 0.1g.

9.3 Perform the gradation analysis according to FOP for WAQTC T 27/T11.

10. Report

10.1 Report the test method (A), corrected asphalt binder content, calibration factor, temperature compensation factor (if applicable), total percent loss, specimen mass, moisture content (if determined) and the test temperature. Attach the original printed tickets to the report for units with internal balances.

10.2 The asphalt percentage and aggregate gradation shall be reported on one or more of the following:

- Materials Testing System (MATS)
- WSDOT Form 350-092 and 350-157
- Form approved in writing by the State Materials Engineer

11. Precision and Bias

See AASHTO T 308 for Precision and Bias.
Performance Exam Checklist

WSDOT FOP for AASHTO T 308
Determining the Asphalt Cement Content of Hot Mix Asphalt (HMA) by the Ignition Method

Participant Name ________________________________  Exam Date __________________

Procedure Element
1. The tester has a copy of the current procedure on hand?  Yes ☐  No ☐
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?  Yes ☐  No ☐

Procedure
1. Oven at correct temperature 538 C?  Yes ☐  No ☐
2. Mass of specimen baskets and catch pan recorded?  Yes ☐  No ☐
3. Specimen evenly distributed in basket?  Yes ☐  No ☐
4. Mass of specimen recorded?  Yes ☐  No ☐

Method A
5. Enter calibration factor for specific mix design?  Yes ☐  No ☐
6. Initial mass entered into furnace controller?  Yes ☐  No ☐
7. Specimen correctly placed into furnace?  Yes ☐  No ☐
8. Test continued until stable indicator signals?  Yes ☐  No ☐
9. Binder content obtained on printed ticket?  Yes ☐  No ☐
10. Binder content corrected for moisture?  Yes ☐  No ☐
11. All calculations performed correctly?  Yes ☐  No ☐

First Attempt:  Pass ☐  Fail ☐  Second Attempt:  Pass ☐  Fail ☐

Signature of Examiner

Comments:
1. Scope

1.1 This test method describes the procedure for determining the in-place density and moisture of soil and soil-aggregate by use of nuclear equipment. The density of the material may be determined by direct transmission, backscatter, or backscatter/air-gap ratio method. The WSDOT standard method for determining density is by direct transmission.

1.2 Density – The total or wet density of soil and soil-rock mixtures is determined by the attenuation of gamma radiation where the source or detector is placed at a known depth up to 12 in (300 mm) while the detector(s) or source remains on the surface (Direct Transmission Method) or the source and detector(s) remain on the surface (Backscatter Method).

1.2.1 The density in mass per unit volume of the material under test is determined by comparing the detected rate of gamma radiation with previously established calibration data.

1.3 Moisture – The moisture content of the soil and soil-rock mixtures is determined by thermalization or slowing of fast neutrons where the neutron source and the thermal neutron detector both remain at the surface.

1.3.1 The water content in mass per unit volume of the material under test is determined by comparing the detection rate of thermalized or slow neutrons with previously established calibration data.

1.4 SI Units – The values stated in SI units are to be regarded as the standard.

1.5 This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. See Section 6. Hazards.

2. Referenced Documents

2.1 AASHTO Standards

T 9 – Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop

T 180 – Moisture-Density Relations of Soils Using a 10 lb (4.54 kg) Rammer and a 18 in (457 mm) Drop

T 191 – Density of Soil In-Place by the Sand-Cone Method

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1 This FOP is based on AASHTO 310-06 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

T 217 – Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester
T 224 – Correction for Coarse Particles in the Soil Compaction Test
T 255 – Total Evaporable Moisture Content of Aggregate by Drying
T 265 – Laboratory Determination of Moisture Content of Soils
T 272 – Family of Curves – One-Point Method

2.2 ASTM Test Method
D 2216 – Laboratory Determination of Moisture Content of Soil
D 2487 – Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D 2488 – Description and Identification for Soils (Visual-Manual Procedure)
D 2937 – Density of Soil in Place by the Drive-Cylinder Method
D 4253 – Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
D 4254 – Maximum Index Density and Unit Weight of Soils and Calculation of Relative Density

2.3 WSDOT Standards
T 606 – Method of Test for Compaction Control of Granular Materials
SOP 615 – Determination of the % Compaction for Embankment & Untreated Surfacing Materials using the Nuclear Moisture-Density Gauge

3. Significance
3.1 The test method described is useful as a rapid, nondestructive technique for the in-place determination of the wet density and water content of soil and soil-aggregate.

3.2 The test method is used for quality control and acceptance testing of compacted soil and rock for construction and for research and development. The non-destructive nature allows repetitive measurements at a single test location and statistical analysis of the results.

3.3 Density – The fundamental assumptions inherent in the methods are that Compton scattering is the dominant interaction and that the material under test is homogeneous.

3.4 Moisture – The fundamental assumptions inherent in the test method are that the hydrogen present is in the form of water as defined by ASTM D 2216, and that the material under test is homogeneous.
3.5 Test results may be affected by chemical composition, sample heterogeneity, and, to a lesser degree, material density and the surface texture of the material being tested. The technique also exhibits spatial bias in that the gauge is more sensitive to water contained in the material in close proximity to the surface and less sensitive to water at deeper levels.

4. Interferences

4.1 In-Place Density Interferences

4.1.1 The chemical composition of the sample may affect the measurement, and adjustments may be necessary.

4.1.2 The gauge is more sensitive to the density of the material in close proximity to the surface in the Backscatter Method.

*Note 1:* The nuclear gauge density measurements are somewhat biased to the surface layers of the soil being tested. This bias has largely been corrected out of the Direct Transmission Method and any remaining bias is insignificant. The Backscatter Method is still more sensitive to the material within the first several inches from the surface. Density measurements with direct transmission is the WSDOT standard method.

4.1.3 Oversize rocks or large voids in the source-detector path may cause higher or lower density determination. Since there is lack of uniformity in the soil due to layering, rock or voids the test site beneath the gauge will be excavated and a representative sample will be taken to determine the gradation per WSDOT SOP 615.

4.1.4 Keep all other radioactive sources at least the minimum distance recommended by the manufacture away from the gauge to avoid affecting the measurement.

4.2 In-Place Moisture Content Interferences

4.2.1 The chemical composition of the sample may dramatically affect the measurement and adjustments may be necessary. Hydrogen in forms other than water, as defined by ASTM D 2216, and carbon will cause measurements in excess of the true value. Some chemical elements such as boron, chlorine, and minute quantities of cadmium will cause measurements lower than the true value.

4.2.2 The water content determined by this test method is not necessarily the average water within the volume of the sample involved in the measurement. The measurement is heavily influenced by the water content of the material closest to the surface. The volume of soil and rock represented in the measurement is indeterminate and will vary with the water content of the material. In general, the greater the water content of the material, the smaller the volume involved in the measurement. At 10 lbs/ft³ (160 kg/m³), approximately 50 percent of the typical measurement results from the water content of the upper 2 to 3 in (50 to 75 mm).

4.2.3 Keep all other neutron sources at least the minimum distance recommended by the manufacture away from the gauge to avoid affecting the measurement.
5. Apparatus

5.1 Nuclear Density/Moisture Gauge – While exact details of construction of the gauge may vary, the system shall consist of:

5.1.1 A sealed source of high energy gamma radiation such as cesium or radium.

5.1.2 Gamma Detector – Any type of gamma detector such as a Geiger-Mueller tube(s).

5.2 Fast Neutron Source – A sealed mixture of a radioactive material such as americium, radium, or californium-252 and a target material such as beryllium.

5.3 Slow Neutron Detector – Any type of slow neutron detector such as boron trifluoride or helium-3 proportional counter.

5.4 Reference Standard – A block of material used for checking instrument operation, correction of source decay, and to establish conditions for a reproducible reference count rate.

5.5 Site Preparation Device – A plate, straightedge, or other suitable leveling tool which may be used for planing the test site to the required smoothness, and in the Direct Transmission Method, guiding the drive pin to prepare a perpendicular hole.

5.6 Drive Pin – A pin not to exceed the diameter of the rod in the Direct Transmission Gauge by more than ¼ in (6mm) or as recommended by the gauge manufacturer used to prepare a hole in the material under test for inserting the rod.

5.6.1 A slide hammer, with a drive pin attached, may also be used both to prepare a hole in the material to be tested and to extract the pin without distortion to the hole. In place of a slide hammer a hammer of significant size and weight for preparing a hole in the material to be tested using the drive pin along with an extraction tool.

5.7 Drive Pin Extractor – A tool that may be used to remove the drive pin in a vertical direction so that the pin will not distort the hole in the extraction process.

6. Hazards

6.1 This gauge utilizes radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of this gauge must become familiar with applicable safety procedures and government regulations.

6.2 Effective user instructions together with routine safety procedures, such as source leak tests, recording and evaluation of film badge data, etc., are a recommended part of the operation and storage of this gauge.

7. Calibration

Nuclear gauges used for the purpose of acceptance testing, independent assurance testing, or dispute resolution shall be calibrated

WSDOT owned nuclear density gauges will be calibrated by WSDOT using the manufacturer’s recommended procedures or may be calibrated by an external calibration facility that has been approved by the State Materials Engineer.
Nuclear gauges that are not owned by WSDOT shall be calibrated in accordance with AASHTO T 310 Annexes A1, A2, and A3.

8. Standardization

8.1 Turn the gauge on and allow it to stabilize (approximately 10 to 20 minutes) prior to standardization. Leave the power on during the day’s testing.

8.2 Standardize the nuclear gauge at the construction site at the start of each day’s work and as often as deemed necessary by the operator or agency. Daily variations in standard count shall not exceed the daily variations established by the manufacturer of the gauge. If the daily variations are exceeded after repeating the standardization procedure, the gauge should be repaired and or recalibrated.

8.3 Record the standard count for both density and moisture in the Daily Standard Count Log. The exact procedure for standard count is listed in the manufacturer’s Operators Manual.

9. Procedure

9.1 Turn on and allow the equipment to stabilize (warm up) according to the manufacturer’s recommendations (see 8.2.1). Prior to performing density test verify that today’s Standardization Count has been preformed.

Select a test location per WSDOT SOP 615.

9.2 Prepare the test site in the following manner:

9.2.1 Remove all loose and disturbed material and additional material as necessary to expose the top of the material to be tested.

**Note 2:** The spatial bias should be considered in determining the depth at which the gauge is to be seated.

9.2.2 Select a horizontal area sufficient in size to accommodate four gauge readings that will be 90° to each other, by planing the area to a smooth condition so as to obtain maximum contact between the gauge and material being tested.

9.2.3 The maximum void beneath the gauge shall not exceed ⅛ in (3 mm). Use native fines or fine sand to fill the voids and smooth the surface with a rigid plate or other suitable tool. The depth of the filler shall not exceed approximately ⅛ in (3 mm).

9.3 This Section has been deleted because WSDOT does not use this method

9.4 *Direct Transmission Method of In-Place Nuclear Density & Moisture Content*

9.4.1 Select a test location where the gauge in test position will be at least the minimum distance recommended by the manufacture away from any vertical projection. If gauge will be within the minimum distance recommended by the manufacture follow instructions outlined by manufactures instruction manual.
9.4.2 Make a hole perpendicular to the prepared surface using the guide and the hole-forming device (Section 5). The hole shall be a minimum of 2 in (50 mm) deeper than the desired measurement depth and of an alignment that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area.

9.4.3 Mark the test area to allow the placement of the gauge over the test site and to allow the alignment of the source rod to the hole. Follow manufacturer recommendations if applicable.

**WSDOT Note:** For alignment purposes, the user may expose the source rod for a maximum of ten seconds.

9.4.4 Remove the hole forming device carefully to prevent the distortion of the hole, damage to the surface, or loose material to fall into the hole.

**WSDOT Note:** If the hole cannot be maintained contact Regional Materials Laboratory for directions on how to proceed.

9.4.5 Place the instrument on the material to be tested, making sure of maximum surface contact as described above.

9.4.6 Lower the source rod into the hole to the desired test depth. Pull gently on the gauge in the direction that will bring the side of the probe to face the center of the gauge so that the probe is in intimate contact with the side of the hole in the gamma measurement path.

9.4.7 When selecting a test location, the tester shall visually select a site where the least compactive effort has been applied. Select a test location where the gauge will be at least 6 in (150 mm) away from any vertical mass. If closer than 24 in (600 mm) to a vertical mass, such as in a trench, follow gauge manufacturer correction procedures.

The test location should be at least 33 ft (10 m) away from other sources of radioactivity and at least 10 ft (3 m) away from large objects or the minimum distance recommended by the manufacturer, whichever is the greater distance.

9.4.8 If the gauge is so equipped, set the depth selector to the same depth as the probe before recording the automated (gauge computed densities, moisture contents, and weights) values.

9.4.9 Secure and record one, one minute dry density and moisture content readings, then turn the gauge 90° and perform another set of readings. If the two dry density readings are not within 3 lbs/cf (50 kg/m³) of each other see Note 5.

**Note 5:** If two readings are not within tolerances stated, rotate gauge 90° and retest. Again compare both 90° readings. If after four readings, the results are not within the tolerances stated, rotate gauge 90° and retest. Again compare both readings. If these reading are still not within tolerances stated move to another location to perform test.
10. Calculation of Results

10.1 If dry density is required, the in-place water content may be determined by using the nuclear methods described herein; gravimetric samples and laboratory determination; or other approved instrumentation.

10.1.1 If the water content is determined by nuclear methods, use the gauge readings directly.

10.1.2 If the water content is determined by other methods, and is in the form of percent, proceed as follows:

\[ d = \frac{100}{100+W} (m) \]

where:

- \( d \) = dry density in lb/ft\(^3\) (kg/m\(^3\))
- \( m \) = wet density in lb/ft\(^3\) (kg/m\(^3\))
- \( W \) = water as a percent of dry mass.

10.2. Percent Compaction

WSDOT has deleted this section refer to WSDOT SOP 615 for determining the percent compaction.

11. Report

WSDOT has deleted this section refer to WSDOT SOP 615 for reporting.

12. Precision and Bias

This section has been deleted by WSDOT. Refer to AASHTO T310 for precision and bias information.

Appendix

WSDOT has deleted this section; WSDOT uses the manufacturer’s software to calibrate the gauge.
Performance Exam Checklist

In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
FOP FOR AASHTO T 310

Participant Name ________________________________    Exam Date ______________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Gauge turned on and allowed to stabilize per manufacturer’s recommendations?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Gauge standardized and standard count recorded in accordance with manufacturer’s instructions?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Test location selected per WSDOT SOP 615?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Loose, disturbed material removed?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Flat, smooth area prepared?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Surface voids filled with native fines (⅛ in (3 mm) maximum thickness)?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Hole driven 2 in (50 mm) deeper than material to be tested?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Gauge placed, probe placed, and source rod lowered without disturbing loose material?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. For alignment purposes, did not expose the source rod for more than 10 seconds.</td>
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<td>☐</td>
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<tr>
<td>12. Method B:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Gauge firmly seated, and gently pulled back so that source rod is against hole?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>b. A one minute count taken; dry density and moisture data recorded?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>c. Gauge turned 90° (180° in trench)?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>d. Gauge firmly seated, and gently pulled back so that source rod is against hole?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>e. A second one-minute count taken; dry density and moisture data recorded?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>f. Density counts within 3 lb/ft³ (50 kg/m³)?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>g. Average of two tests?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. A minimum 9 lbs (4 kg) sample obtained from below gauge?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14. Oversize determined following WSDOT SOP 615?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. All calculations performed correctly?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>16. Nuclear Gauge secured in a manner consistent with current DOH requirements?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

First Attempt:  Pass ☐  Fail ☐    Second Attempt:  Pass ☐  Fail ☐

Signature of Examiner ____________________________________________
Comments:
WSDOT FOP for AASHTO T 3121
Preparing Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

1. Scope
   1.1 This standard covers the compaction of cylindrical specimens of hot-mix asphalt (HMA) using the Superpave gyratory compactor.
   1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents
   2.1 AASHTO Standards
      M 231 – Weighing Devices Used in Testing of Materials
      TP 71 – Evaluation of the Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading
      R 30 – Mixture Conditioning of Hot-Mix Asphalt (HMA)
      R 35 – Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
      T 166 – Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
      T 168 – Sampling Bituminous Paving Mixtures
      T 209 – Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt (HMA)
      T 275 – Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
      T 316 – Viscosity Determination of Asphalt Binder Using Rotational Viscometer
   2.2 Other Standards
      WSDOT SOP 731 – Method for Determining Volumetric Properties of Hot Mix Asphalt (HMA)

3. Significance and Use
   3.1 This standard is used to prepare specimens for determining the mechanical and volumetric properties of HMA. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedure is used in the placement of the paving mix.

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1This FOP is based on AASHTO T 312-09 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
3.2. This test method may be used to monitor the density of test specimens during their preparation. It may also be used for field control of an HMA production process.

4. Apparatus

4.1. Superpave Gyratory Compactor—An electrohydraulic or electromechanical compactor with a ram and ram heads as described in Section 4.3. The axis of the ram shall be perpendicular to the platen of the compactor. The ram shall apply and maintain a pressure of 600 ± 18 kPa perpendicular to the cylindrical axis of the specimen during compaction (Note 1). The compactor shall tilt the specimen molds at an average internal angle of 1.16 ± 0.02° (20.2 ± 0.35 mrad), determined in accordance with AASHTO TP 71. The compactor shall gyrate the specimen molds at a rate of 30.0 ± 0.5 gyrations per minute throughout compaction.

**Note 1:** This stress calculates to 10,600 ± 310 N total force for 6 inches (150 mm) specimens.

4.1.1 Specimen Height Measurement and Recording Device—When specimen density is to be monitored during compaction, a means shall be provided to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction once per gyration.

4.1.2 The system may include a connected printer capable of printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.

4.2 Specimen Molds—Specimen molds shall have steel walls that are at least 0.3 inches (7.5 mm) thick and are hardened to at least a Rockwell hardness of C48. The initial inside finish of the molds shall have a root mean square (rms) of 1.60 um or smoother (Note 2). Molds shall have an inside diameter of 5.9 to 6.0 inches (149.90 to 150.00 mm) and be at least 9.8 inches (250 mm) high at room temperature.

**Note 2:** Smoothness measurement is in accordance with ANSI B 46.1. One source of supply for a surface comparator, which is used to verify the rms value of 1.60 um, is GAR Electroforming, Danbury, Connecticut.

4.3 Ram Heads and Mold Bottoms—Ram heads and mold bottoms shall be fabricated from steel with a minimum Rockwell hardness of C48. The ram heads shall stay perpendicular to its axis. The platen side of each mold bottom shall be flat and parallel to its face. All ram and base plate faces (the sides presented to the specimen) shall be flat to meet the smoothness requirement in Section 4.2 and shall have a diameter of 5.88 to 5.90 inches (149.50 to 149.75 mm).

4.4 Thermometric Device—used for determining the temperature of aggregates, binder, and HMA between 18 to 418°F (10 and 232°C).

4.5 Balance—A balance meeting the requirements of M 231, Class G5, for determining the mass of aggregates, binder, and HMA.
4.6 Oven – An oven, thermostatically controlled to ± 5\(^\circ\) F (± 3\(^\circ\) C), for heating aggregates, binder, HMA, and equipment as required. The oven shall be capable of maintaining the temperature required for mixture conditioning in accordance with R 30.

4.7 Miscellaneous – Flat-bottom metal pans for heating aggregates, scoop for batching aggregates, containers (grill-type tins, beakers, containers for heating asphalt), large mixing spoon or small trowel, large spatula, gloves for handling hot equipment, paper disks, mechanical mixer (optional), lubricating materials recommended by the compactor manufacturer.

4.8 Maintenance – In addition to routine maintenance recommended by the manufacturer, check the Superpave gyratory compactor’s mechanical components for wear, and perform repair, as recommended by the manufacturer.

5. Hazards

5.1 Use standard safety precautions and protective clothing when handling hot materials and preparing test specimens.

6. Standardization

6.1 Items requiring periodic verification of calibration include the ram pressure, angle of gyration, gyration frequency, LVDT (or other means used to continuously record the specimen height), and oven temperature. Verification of the mold and platen dimensions and the inside finish of the mold are also required. When the computer and software options are used, periodically verify the data processing system output using a procedure designed for such purposes. Verification of calibration, system standardization, and quality checks may be performed by the manufacturer, other agencies providing such services, or in-house personnel. Frequency of verification shall follow the manufacturer’s recommendations.

6.2 The angle of gyration refers to the internal angle (tilt of mold with respect to end plate surface within the gyratory mold). The calibration of the internal angle of gyration should be verified in accordance with AASHTO TP 71.

7. Preparation of Apparatus

7.1 Immediately prior to the time when the HMA is ready for placement in the mold, turn on the main power for the compactor for the manufacturer’s required warm-up period.

7.2 Verify the machine settings are correct for angle, pressure, and number of gyrations.

7.3 Lubricate any bearing surfaces as needed per the manufacturer’s instructions.

7.4 When specimen height is to be monitored, the following additional item of preparation is required. Immediately prior to the time when the HMA is ready for placement in the mold, turn on the device for measuring and recording the height of the specimen, and verify the readout is in the proper units, mm, and the recording device is ready. Prepare the computer, if used, to record the height data, and enter the header information for the specimen.
8. HMA Mixture Preparation

8.1 Weigh the appropriate aggregate fractions into a separate pan, and combine them to the desired batch weight. The batch weight will vary based on the ultimate disposition of the test specimens. If a target air void level is desired, as would be the case for Superpave mix analysis and performance specimens, batch weights will be adjusted to create a given density in a known volume. If the specimens are to be used for the determination of volumetric properties, the batch weights will be adjusted to result in a compacted specimen having dimensions of 6 inches (150 mm) in diameter and 4.53 ± 0.12 inches (115 ± 5 mm) in height at the desired number of gyrations.

**Note 3:** It may be necessary to produce a trial specimen to achieve this height requirement. Generally, 4500–4700 g of aggregate are required to achieve this height for aggregates with combined bulk specific gravities of 2.55–2.70, respectively.

8.2 Place the aggregate and binder container in the oven, and heat them to the required mixing temperature.

8.2.1 The mixing temperature range is defined as the range of temperatures where the unaged binder has a kinematic viscosity of 170 ± 20 mm²/s (approximately 0.17 ± 0.02 Pa·s for a binder density of 1.00 g/cm³) measured in accordance with T 316.

**Note 4:** Modified asphalts may not adhere to the equi-viscosity requirements noted, and the manufacturer’s recommendations should be used to determine mixing and compaction temperatures.

**Note 5:** The SI unit kinematic viscosity is m²/s; for practical use, the submultiple mm²/s is recommended. The more familiar centistokes is a cgs unit of kinematic viscosity; it is equal to 1 mm²/s. The kinematic viscosity is the ratio of the viscosity of the binder to its density. For a binder with a density equal to 1.000 g/cm³, a kinematic viscosity of 170 mm²/s is equivalent to a viscosity of 0.17 Pa·s measured in accordance with T 316.

8.3 Charge the mixing bowl with the heated aggregate from one pan, and dry-mix thoroughly. Form a crater in the dry blended aggregate, and weigh the required amount of binder into the mix. Immediately initiate mixing.

8.4 Mix the aggregate and binder as quickly and thoroughly as possible to yield HMA having a uniform distribution of binder. As an option, mechanical mixing may be used.

8.5 After completing the mixture preparation perform the required mixture conditioning in accordance with R 30.

8.6 Place a compaction mold and base plate in an oven not to exceed 350°F for a minimum of 60 minutes prior to the estimated beginning of compaction (during the time the mixture is being conditioned in accordance with R 30).
8.7 Following the mixture conditioning period specified in R 30, if the mixture is at the compaction temperature, proceed immediately with the compaction procedure as outlined in Section 9. If the compaction temperature is different from the mixture conditioning temperature used in accordance with R 30, place the mix in another oven at the compaction temperature for a brief time (maximum of 30 minutes) to achieve the required temperature.

8.7.1. The compaction temperature is the mid-point of the range of temperatures where the unaged binder has a kinematic viscosity of 280 ± 30 mm²/s (approximately 0.28 ± 0.03 Pa·s) measured in accordance with T 316 (Note 4).

8.8 If loose HMA plant mix is used, the sample should be obtained in accordance with T 168. The mixture shall be brought to the compaction temperature range by careful, uniform heating in an oven immediately prior to molding.

9. Compaction Procedure

9.1 When the temperature of the HMA is five degrees above the compaction temperature as shown on the “Mix Design Verification Report,” remove the heated mold, base plate, and upper plate (if required) from the oven. Place the base plate and a paper disk in the bottom of the mold.

9.2 Remove the pan of HMA from the oven and in one motion invert the pan onto the construction paper, vinyl mat, etc. Quickly remove any material that remains in the pan and include it with the HMA sample to be compacted. Grasp opposing edges of the paper and roll them together to form the HMA into a cylindrical shape. Insert one end of the paper roll into the bottom of the compaction mold and remove the paper as the HMA slides into the mold. This process needs to be accomplished in approximately 60 seconds. Place the mixture into the mold in one lift. Care should be taken to avoid segregation in the mold. After all the mix is in the mold, level the mix, and place another paper disk and upper plate (if required) on top of the leveled materials.

9.3 Load the charged mold into the compactor, and center the loading ram.

9.4 Apply a pressure of 600 ± 18 kPa on the specimen.

9.5 Apply a 1.16 ± 0.02° (20.2 ± 0.35 mrad) average internal angle, as appropriate, to the mold assembly, and begin.

9.6 Allow the compaction to proceed until the desired number of gyrations specified in R 35 is reached and the gyratory mechanism shuts off.

9.7 Remove the angle from the mold assembly; retract the loading ram; remove the mold from the compactor (if required); and extrude the specimen from the mold.

Note 6: The specimens can be extruded from the mold immediately after compaction for most HMA. However, a cooling period of 5 to 10 minutes in front of a fan may be necessary before extruding some specimens to insure the specimens are not damaged.
9.8 Remove the paper disks from the top and bottom of the specimens.

*Note 7:* Before reusing the mold, place it in an oven for at least 5 minutes. The use of multiple molds will speed up the compaction process.

10. Density Procedure

10.3 When the specimen height is to be monitored, record the specimen height to the nearest 0.1 mm after each revolution.

11. Density Calculations

WSDOT has removed this section refer to WSDOT SOP 731.

12. Report

WSDOT has removed this section refer to WSDOT SOP 731.

13. Precision and Bias

See AASHTO T 312 for Precision and Bias.
Performance Exam Checklist

*Determining Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor*

*FOP for AASHTO T 312*

<table>
<thead>
<tr>
<th>Procedure Element</th>
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<tbody>
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<td>1. The tester has a copy of the current procedure on hand?</td>
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<td>☐</td>
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<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Main power for compactor turned on for manufacturer’s required warm-up period if applicable?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Angle, pressure and number of gyrations set?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Bearing surfaces, rotating base surface and rollers lubricated?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Preparation of Mixtures**

1. Is mixture 5°F above compaction temperature? If not, was mixture placed in an oven and brought up to 5°F above compaction temperature? | ☐  | ☐ |
2. Mold and base plate heated for a minimum of 60 minutes in an oven at a temperature not to exceed 350°F? | ☐  | ☐ |

**Plant Mix – Loose mix brought to compaction temperature by uniform heating immediately prior to molding.**

1. Mold, base plate, and upper plate (if required) removed from oven and paper disk placed on bottom of mold? | ☐  | ☐ |
2. Mixture placed into mold in one lift, mix leveled, and paper disk and upper plate (if required) placed on top of material? | ☐  | ☐ |
3. Mold loaded into compactor and a pressure of 600 ± 18 kPa applied? | ☐  | ☐ |
4. Angle of 1.16 ± 0.02° (20.2 ± 0.35 mrad) applied to the mold assembly and gyratory compaction started? | ☐  | ☐ |
5. Compactor shuts off when appropriate gyration level is reached? | ☐  | ☐ |
6. Mold removed and specimen extruded? | ☐  | ☐ |
7. Paper disks removed? | ☐  | ☐ |
8. If specimens are used for determination of volumetric properties, are the heights of the specimens 115 ± 5mm? | ☐  | ☐ |
9. All calculations performed correctly? | ☐  | ☐ |

First Attempt: Pass ☐ Fail ☐  Second Attempt: Pass ☐ Fail ☐  
Signature of Examiner ________________________________
WSDOT FOP for AASHTO T 329
Moisture Content of Asphalt (HMA) by Oven Method

1. Scope

1.1 This method is intended for the determination of moisture content of hot mix asphalt (HMA) by drying in an oven.

1.2 The values stated in SI units are to be regarded as the standard.

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 AASHTO Standards
   M 231 – Weighing Devices Used in the Testing of Materials
   T 168 – Sampling Bituminous Paving Mixtures

2.2 WAQTC Standards
   T 168 – Sampling Bituminous Paving Mixtures

2.3 WSDOT Standards
   T 712 – Standard Method of Reducing Hot Mix Asphalt Paving Mixtures

3. Terminology

3.1 Constant mass shall be defined as the mass at which further drying at 325 ± 25°F (163 ± 14°C) does not alter the mass by more than 0.1 percent.

4. Summary of Test Method

4.1 A sample of HMA is dried in a forced-air, ventilated, or convection oven to a constant mass.

5. Apparatus

5.1 Balance or Scale – 4.4-lb (2-kg) capacity, readable to at least 0.1 g and conforming to the requirements of M 231.

5.2 Forced-Air, Ventilated, or Convection Oven – Capable of maintaining the temperature surrounding the sample at 325 ± 25°F (163 ± 14°C).

5.3 Sample Container – The container in which the sample is dried shall be of sufficient size to contain the sample without danger of spilling and to allow the sample to be evenly distributed in a manner that will allow completion of the test in an expeditious manner.

---

1This FOP is based on AASHTO T 329-08 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
5.4 Thermometric Devices – Armored glass, Infrared gun or dial-type thermometers with metal stems for determining the temperature of aggregates, binder, and HMA.

6. Sample

6.1 A sample of HMA shall be obtained in accordance with WSDOT FOP for WAQTC T 168.

6.2 The sample shall be reduced in size in accordance with WSDOT T 712. The size of the test sample shall be a minimum of 1,000 g.

7. Procedure

7.1 Determine and record the mass of the sample container to the nearest 0.1 g.

7.2 Place the test sample in the sample container. Determine and record the temperature of the test sample. To facilitate drying, evenly distribute the test sample in the sample container.

7.3 Determine and record the total mass of the sample container and moist test sample to the nearest 0.1 g.

7.4 Preheat the oven to drying temperature of 325 ± 25°F (163 ± 14°C).

Note 1: For repeatability between operators and or laboratories the difference between drying temperatures for samples should not exceed 15°F (9°C).

7.5 Calculate the mass of the initial, moist test sample by subtracting the mass of the sample container determined in Section 7.1 from the total mass of the sample container and moist test sample determined in Section 7.3.

7.6 The test sample shall be initially dried for a minimum of 90 minutes, and it's mass determined. Then, at 30 min intervals until constant mass is achieved.

Note 2: The moisture content of test samples and the number of test samples in the oven will affect the rate of drying at any given time. Placing wet test samples in the oven with nearly dry test samples could affect the drying process.

7.7 Cool the sample container and test sample to approximately the same temperature as determined in Section 7.2.

7.8 Determine and record the total mass of the sample container and dry test sample to the nearest 0.1 g.

Note 3: Do not attempt to remove the test sample from the sample container for the purposes of determining the dry mass of the test sample.

7.9 Calculate the mass of the final, dry test sample by subtracting the mass of the sample container determined in Section 7.1 from the total mass of the sample container and dry test sample determined in Section 7.8.
8. Calculations

8.1 WSDOT uses the following formula to calculate moisture content:

\[
\text{Moisture Content, } \% = \frac{M_i - M_f}{M_i} \times 100
\]

Where:
- \( M_i \) = Mass of the initial, moist test sample
- \( M_f \) = Mass of the final, dry test sample

Example: \( M_i = 1,389.8 \) g
\( M_f = 1,388.0 \) g

\[
\text{Moisture Content} = \frac{1,389.8 - 1,388.0}{1,389.8} \times 100 = 0.129\% = 0.13\%
\]

9. Report

9.1 Report the moisture content to the nearest 0.01 percent.

9.2 Report the results using one or more of the following:
- Materials Testing System (MATS)
- WSDOT Form 350-092 and 350-157
- Form approved in writing by the State Materials Engineer
Performance Exam Checklist
*Moisture Content of Asphalt (HMA) by Oven Method*
WSDOT FOP for AASHTO T 329

Participant Name _____________________________  Exam Date ________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>has the current calibration/verification tags present?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Test for Moisture**

1. Representative sample obtained; 1,000 g minimum?  
2. Mass of sample determined to nearest 0.1 g?  
3. Initial temperature recorded?  
4. Sample placed in drying oven for a minimum of 90 minutes?  
5. Sample dried to a constant weight at 325 ±25° F?  
6. Samples checked for additional loss?  
7. Sample and container cooled to approximately the initial temperature before mass determined?  
8. Calculation of moisture content performed correctly?

% Moisture as percent of Wet Mass

\[
\frac{M_i - M_f}{M_i} \times 100
\]

First Attempt:  Pass ☐  Fail ☐  Second Attempt:  Pass ☐  Fail ☐

Signature of Examiner ______________________________________

Comments:
WSDOT FOP for AASHTO T 335¹
Determining the Percentage of Fracture in Coarse Aggregate

1. Scope

1.1 This test method covers the determination of the percentage, by mass, of a coarse aggregate sample that consists of fractured particles meeting specified requirements.

1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 The text of the standard reference notes provide explanatory material. These notes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 Method 1 will be used by WSDOT for determining the fracture of aggregate as required by the Standard Specifications.

2. Referenced Documents

2.1 AASHTO Standards

M 92, Wire-Cloth Sieves for Testing Purposes
M 231, Weighing Devices Used in the Testing of Materials

2.2 WSDOT Standards

T 2 – FOP for AASHTO Sampling of Aggregates
T 27/11 – FOP for WAQTC/AASHTO Sieve Analysis of Fine and Coarse Aggregates
T 248 – FOP for AASHTO Reducing Samples of Aggregate to Testing Size
T 255 – FOP for AASHTO Total Evaporable Moisture Content of Aggregate by Drying

3. Summary of Test Method

3.1 A sample of aggregate is separated using the designated size of screen conforming to the specification controlling the determination of coarse and fine aggregate. The coarse aggregate particles are visually evaluated to determine their conformance to the defined fracture. The percentage of conforming particles, by mass, is determined for comparison to standard specifications.

4. Apparatus

4.1 Balance – Shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of M 231 for general-purpose balance required for the principle sample mass being tested.

¹This FOP is based on AASHTO T 335-09 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
4.2 Sieves – Meeting the requirements of M 92.

4.3 Splitter – Meeting the requirements of T 248.

5. Terminology

5.1 Fractured Face – An angular, rough, or broken surface of an aggregate particle created by crushing, or by other means. A face is considered a “fractured face” whenever one-half or more of the projected area, when viewed normal to that face, is fractured with sharp and well-defined edges (this excludes small nicks).

5.2 Fractured Particle – A particle of aggregate having at least the minimum number of fractured faces specified.

6. Sampling

Sample the aggregate in accordance with WSDOT FOP for AASHTO T 2 and reduce the sample in accordance with WSDOT FOP for AASHTO T 248, to the sample sizes shown in Table 2 of WSDOT FOP for AASHTO T 27/11.

7. Sample Preparation

7.1 Where the specifications list only a total fracture percentage, the sample shall be prepared in accordance with Method 1.

7.2 Method 1 – Combined Fracture Determination

7.2.1 Dry the sample sufficiently to obtain a clean separation of fine and coarse material in the sieving operation. Sieve the sample in accordance with WSDOT FOP for WAQTC/AASHTO T 27/11 over the No. 4 (4.75 mm) sieve.

Note 1: Where necessary, wash the sample over the sieve or sieves designated for the determination of fractured particles to remove any remaining fine material, and dry to a constant mass in accordance with WSDOT FOP for AASHTO T 255.

7.2.2 Reduce the sample using a splitter in accordance with WSDOT FOP for AASHTO T 248 to the appropriate size for test.
Determining the Percentage of Fracture in Coarse Aggregate

<table>
<thead>
<tr>
<th>Nominal Maximum Particle Size</th>
<th>Minimum Sample Mass Retained No. 4 (4.75 mm) Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½ in (37.5 mm)</td>
<td>6 lb (2500 g)</td>
</tr>
<tr>
<td>1 in (25 mm)</td>
<td>3.5 lb (1500 g)</td>
</tr>
<tr>
<td>¾ in (19.0 mm)</td>
<td>2.5 lb (1000 g)</td>
</tr>
<tr>
<td>⅜ in (16.0 mm)</td>
<td>2.0 lb (800 g)</td>
</tr>
<tr>
<td>½ in (12.5 mm)</td>
<td>1.5 lb (700 g)</td>
</tr>
<tr>
<td>⅜ in (9.5 mm)</td>
<td>0.9 lb (400 g)</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>0.4 lb (200 g)</td>
</tr>
</tbody>
</table>

*For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

Note: For an aggregate specification having a generally unrestrictive gradation (i.e., wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

Sample Size (Method 1, Combined Sieve Fracture)
Table 1

7.3 Method 2 – Individual Sieve Fracture Determination WSDOT has deleted this section

8. Procedure

8.1 Spread the sample on a clean flat surface large enough to permit careful inspection of each particle. To verify that a particle meets the fracture criteria, hold the aggregate particle so that the face is viewed directly. (See Section 5.1.)

8.2 To aid in making the fracture determination separate the sample into three categories: (1) fractured particles meeting the above criteria, (2) particles not meeting specification criteria, and (3) questionable or borderline particles.

8.3 Determine the mass of particles in the fractured category, the mass of questionable particles, and the mass of the unfractured particles.

9. Calculation

9.1 Report the following information:

9.1.1 Calculate the mass percentage of fracture faces to the nearest 1 percent as follows:

\[ P = \left( \frac{F + Q/2}{F + Q + N} \right) \times 100 \]

where:

- \( P \) = percent of fracture,
- \( F \) = mass of fractured particles,
- \( Q \) = mass of questionable or borderline particles, and
- \( N \) = mass of unfractured particles.
10. Report

Results shall be reported on standard forms approved for use by the agency. Report fracture to the nearest 1 percent.

Report the results using one or more of the following:

- Materials Testing System (MATS)
- WSDOT Form 350-092 and 350-157
- Form approved in writing by the State Materials Engineer

11. Precision and Bias

See AASHTO T 335 for precision and bias statements.
### Performance Exam Checklist

**Determining the Percentage of Fracture In Coarse Aggregate**  
**WSDOT FOP for AASHTO T 335**

<table>
<thead>
<tr>
<th>Participant Name</th>
<th>Exam Date</th>
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</table>

#### Procedure Element

<table>
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<th>Procedure Element</th>
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<th>No</th>
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<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
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<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Sample reduced to correct size, if needed?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Sample dried and cooled, if necessary?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Sample properly sieved through specified sieve(s)?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Particles separated into fractured, unfractured, and questionable categories?</td>
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<td>☐</td>
</tr>
<tr>
<td>7. Dry mass of each category determined to nearest 0.1 g?</td>
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<td>☐</td>
</tr>
<tr>
<td>8. Calculation performed correctly?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

First Attempt:  Pass ☐  Fail ☐  Second Attempt:  Pass ☐  Fail ☐

Signature of Examiner  ________________________________

Comments:
WSDOT Standard Operating Procedure SOP 615

Determination of the % Compaction for Embankment & Untreated Surfacing Materials Using the Nuclear Moisture-Density Gauge

1. Scope

This procedure covers the procedures for determining the in-place density, moisture content, gradation analysis, oversize correction, and determination of maximum density of compacted soils and untreated surfacing materials using a nuclear density device in the direct transmission mode.

2. References

a. AASHTO T 99 for Method of Test for Moisture-Density Relations of Soils
b. AASHTO T 180 for Method of Test for Moisture-Density Relations of Soils
c. AASHTO T 224 for Correction for Coarse Particles in Soil Compaction Test
d. T 255 – WSDOT FOP for AASHTO for Total Moisture Content of Aggregate by Drying
e. T 272 – WSDOT FOP for AASHTO for Family of Curves — One Point Method
f. T 310 – WSDOT FOP for AASHTO for In-Place Densities and Moisture Content of Soils and Soil-Aggregate by Nuclear Methods (Shallow Depth)
g. WSDOT T 606 Method of Test for Compaction Control of Granular Materials

3. Test Location

When selecting a test location, the tester shall visually select a site where the least compactive effort has been applied. Select a test location where the gauge will be at least 6 in (150 mm) away from any vertical mass. If closer than 24 in (600 mm) to a vertical mass, such as in a trench, follow gauge manufacturer correction procedures.

Note 1: When retesting is required due to a failing test; retest within a 10-foot radius of the original station and offset.

4. Nuclear Density Test

Determine the dry density and moisture content of soils and untreated surfacing materials using the nuclear moisture-density gauge in accordance with WSDOT FOP for AASHTO T 310, and record in the Materials Testing System (MATS), WSDOT Form 350-074, Field Density Test, or other form approved in writing by the State Materials Engineer.
5. Oversize Determination

a. AASHTO T 99 and WSDOT T 606

A sample weighing a minimum of 9 lbs will be taken from beneath the gauge. Care shall be taken to select material that is truly representative of where the moisture density gauge determined the dry density and moisture content.

There are two methods for determining the percentage of material retained on the No. 4 sieve:

Method 1

(1) Dry the sample to SSD conditions (i.e., dried until no visible free moisture is present, material may still appear damp). Allow the sample to cool sufficiently and record mass to the nearest 0.1 percent of the total mass or better.

(2) Shake sample by hand over a verified No. 4 (4.75 mm) sieve. Limit the quantity of material on the sieve so that all particles have the opportunity to reach the sieve openings a number of times during the sieving operation. The mass retained on the No. 4 (4.75 mm) sieve at the completion of the sieving operation shall not exceed 800 grams, 1.8 pounds, for the 12 in sieve, or 340 grams, 0.75 pounds; for the 8 in sieve.

(3) Remove and weigh the material on the No. 4 (4.75 mm) sieve to the nearest 0.1 percent of the total mass or better and record.

Method 2 – Method 2 is recommended for crushed surfacing materials, materials with high clay content, or other granular materials that are at or near the optimum moisture content for compaction.

(1) Determine the mass of the sample to the nearest 0.1 percent of the total mass or better and record.

(2) Charge the material in a suitable container with water, agitate the material to suspend the fines, then slowly decant and screen the material over a verified No. 4 (4.75 mm) sieve. Repeat the process as necessary to remove as much No. 4 (4.75 mm) minus material as possible. DO NOT overload the sieve.

(3) Place the washed sample retained on the No. 4 (4.75 mm) sieve into a tared container. Blot the material to a SSD condition (i.e., no visible free moisture present, material may still appear damp) during this step.

(4) Weigh the mass of the material on the No. 4 (4.75 mm) sieve to the nearest 0.1 percent of the total mass or better and record.

b. AASHTO T 180

Follow either Method 1 or Method 2 in 5 a. with the following exception; sieve the material over a \( \frac{3}{4} \) in (19.0 mm) sieve.
6. Calculations

a. Calculate the percent retained as follows:
\[
\% \text{ retained} (P_c) = 100 \times \frac{\text{mass retained on sieve}}{\text{original mass}} \quad \text{(round to nearest percent)}
\]

b. Calculate percent passing as follows:
\[
\% \text{ passing} = 100 - \% \text{ retained}
\]

c. Calculate the dry density as follows:
\[
d = \frac{100}{100 + W} \quad \text{(m)}
\]

Where:
- \(d\) = dry field density of total sample, pcf
- \(m\) = total field wet density, pcf
- \(W\) = moisture content of total field sample

d. Calculate the corrected theoretical maximum density as follows:
\[
D_f = \frac{D_d \times P_f}{\left(100 - \left(\frac{D_d \times P_c}{k}\right)\right)}
\]

Where:
- \(D_f\) = corrected theoretical maximum density, pcf
- \(D_d\) = dry density, pcf
- \(P_f\) = percent passing
- \(P_c\) = percent retained
- \(k\) = 62.4 × (specific gravity of coarse particles) (Note 2)

**Note 2:** If the specific gravity of the coarse particles has been determined, use this value in the calculation for the “\(k\)” value. If the specific gravity is unknown then use 2.67. Either AASHTO T 85 or WSDOT T 606 Test 3 may be used to determine the specific gravity of the coarse particles.

e. Calculate the percent of compaction using the following equation:
\[
\% \text{ compaction} = \frac{\text{Dry Density (lbs/ft}^3\text{)}}{\text{corrected theoretical maximum density (lbs/ft}^3\text{)}}
\]

7. Density Curve Tables

The Materials Testing System (MATS) Density Curve Tables is the WSDOT preferred method for determining the corrected theoretical maximum density.

a. MATS calculates the corrected theoretical maximum density in accordance with AASHTO T224 Section 4.2 and reports the results in the Density Curve Table.

b. To determine the corrected theoretical maximum density using the Density Curves Table enter the Table at the line corresponding to the % passing or % retained (T99 & T 180 requires percent retained, T 606 requires percent passing), read across to the column labeled Max this number is the Corrected Theoretical Maximum Density.
8. Report
   a. Report the results using one or more of the following:
      • Materials Testing System (MATS)
      • WSDOT Form 350-074 and 351-015
      • Form approved in writing by the State Materials Engineer
   b. Report the percent of compaction to the nearest whole number.
Performance Exam Checklist

WSDOT Standard Operating Procedure SOP 615
Determination of the % Compaction for Embankment & Untreated Surfacing Materials Using the Nuclear Moisture-Density Gauge

Participant Name ____________________________ Exam Date ____________

Procedure Element
1. The tester has a copy of the current procedure on hand? □ □
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present? □ □

Gradation Analysis
3(A) Method 1
1. Sample Dried to a SSD condition (dried until no visible free moisture present) and mass recorded? □ □
2. Sample allowed to cool sufficiently prior to sieving? □ □
3. Sample was shaken by hand through the appropriate sieve for a sufficient period of time? □ □
4. Recorded mass of material retained on the appropriate sieve? □ □
5. Calculated and recorded percent of material retained and passing the appropriate sieve? □ □

3(B) Method 2
1. Mass of sample determined prior to washing? □ □
2. Material charged with water in suitable container and agitated to suspend fines? □ □
3. Sample decanted over required sieve for a sufficient amount of time without overloading sieve? □ □
4. Retained material dried to SSD condition and mass determined? □ □
5. Recorded mass of material retained on appropriate sieve? □ □
6. Calculated and recorded percent of material retained and passing appropriate sieve? □ □

Correction for Coarse Particles
7. Appropriate MATS Density Curve Table used to determine the corrected theoretical maximum density, based on the percent passing or retained on the appropriate sieve? □ □
8. All calculations performed correctly? □ □

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ____________________________
Comments:
A. Scope

1. This method outlines the procedure for selecting sampling and testing sites in accordance with accepted random sampling techniques. It is intended that all testing and sampling locations be selected in an unbiased manner based entirely on chance.

2. Testing and sampling locations and procedures are as important as testing. For test results or measurements to be meaningful, it is necessary that the sampling locations be selected at random, typically by use of a table of random numbers. Other techniques yielding a system of randomly selected locations are also acceptable.

B. Summary of Method for Selecting Random Test Location

- Method A – Determining a Random Location for Hot Mixture Asphalt (HMA) Density Tests
- Method B – Determining Random Test Location for Sampling HMA Mix, Aggregates, and Miscellaneous Materials
- Method C – Determining Random Test Location for Portland Cement Concrete
- Appendix A – Hot Mix Asphalt Density (400 Ton Lots)
- Appendix B – Hot Mix Asphalt Density 80 Tons (Milepost)
- Appendix C – Hot Mix Asphalt Density Test Locations for Irregular Paving Areas
- Appendix D – Hot Mix Asphalt Density 400 Ton (Milepost)

C. Procedure for Determining Random Test/Sampling Location

1. Method A – Selection of Random Location for HMA Density

   This method outlines the procedure for determining the random location of HMA Density testing sites for 80 ton sublots. Calculate the linear foot distance for an 80 ton sublot.

   Example:

   Pavement – 12 ft wide, 0.15 ft deep, 80 ton sublot

   \[
   \text{Tons per linear Foot} = \frac{1.0 \text{ ft} \times 12 \text{ ft} \times 0.15 \text{ ft} \times 2.05 \text{ tons}}{27} = 0.137 \text{ Tons per linear Foot}
   \]

   \[
   \text{Sublot length} = \frac{80 \text{ Tons}}{0.137 \text{ Tons per linear Foot}} = 583.9 \text{ lf (round to 584 lf)}
   \]

   a. Choose a number at random (see Section 2b) to enter Table 1 to determine the X and Y multiplier. The recommended method for choosing a random number for HMA density is to use the last two digits from the most recent standard count on the nuclear gauge. A new random number is selected at the start of production each day.
b. Determine the test station and offset as follows:

Test Station = (sublot length × “X” multiplier) + beginning station of paving

Offset (from right side of pavement) = (width of pavement × “Y” multiplier)

**Note:** The values in the table have been set so that no measurements are taken within 0.5 LF of the edge of the lane. When a test falls within an area that is not appropriate for a test location (i.e., a bridge end, track crossing, night joint) move the testing location 25 if ahead or back on stationing, as appropriate.

**Example:**

**Beginning Station** = 168 + 75

Width = 12 ft
Sublot length = 584

Ending Station = (Beginning Station + Sublot length) = (16875 + 584) = 174 +59

Standard Count = 2951

**Beginning Test Location**
Enter table at line (51): “X” multiplier = 0.762, “Y” multiplier = 0.65
Stationing = (584 × 0.762) + 16875 = 173 +20
Offset = (12 × 0.65) = 7.8 ft

c. Determine subsequent testing locations as follows:

Enter the random number table on the next line in sequence (if original table entry 51, next line entry 52, then 53, etc.)

New beginning station = previous ending station
X coordinate = (sublot length × “X” multiplier) + new beginning station
Y coordinate = (width of pavement × “Y” multiplier)

**Example:**

**Second Test Location**

New beginning station = 174+59
Enter table at line (52): “X” multiplier = 0.285, “Y” multiplier = 0.28
Test station = (584 × 0.285) + 17459 = 176 +25
Offset = (12 × 0.28) = 3.4 ft from right edge
Y values are selected so that lateral locations are no closer than 0.5 feet (0.15 m) from the edge of a paving lane.

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<th>Y</th>
<th>Sequence</th>
<th>X</th>
<th>Y</th>
<th>Sequence</th>
<th>X</th>
<th>Y</th>
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</table>

Random Numbers With X and Y Value

Table 1

2. Method B – Hot Mix Asphalt (HMA) Pavement Mixture or Aggregates
   a. Determine the sublot increment of the material.
   b. Choose a number at random to enter Table 2. The recommended method for choosing a random number for HMA is to choose the last two digits from the first civilian license plate seen that day (do not use vehicles associated with the project site) or use a digital stopwatch or a computer generated random number. A new random number is selected for each new sublot.

   Note: To use the stop watch method; randomly start and stop the stop watch 10 or more times then use the decimal part of the seconds as your entry point.
c. Determine the test location.

d. Calculate the first test location as follows:
   
   **Sampling Site = Sublot increment × “X” multiplier (Table 2)**

   Example:

   The car license plane ends in 45. Use 45 as the starting point to enter random number Table 2. “X” = 0.604.

   **First Test Location:**

   Sublot increment = 800 tons
   Beginning tonnage: 0
   Sublot increment: 800 × 0.604 = 483
   Test tonnage Sample 1: Beginning tonnage + 483 tons = 483 tons

   Random sample tonnage may be adjusted per sublot to accommodate field testing. Adjustments to random sample tonnage should be documented.

   Determine subsequent test locations by choosing a new random number for each new sublot and using that number to enter Table 2.

   **Second Test Location:**

   Sampling Site = Sublot increment × “X” multiplier (Table 2)
   Beginning tonnage = 800

   Example:

   The computer generated number was 53. Use 53 as the starting point to enter random number Table 2. “X” = 0.266.

   Enter Table 2 at (53) “X” = 0.266
   Sublot increment: 800 × 0.266 = 212.8
   Testing tonnage Sample 2: 800 + 213 = 1013 tons

   **Third Test Location:**

   Sampling Site = Sublot increment × “X” multiplier (Table 2)
   Beginning tonnage = 1600

   Example:

   The computer generated number was 12. Use 12 as the starting point to enter random number Table 2. “X” = 0.957.

   Enter Table 2 at (12) “X” = 0.957
   Sublot increment: 800 × 0.957 = 765.6
   Testing tonnage Sample 2: 1600 + 766 = 2366 tons
Method of Random Sampling for Locations of Testing and Sampling Sites  

3. Method C – Portland Cement Concrete (PCC)
   a. Determine the sublot increment for the random test sample. A sublot for PCC is based on a sampling frequency of one in five trucks after, two successive trucks within specification.

   \[
   \text{Sublot increment} = \text{Cubic Yards per truck} \times 5 \text{ trucks}
   \]

   Example:
   Each truck carries 10 CY of concrete
   Sublot Increment = 10 CY \times 5 \text{ trucks} = 50 \text{ CY}

   b. Choose a two digit number at random to enter Table 2. The recommended method for choosing a random number for Portland Cement Concrete is to choose the last two digits from the first civilian license plate seen that day (do not use vehicles associated with the project site).

   \textbf{Note:} Start each day of concrete placement with a new “X” value determined by chance in order to obtain a random selection

   c. Determine the sample location as follows:

   \[
   \text{Sampling Location} = \text{Sublot increment} \times \text{“X” multiplier (Table 2)}
   \]

   Example:
   The civilian license plate ends in 37. Use 37 as the starting point to enter random number Table 2 “X”= 0.829.

   Sample location = 50 CY \times 0.829 = 41 CY
d. Determine where the first sample will be taken:

Sample Yardage = (CY per truck × 2 (for the first two trucks)) + Sample location

Example:

**First Sample Location:**
Sample location = (10 CY × 2) + 41 CY = 61 CY

e. The sample will be taken from the truck containing the 61st CY or in this example the seventh truckload of the pour. Allow approximately ½ CY of concrete to be discharged before sampling the truck.

Example:
(41/10) CY = 4.1 trucks + original 2 truck = 6.1 trucks
Sample is located in the first ⅓ of the 7th truck of the pour.

f. Determine subsequent sampling locations as follows:

Example:

**Second Sample Location:**
Use the next sequential line of the chart after the beginning random number. Original number was 37 use line (38) as the starting point to enter random number Table 2. “X” = 0.998.
Sample location = 50 CY × 0.998 = 49.9 CY = 50 CY

g. The second sample will be taken at 120 CY

Example:
20 CY (first two trucks) + 50 (first random sample of 5 trucks) + 50 CY
The sample would come from the last ⅓ of the truck 12th truck of the pour.
Appendix A

**Hot Mix Asphalt Density (400 Ton Lots)**

a. Determine the LOT size and number of tests per LOT. The Standard specifications set the size of a density test lot for Hot Mix Asphalt Pavement to no greater than a single day’s production or 400 tons, whichever is less, and require five tests per LOT. At the end of a day’s production the final lot may be increased to a maximum of 600 tons.

b. Convert this LOT size to an area segment of the roadway based on the roadway section and depth being constructed for the course being tested. The calculations in Example 1 show how this is performed. Table A1 has been provided to give you recommend lot lengths for standard lane widths at various depths. Lot length needs to be determined to the nearest 100 feet.

**Example 1**

Sample Computation for Lot Length

Using nominal compacted density of 2.05 tons/cy, and a 400 ton lot:

\[
\text{Tons per linear foot} = \frac{1.0 \text{ (foot)} \times \text{width (feet)} \times \text{depth (feet)}) \times 2.05 \text{Tons/cy}}{27}
\]

\[
\text{Tons per linear Foot} = \frac{1.0 \text{ ft} \times 12 \text{ ft} \times 0.15 \text{ ft} \times 2.05 \text{ tons}}{27} = 0.137 \text{Tons per linear Foot}
\]

\[
\text{Lot length} = \frac{400 \text{Tons}}{0.137 \text{Tons per linear Foot}} = 2900 \text{ linear Feet}
\]

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<tr>
<th>Lane Width</th>
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<th>Computed Lot Length</th>
<th>Recommended Lot Length</th>
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**Table A1**

LOT length may also be determined based on Nominal Designated LOT sizes. To utilize this concept, compacted mix volumes equivalent to the designated mix quantity per LOT have been determined using the nominal compacted unit weight of Hot Mix asphalt. These volumes are then converted into Density LOT lengths using the typical lane width and specified compacted depth.
c. Determine the locations of the test (or sampling) sites by using values from the random number table to determine the coordinate location on the roadway. In the table, use the “X” values as decimal fractions of the total length of the lot; use the “Y” values as fractions of the width, customarily measured from the right edge of the pavement. The values in the table have been set so that no measurements are taken within 0.5 LF (0.15 m) of the edge of the pavement. Whenever a test location is determined to fall within such an area (i.e., bridge end, track crossing, or night joint) the test location should be moved ahead or back on stationing, as appropriate, by 25 LF (8 m).

d. In order to determine which “X” and “Y” values should be used, enter the table on a line chosen by chance. Recommended procedure is selection of a line based on the last two digits from the most recent standard count on the nuclear density gage. Subsequent “X” and “Y” values are then taken from the lines that follow. Based on the specified sampling frequency, 20 lots can be accommodated by one cycle through the table. Start each shift with a set of values determined by chance in order to obtain random selection.

e. Example 2 shows the calculations for determining the testing location for asphalt pavement density.

Example 2

Test Location Within the LOT for Hot Mix Asphalt Density

For the lot: (12 ft wide, 0.15 ft deep, starting at station 168 + 75 with paving progressing ahead on station), Lot length was previously determined as 2,900 LF. Using the last two digits of the standard count, as in the example, 2951, assume “X” and “Y” values from line (51) in random number table: X = 0.762, Y = 0.65.

For the first test:

Beginning station: 168 + 75
Sublot length increment: 580 × 0.762 = 442
Width offset: 12 × 0.65 = 7.8 ft (from right edge)
Location is: station: (168+75) + 442 = 173 + 17, 7.8 ft from right edge

For the second test:

Beginning station: (168 + 75) + (580) = 174 + 55
Sublot length increment: 580 × 0.285 = 165
Width offset: 12 × 0.28 = 3.4 ft (from right edge)
Location is: station: (174 + 55) + 165 = (176 + 20), 3.4 ft from right edge

For the third test:

Beginning station: (168 + 75) + 580 + 580 = 180 + 35
Sublot length increment: 580 × 0.347 = 201
Width offset: 12 × 0.87 = 10.4 ft (from right edge)
Location is: station: (180 + 35) + 201 = (182 + 36), 10.4 ft from right edge
Appendix B

Hot Mix Asphalt Density 80 Ton (Milepost)

a. The testing location will be calculated using 80 ton sublots.

b. Convert to tons per mile using the roadway area based on the roadway width and depth. The calculations in Example 1 show how this is done. Table A2 has been provided to give you recommend lot lengths for standard lane widths at various depths. Lot length needs to be determined to the nearest .01 mile.

Example 1
Sample Computation for Sublot Length

\[
\text{Tons per linear foot} = \frac{1 \text{ ft} \times \text{width} \times \text{Depth} \times 2.05 \text{ tons/cy}}{27}
\]

\[
\text{Tons per mile} = \text{Tons per lf} \times 5,280 \text{ lf}
\]

\[
\text{Sublot length} = \frac{80 \text{ tons}}{\text{tons per mile}}
\]

<table>
<thead>
<tr>
<th>Lane Width</th>
<th>Compacted Depth</th>
<th>Computed Sublot Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 feet</td>
<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>.25</td>
<td>0.07</td>
</tr>
<tr>
<td>11 feet</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Hot Mix Asphalt Density Test Sublot Length for 80 Ton Sublots at 2.05 Tons/Cubic Yard

Table A2

c. Determine the locations of the test (or sampling) sites by using values from the random number table to determine the coordinate location on the roadway. In the table, use the “X” values as decimal fractions of the total length of the lot; use the “Y” values as fractions of the width, customarily measured from the right edge of the pavement. The values in the table have been set so that no measurements are taken within 0.5 LF (0.15 m) of the edge of the pavement. Whenever a test location is determined to fall within such an area (i.e., bridge end, track crossing, or night joint) the test location should be moved ahead or back on milepost, as appropriate, by .01 mile.

d. In order to determine which “X” and “Y” values should be used, enter the table on a line chosen by chance. Recommended procedure is selection of a line based on the last two digits from the most recent standard count on the nuclear density gage. Subsequent “X” and “Y” values are then taken from the lines that follow. Start each shift with a set of values determined by chance in order to obtain random selection.
e. Example 2 shows the calculations for determining the testing location for asphalt pavement density.

Example 2
Test Location for Hot Mix Asphalt Density

For the Lot: (12 ft wide, 0.12 ft deep, starting at Milepost 1.00 with paving progressing ahead on Milepost), sublot length is 0.14 miles. Using the last two digits of the standard count, as in the example, 2951, assume “X” and “Y” values from line (51) in random number table: X = 0.762, Y = 0.65.

For the first test:
  - Beginning Milepost: 1.00
  - Sublot length increment: \(0.14 \times 0.762 = 0.11\)
  - Width offset: \(12 \times 0.65 = 7.8\) ft (from right edge)
  - Location is: Milepost: \((1.00) + 0.11 = 1.11\), 7.8 ft from right edge

**Ending Milepost** = \(1.00 + 0.14 = 1.14\)

For the second test:
  - New Beginning Milepost: previous ending milepost
  - Sublot length increment: \(0.14 \times 0.285 = 0.04\)
  - Width offset: \(12 \times 0.28 = 3.4\) ft (from right edge)
  - Location is: Milepost: \((1.14) + 0.04 = (1.18)\), 3.4 ft from right edge

**Ending Milepost** = \(1.14 + 0.14 = 1.28\)

For the third test:
  - Beginning Milepost: previous ending milepost
  - Sublot length increment: \(0.14 \times 0.347 = 0.05\)
  - Width offset: \(12 \times 0.87 = 10.4\) ft (from right edge)
  - Location is: Milepost: \((1.28) + 0.05 = (1.78)\), 10.4 ft from right edge
Appendix C

Hot Mix Asphalt Density Test Locations for Irregular Paving Areas

a. Track tonnage placed in the irregular shaped area until 80 tons have been placed, note the stationing.

b. Measure back to the beginning of the paving or end of the previous lot to obtain the length (this is also your beginning station).

c. Choose a random number (see Section 2b) or use the next random number in sequence to enter the random number table.

d. Multiply the length by the “X” value and add to the beginning station to locate your testing site.

e. Measure the width at the testing station and multiply the width time the “Y” value to determine the offset of the testing site.

f. Make a sketch of the area to document the test location in the event a retest is required.

Example:

Paving began at Station 101 + 00. The tester determined that Station 105 + 75 was the end of the 80 ton lot. The random number was 45.

Calculate Testing Station

\[
\text{Sta } 105 + 75 - \text{ Sta } 101 + 00 = 475 \text{ ft} \\
\text{Random } \# \ 45 \ “X” \ \text{value} = 0.552 \\
475 \text{ ft } \times 0.552 = 262 + 101+00=102+62
\]

Calculating Offset

Random \# 45 “Y” value = 0.17
Offset = \(10.5’ \times 0.17 = 1.8’\)
Appendix D

Hot Mix Asphalt Density 400 Ton (Milepost)

a. Determine the LOT size and number of tests per LOT. The Standard specifications set the size of a density test lot for Hot Mix Asphalt Pavement to no greater than a single day’s production or 400 tons, whichever is less, and require five tests per LOT. At the end of a day’s production the final lot may be increased to a maximum of 600 tons.

b. Convert this LOT size to an area segment of the roadway based on the roadway section and depth being constructed for the course being tested. The calculations in Example 1 show how this is performed. Table A3 has been provided to give you recommend lot lengths for standard lane widths at various depths. Lot length needs to be determined to the nearest .01 of a mile.

Example 1
Sample Computation for Lot Length

Using nominal compacted density of 2.05 tons/cy and a 400 ton lot:

\[ \text{Tons per linear Foot} = \frac{1.0 \text{ (foot)} \times \text{width (feet)} \times \text{depth (feet)} \times 2.05 \text{ tons/cy}}{27} \]

\[ \text{Tons per linear Foot} = \frac{1.0 \text{ ft} \times 12 \text{ ft} \times 0.15 \text{ ft} \times 2.05 \text{ tons}}{27} = 0.137 \text{ tons per linear foot} \]

0.137 tons per lineal foot x 5,280 ft = 723.36 tons per mile

\[ \text{Lot length} = \frac{400 \text{ tons}}{723.36 \text{ tons per mile}} = 0.55 \text{ linear miles} \]

<table>
<thead>
<tr>
<th>Lane Width</th>
<th>Compacted Depth</th>
<th>Computed Lot Length</th>
<th>Recommended Lot Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 feet</td>
<td>0.12</td>
<td>0.69</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.55</td>
<td>.55</td>
</tr>
<tr>
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<td>0.20</td>
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<td>.42</td>
</tr>
<tr>
<td></td>
<td>.25</td>
<td>0.33</td>
<td>.034</td>
</tr>
<tr>
<td>11 feet</td>
<td>0.12</td>
<td>0.76</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
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<td>0.46</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.35</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Hot Mix Asphalt Density Test Lot Length 400 Ton Lot at 2.05 Tons/Cubic Yard

Table A3

LOT length may also be determined based on Nominal Designated LOT sizes. To utilize this concept, compacted mix volumes equivalent to the designated mix quantity per LOT have been determined using the nominal compacted unit weight of Hot Mix asphalt. These volumes are then converted into Density LOT lengths using the typical lane width and specified compacted depth. The included tables present the values for LOT Lengths based on mileposts.
c. Determine the locations of the test (or sampling) sites by using values from the random number table to determine the coordinate location on the roadway. In the table, use the “X” values as decimal fractions of the total length of the lot; use the “Y” values as fractions of the width, customarily measured from the right edge of the pavement. The values in the table have been set so that no measurements are taken within 0.5 LF (0.15 m) of the edge of the pavement. Whenever a test location is determined to fall within such an area (i.e., bridge end, track crossing, or night joint) the test location should be moved ahead or back on milepost, as appropriate, by .01 mile.

d. In order to determine which “X” and “Y” values should be used, enter the table on a line chosen by chance. Recommended procedure is selection of a line based on the last two digits from the most recent standard count on the nuclear density gage. Subsequent “X” and “Y” values are then taken from the lines that follow. Based on the specified sampling frequency, 20 lots can be accommodated by one cycle through the table. Start each shift with a set of values determined by chance in order to obtain random selection.

e. Example 2 shows the calculations for determining the testing location for asphalt pavement density.

Example 2
Test Location Within the LOT for Hot Mix Asphalt Density

For the lot: (12 ft wide, 0.15 ft deep, starting at Milepost 1.00 with paving progressing ahead on Milepost), Lot length was previously determined as 0.55 miles. Using the last two digits of the standard count, as in the example, 2951, assume “X” and “Y” values from line (51) in random number table: X = 0.762, Y = 0.65.

For the first test:
   Beginning Milepost: 1.00
   Sublot length increment: .11 × 0.762 = .08
   Width offset: 12 × 0.65 = 7.8 ft (from right edge)
   Location is: Milepost: (1.00) + .08 = 1.08, 7.8 ft from right edge

For the second test:
   Beginning Milepost: (1.00) + (.11) = 1.11
   Sublot length increment: .11 × 0.285 = .03
   Width offset: 12 × 0.28 = 3.4 ft (from right edge)
   Location is: Milepost: (1.11) + .03 = (1.14), 3.4 ft from right edge

For the third test:
   Beginning Milepost: (1.00) + .11 + .11 = 1.22
   Sublot length increment: .11 × 0.347 = .04
   Width offset: 12 × 0.87 = 10.4 ft (from right edge)
   Location is: Milepost: (1.22) + .04 = (1.26), 10.4 ft from right edge
Determination of the Moving Average of Theoretical Maximum Density (TMD) for HMA

1. Scope

This procedure covers the process for obtaining the moving average of the Theoretical Maximum Density (TMD) for calculating pavement compaction in accordance with WSDOT FOP for WAQTC TM 8. The TMD is to be determined in accordance with WSDOT FOP for AASHTO T 209.

2. Procedure

The procedure for determining the moving average of TMD is as follows:

a. On the initial day of production of a new Job Mix Formula, two determinations shall be made to establish an initial average value. The samples shall not be from the same truck. Average the two TMDs and report the result to the Moisture Density Gauge Operator. The TMD value from the Mix Design Verification Report shall not be included in the average. If the two TMDs determined on the initial day do not agree within 1.5 lb/ft$^3$ (24 kg/m$^3$), a third determination shall be made. The initial average density shall be based on the two closest results.

b. A TMD test shall be taken with each mix sample. The moving average is defined as the average of the last five TMD values for the HMA being placed. Until five TMD values have been determined, the moving average will consist of all previous TMD values plus the first TMD value for the current production shift. When five TMD values have been determined, the moving average for each shift will include the last four TMD values plus the first TMD value for the current paving shift. This new moving average value will be used for the entire paving shift.

c. Each TMD shall be compared with the previously computed moving average. If a TMD deviates from the moving average by more than 1.5 lb/ft$^3$ (± 24 kg/m$^3$), a second test shall be made on another portion of the same sample. If the second TMD agrees within 1.5 lb/ft$^3$ (± 24 kg/m$^3$) of the moving average then the first TMD will be discarded and the second TMD will be included in the moving average. If the second TMD is not within 1.5 lb/ft$^3$ (± 24 kg/m$^3$) of the moving average but is within 1.5 lb/ft$^3$ (± 24 kg/m$^3$) of the first TMD, a new moving average will be initiated, discarding all previous results. The new moving average will be sent to the Moisture Density Gauge operator and will replace the current moving average.

d. A moving average will be sent to the Moisture Density Gauge operator once per production shift, unless two tests during a shift are not within 1.5 lb/ft$^3$ (± 24 kg/m$^3$), then a new moving average will be calculated in accordance with “c” of this procedure and sent to the Moisture Density Gauge operator as the new moving average for the shift. The Moisture Density Gauge Operator will continue to use the previous moving average until a new moving average is available.
3. Report

The gauge operator will record the average TMD received from the tester at the HMA plant on WSDOT Form 350-092 and 350-157 or in the MATS database. The average TMD will be used in WSDOT FOP for WAQTC TM 8 to calculate the percent of compaction for statistical evaluation.
WSDOT SOP 730

Correlation of Nuclear Gauge Densities With Hot Mix Asphalt (HMA) Cores

1. When evaluating HMA compaction:
   1.1 A gauge correlation is required:
      a. For each combination of gauge and HMA Mix Design (initial JMF).
      b. When gauge mode changes (i.e., direct transmission to thin layer).
      c. When a gauge is recalibrated.
   1.2 A gauge correlation is not required but may be considered by the Region Materials Engineer when:
      a. Base material changes from the original correlation base (i.e., from a surfacing base to an asphalt base).
      b. Lift thickness change (i.e., 2” to 4”)
      c. The same gauge-HMA Mix Design (Reference Mix Design) combination are used on a different contract within the same construction year
      d. When JMF has been adjusted in accordance with Standard Specifications Section 9-03.8(7)A.

2. Gauge correlation is based on 10 in-place HMA densities and 10 cores taken at the same locations. In-Place HMA densities shall be determined in accordance with WSDOT FOP for WAQTC TM 8. Cores should be taken no later than the day following paving and before traffic has been allowed on roadway. Correlation cores are not required to be taken at record density locations therefore, a site outside the traveled way should be considered for worker safety.

   Note 1: If a core becomes damaged, it shall be eliminated from the average.

   Note 2: Cores may be taken sooner than the day after paving if the HMA is cooled to prevent damage during coring and removal of cores. Water, ice, or dry-ice may be used to cool the pavement. Another method of cooling that may be used is substitution of nitrogen gas or CO2 for drilling fluids.

3. Obtain a pavement core from each of the test sites in accordance with WSDOT SOP 734. The core shall be taken in the nuclear gauge footprint. If direct transmission was used, locate the core at least 1 in (25 mm) away from the edge of the drive pin hole.

4. Core densities shall be determined in conformance with AASHTO T 166 Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens.

5. Correlation factor shall be determined to 0.001 using Standard Form 350-112: Correlation Nuclear Gauge to Core Density, or the MATS database.
WSDOT SOP 731

*Method for Determining Volumetric Properties of Hot Mix Asphalt*

1. Scope

This procedure covers the determination of volumetric properties of Hot Mix Asphalt, i.e., Air Voids (Va), Voids in Mineral Aggregate (VMA), Voids Filled with Asphalt (VFA), and Dust to Binder Ratio (P_{#200}/P_{be}).

2. References

- T 329 – WSDOT FOP for AASHTO Moisture Content of Hot Mix Asphalt (HMA) by Oven Method
- T 27/11 – WSDOT FOP for WAQTC/AASHTO Sieve Analysis of Fine and Coarse Aggregates
- T 166 – WSDOT FOP for AASHTO Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens
- T 168 – WSDOT FOP for WAQTC/AASHTO Sampling of Hot Mix Asphalt Paving Mixtures
- T 209 – WSDOT FOP for AASHTO Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
- T 308 – WSDOT FOP for AASHTO Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
- T 312 – WSDOT FOP for AASHTO Preparing Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
- T 712 – WSDOT Test Method Standard Method of Reducing Hot Mix Asphalt Paving Mixtures

3. Calibration of Compactor

a. The gyratory compactor will be calibrated in accordance with WSDOT VP-58 and according to the manufacturer’s established calibration procedure. Anytime the gyratory compactor is moved to a new testing site a new calibration is required in accordance with WSDOT VP-58.

4. Test Samples

a. All test samples shall be obtained per WSDOT FOP for WAQTC/AASHTO T 168, and reduced in accordance with WSDOT Test Method T 712. It is recommended that the gyratory test sample be the first sample acquired in order to minimize heat loss.

b. The size of the gyratory sample shall be such that it will produce a compacted specimen 115.0 ± 5.0 mm in height. Generally, the mix design verification report from the State Materials Laboratory initial starting mass is adequate.

c. Place the gyratory sample in an oven set no more than 25° F above the compaction temperature (Note 1) as soon as possible to reduce sample cooling. The gyratory test is
temperature sensitive. The sample should be heated five degrees above the compaction temperature as shown on the mix design verification report.

**Note 1:** Any change in compaction temperature must be confirmed by the temperature viscosity chart provided by the asphalt supplier, which can be obtained from the Paving Contractor.

5. **Procedure**

a. Place a compaction mold, base plate, and top plate (if required), in an oven set at no more than 350°F for a minimum of 60 minutes prior to the estimated beginning of compaction. Subsequent uses of a conditioned mold will require 5 minutes of reheating.

b. Place a thermometer into the center of the mix, do not stir the mixture. (Note 3) Compact the sample immediately upon achieving compaction temperature in accordance with step 4 (c).

**Note 2:** While the gyratory test sample is heating it is beneficial to prepare and/or run the other tests as times permits.

c. Perform the sample compaction in accordance with WSDOT FOP for AASHTO T 312 Section 9.

d. Determine theoretical maximum density per WSDOT FOP for AASHTO T 209.

e. Determine asphalt content and gradation per WSDOT FOP for AASHTO T 308 and WSDOT FOP for WAQTC/AASHTO T 27/11.

f. Determine moisture content per WSDOT FOP for AASHTO T 329.

g. Allow the gyratory compacted specimen to cool at room temperature for 15 to 24 hours. Determine the Bulk Specific Gravity (Gmb) of the specimen in accordance with WSDOT FOP for AASHTO T 166 Method A.

**Note 3:** For repeatability between operators the retest sample should be cooled for the same amount of time at room temperature as the original specimen. When sending retest samples to the Region or State Laboratory, note the time the original sample was cooled at room temperature in the remarks section of the transmittal.

6. **Volumetric Calculations**

Calculations

a. Calculate \( \%G_{mm@N_{design}} \) as follows:

\[
\%G_{mm@N_{design}} = \frac{G_{mb}}{G_{mm}} \times 100
\]

**Example:**

\[
\%G_{mm@N_{design}} = \frac{2.383}{2.493} \times 100 = 95.6\%
\]

Where:

- \( \%G_{mm@N_{design}} \) = % theoretical maximum specific gravity @ \( N_{design} \)
- \( G_{mb} \) = Bulk specific gravity of the compacted specimen
- \( G_{mm} \) = Maximum specific gravity of the paving mixture
- \( N_{design} \) = Number of design gyrations
b. Calculate $\%G_{mm}(@N_{ini})$ as follows:

$$\%G_{mm}(@N_{ini}) = 100 \times \left( \frac{G_{mb} \times h_d}{G_{mm} \times h_i} \right)$$

Where:

\begin{align*}
\%G_{mm}(@N_{ini}) & = \text{Percent theoretical maximum specific gravity @ } N_{initial} \\
h_d & = \text{Height of specimen at design gyration level} \\
h_i & = \text{Height of specimen at initial design gyration level} \\
N_{initial} & = \text{Number of initial gyrations}
\end{align*}

Example:

$$\%G_{mm}(@N_{ini}) = 100 \times \left( \frac{2.383 \times 110.0}{2.493 \times 123.1} \right) = 85.4\%$$

c. Calculate Air Voids ($V_a$) as follows:

$$V_a = 100 \times \left( 1 - \left( \frac{G_{mb}}{G_{mm}} \right) \right)$$

Where:

\begin{align*}
V_a & = \text{Percent air voids}
\end{align*}

Example:

$$V_a = 100 \times \left( 1 - \left( \frac{2.383}{2.493} \right) \right) = 4.4\%$$

d. Calculate Voids in Mineral Aggregate (VMA) as follows:

$$\text{VMA} = 100 - \left( \frac{G_{mb} \times P_s}{G_{sb}} \right)$$

Where:

\begin{align*}
P_s & = \text{Percent of aggregate in the mixture (100}-P_b) \\
G_{sb} & = \text{Bulk specific gravity of the combined aggregate} \\
\text{VMA} & = \text{Voids in Mineral Aggregate, percent}
\end{align*}

Example:

$$\text{VMA} = 100 - \left( \frac{2.383 \times 94.8}{2.630} \right) = 14.1\%$$

e. Calculate Voids Filled with Asphalt (VFA) as follows:

$$\text{VFA} = 100 \times \left( \frac{\text{VMA} - V_a}{\text{VMA}} \right)$$

Where:

\begin{align*}
\text{VFA} & = \text{Voids Filled with Asphalt, percent}
\end{align*}

Example:

$$\text{VFA} = 100 \times \left( \frac{14.1 - 4.4}{14.1} \right) = 68.8\%$$
f. Calculate Gravity Stone Effective (G_{se}) as follows:

\[ G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}} \]

Example:

\[ G_{se} = \frac{100 - 5.2}{\frac{100}{2.493} - \frac{5.2}{1.025}} = 2.706 \]

Where:
- \( G_{se} \) = Gravity Stone Effective (specific gravity of aggregates, excluding voids permeable to asphalt)
- \( P_b \) = Percent of binder
- \( G_b \) = Gravity binder

**Note 4:** \( G_b \) is the specific gravity of the asphalt binder. It is imperative that current \( G_b \) is used in the volumetric calculations. Any changes in the binder specific gravity must be confirmed by the temperature viscosity curve provided by the asphalt supplier, which can be obtained from the paving Contractor.

g. Calculate Percent Binder Effective (P_{be}) as follows:

\[ P_{be} = P_b - \left( \frac{P_s \times G_b (G_{se} - G_{sb})}{(G_{se} \times G_{sb})} \right) \]

Example:

\[ P_{be} = 5.2 - \left( \frac{94.8 \times 1.025 (2.706 - 2.630)}{(2.706 \times 2.630)} \right) = 4.2 \]

Where:
- \( P_{be} \) = Percent binder effective, the percent by mass of effective asphalt content minus the quantity of binder lost by absorption into the aggregate particles.
- \( P_s \) = Percent of aggregate in the mixture
- \( G_b \) = Gravity binder
- \( G_{se} \) = Effective specific gravity of the aggregate
- \( G_{sb} \) = Bulk specific gravity of the combined aggregate
- \( P_b \) = Percent of binder

h. Calculate dust-to-binder ratio (P_{200}/P_{be}) as follows:

\[ \frac{P_{200}}{P_{be}} = \frac{P_{200}}{P_{be}} \]

Example:

\[ 5.0 \div 3.6 = 1.4 \]

Where:
- \( \frac{P_{200}}{P_{be}} \) = Dust-to-binder ratio
- \( P_{200} \) = Percent of aggregate passing the No. 200 sieve

7. **Report**

Report the results using one or more of the following of the following:

- Materials Testing System (MATS)
- WSDOT Form 350-560 EF for asphalt content, gradation, and moisture content
- WSDOT Form 350-162 for volumetric properties
- Form approved in writing by the State Materials Engineer
WSDOT SOP 732\textsuperscript{1}

\textit{Volumetric Design for Hot-Mix Asphalt (HMA)}

1. SCOPE

1.1 This standard for mix design evaluation uses aggregate and mixture properties to produce a hot-mix asphalt (HMA) job-mix formula. The mix design is based on the volumetric properties of the HMA in terms of the air voids (V_a), voids in the mineral aggregate (VMA), and voids filled with asphalt (VFA).

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 AASHTO Standards

M 320 – Performance-Graded Asphalt Binder
M 323 – Superpave Volumetric Mix Design
R 30 – Mixture Conditioning of Hot-Mix Asphalt (HMA)
R 35 – Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
T 2 – Sampling of Aggregates
T 11 – Materials Finer Than 75-\textmu m (No. 200) Sieve in Mineral Aggregates by Washing
T 27 – Sieve Analysis of Fine and Coarse Aggregates
T 84 – Specific Gravity and Absorption of Fine Aggregate
T 85 – Specific Gravity and Absorption of Coarse Aggregate
T 100 – Specific Gravity of Soils
T 166 – Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens
T 209 – Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
T 228 – Specific Gravity of Semi-Solid Bituminous Materials
T 248 – Reducing Samples of Aggregate to Testing Size
T 275 – Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
T 283 – Resistance of Compacted Asphalt Mixture to Moisture-Induced Damage

\textsuperscript{1}This Standard Operating procedure is based on AASHTO T 323-04
T 304 – Uncompacted Void Content of Fine Aggregate
T 312 – Preparing and Determining the Density of the Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

2.2 Asphalt Institute

2.3 ASTM Standards

2.4 WSDOT Standards

M 41-01 – Construction Manual
M 41-10 – Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications)
M 46-01 – Materials Manual

SOP 731 – Method for Determining Volumetric Properties of Hot-Mix Asphalt (HMA)

T 2 – WSDOT FOP for AASHTO for Standard Practice for Sampling Aggregate
T 27/11 – WSDOT FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates
T 113 – Method of Test for Determination of Degradation Value
T 166 – WSDOT FOP for AASHTO for Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens
T 176 – WSDOT FOP for AASHTO for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
T 209 – WSDOT FOP for AASHTO for Method of Test for Maximum Specific Gravity of Hot Mix Asphalt Paving Mixtures “Rice Density”
T 248 – WSDOT FOP for AASHTO for Reducing Samples of Aggregates to Testing Size
T 304 – WSDOT Test Method for AASHTO T 304 Uncompacted Void Content of Fine Aggregate
T 312 – WSDOT FOP for AASHTO for Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
T 335 – WSDOT FOP for AASHTO T 335 Determining the Percentage of Fracture in Coarse Aggregate
T 718 – Method of Test for Determining Stripping of Hot Mix Asphalt
T 724 – Method of Preparation of Aggregate for HMA Mix Designs
T 726 – Mixing Procedure for Hot-Mix Asphalt (HMA)

3. Terminology

3.1 HMA – Hot-mix asphalt.

3.2 Design ESALs – Design equivalent (80kN) single-axle loads.

3.2.1 Discussion – Design ESALs are the anticipated project traffic level expected on the design lane over a 15-year period. For pavements designed for more or less than 15 years, determine the design ESALs for 15 years when using this standard.
3.3 Air voids \((V_a)\) – The total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture (Note 1).

**Note 1:** Term defined in Asphalt Institute Manual MS-2, *Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types.*

3.4 Voids in the mineral aggregate (VMA) – The volume of the intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids \((V_a)\), and the effective binder content \((P_{be})\), expressed as a percent of the total volume of the specimen (Note 1).

3.5 Absorbed binder volume \((V_{ba})\) – The volume of binder absorbed into the aggregate (equal to the difference in aggregate volume when calculated with the bulk specific gravity and effective specific gravity).

3.6 Binder content \((P_b)\) – The percent by mass of binder in the total mixture including binder and aggregate.

3.7 Effective binder volume \((V_{be})\) – The volume of binder which is not absorbed into the aggregate.

3.8 Voids filled with asphalt (VFA) – The percentage of the voids in the mineral aggregate (VMA) filled with binder (the effective binder volume divided by the VMA).

3.9 Dust/Asphalt Ratio \((P_{200}/P_{be})\) – By mass, ratio between percent passing the No. 200 (0.075 mm) sieve \((P_{200})\) and the effective binder content \((P_{be})\).

3.10 Nominal maximum aggregate size – For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

**WSDOT Note 1:** For an aggregate specification having a generally unrestrictive gradation (i.e., wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

3.11 Maximum aggregate size – One size larger than the nominal maximum aggregate size (Note 2).

**Note 2:** The definitions given in sections 3.10 and 3.11 apply to Superpave mixes only and differ from the definitions published in other AASHTO standards.

3.12 Reclaimed asphalt pavement (RAP) – Removed and/or processed pavement materials containing asphalt binder and aggregate.

3.13 \(N_{\text{initial}}, N_{\text{design}}, N_{\text{maximum}}\) – the number of gyrations defined in WSDOT Standard Specification 9-03.8(2).

3.14 Effective Asphalt Content \((P_{be})\) – The total asphalt content of a paving mixture minus the portion of asphalt that is lost by absorption into the aggregate particles (Note 1).
4. Summary of the Practice

4.1 Materials Selection – Binder and aggregate and RAP stockpiles are selected that meet the environmental and traffic requirements applicable to the paving project. The bulk specific gravity of all aggregates proposed for blending and the specific gravity of the binder are determined.

*Note 3:* If RAP is used, the bulk specific gravity of the RAP aggregate may be estimated by determining the theoretical maximum specific gravity ($G_{mm}$) of the RAP mixture and using an assumed asphalt absorption for the RAP aggregate to back-calculate the RAP aggregate bulk specific gravity, if the absorption can be estimated with confidence. The RAP aggregate effective specific gravity may be used in lieu of the bulk specific gravity at the discretion of the Agency. The use of the effective specific gravity may introduce an error into the combined aggregate bulk specific gravity and subsequent VMA calculations. The Agency may choose to specify adjustments to the VMA requirements to account for this error based on experience with their local aggregates.

4.2 Design Aggregate Structure – It is recommended at least three trial aggregate blend gradations from selected aggregate stockpiles are blended. For each trial gradation, an initial trial binder content is determined, and at least two specimens are compacted in accordance with WSDOT FOP for AASHTO T 312. A design aggregate structure and an estimated design binder content are selected on the basis of satisfactory conformance of a trial gradation meeting the requirements given in Section 9-03.8(2) of the Standard Specifications for Road, Bridge, and Municipal Construction (*Standard Specifications*) for $V_a$, VMA, VFA, Dust/Asphalt Ratio at $N_{\text{design}}$, and relative density at $N_{\text{initial}}$.

*Note 4:* Previous Superpave mix design experience with specific aggregate blends may eliminate the need for three trial blends.

4.3 Design Binder Content Selection – Replicate specimens are compacted in accordance with WSDOT FOP for AASHTO T 312 at the estimated design binder content and at the estimated design binder content $\pm$ 0.5%. The design binder content is selected on the basis of satisfactory conformance with the requirements of Section 9-03.8(2) of the *Standard Specifications* for $V_a$, VMA, VFA, and Dust/Asphalt Ratio ($P_{200}/P_{be}$) at $N_{\text{design}}$ and the relative density at $N_{\text{ini}}$ and $N_{\text{max}}$. For WSDOT projects, the design binder content selection is determined by the Contractor and is verified by the WSDOT.

4.4 Evaluating Moisture Susceptibility – The moisture susceptibility of the design aggregate structure is evaluated at the design binder content: compacted to approximately 4.0% air voids in accordance with WSDOT FOP for AASHTO T 312, and evaluated according to WSDOT T 718. The design shall meet the tensile strength ratio requirement of WSDOT T 718. The WSDOT State Materials Laboratory will evaluate the HMA for moisture susceptibility.

5. Significance and Use

5.1 The procedure described in this practice is used to produce HMA which satisfies Superpave HMA volumetric mix design requirements.
6. Preparing Aggregate Trial Blend Gradations

6.1 The asphalt binder grade will be indicated in WSDOT Contract Plans.

6.2 Determine the specific gravity of the binder according to T 228.

6.3 Obtain samples of aggregates proposed to be used for the project from the aggregate stockpiles in accordance with WSDOT FOP for AASHTO T 2.

Note 5: Each stockpile usually contains a given size of an aggregate fraction. Most projects employ three to five stockpiles to generate a combined gradation conforming to the job-mix formula and Section 9-03.8(6) of the Standard Specifications.

6.4 Reduce the samples of aggregate fractions according to WSDOT FOP for AASHTO T 248 to samples of the size specified in WAQTC FOP for AASHTO T 27/T 11.

6.5 Wash and grade each aggregate sample according to WAQTC FOP for AASHTO T 27/T 11.

6.6 Determine the bulk and apparent specific gravity for each coarse and fine aggregate fraction in accordance with T 85 and T 84, respectively, and determine the specific gravity of the mineral filler in accordance with T 100. WSDOT requires specific gravity determinations to be reported to an accuracy of 0.001.

6.7 Blend the aggregate fractions using Equation 1:

\[ P = Aa + Bb +Cc, \text{ etc.} \]  

Where:

\[ P \] = Percentage of material passing a given sieve for the combined aggregates \( A, B, C, \text{ etc.} \).

\[ A, B, C, \text{ etc.} \] = Percentage of material passing a given sieve for aggregates \( A, B, C, \text{ etc.} \).

\[ a, b, c, \text{ etc.} \] = proportions of aggregates \( A, B, C, \text{ etc.} \) used in the combination, and where the total = 1.00.

6.8 Prepare a minimum of three trial aggregate blend gradations; plot the gradation of each trial blend on a 0.45-power gradation analysis chart, and confirm that each trial blend meets the Aggregate Gradation Control Points in Section 9-03.8(6) of the Standard Specifications. Gradation control is based on four control sieve sizes: the sieve for the maximum aggregate size, the sieve for the nominal maximum aggregate size, the No. 4 or No. 8 (4.75- or 2.36 mm) sieve, and the No. 200 (0.075 mm) sieve. For WSDOT projects, gradation shall be determined by the following sieves as defined in table W1T An example of three acceptable trial blends in the form of a gradation plot is given in Figure 1.
Sieve Size | ⅜ in | ½ in | ¾ in | 1 in |
--- | --- | --- | --- | --- |
1 ½” | X | | | |
1” | | X | X | |
¾” | | | X | X |
½” | X | X | X | X |
No. 4 | X | X | X | X |
No. 8 | X | X | X | X |
No. 16 | X | X | X | X |
No. 30 | X | X | X | X |
No. 50 | X | X | X | X |
No. 100 | X | X | X | X |
No. 200 | X | X | X | X |

X = indicates sieve is required for gradation determination

Table W1T

6.9 Obtain a test specimen from each of the trial blends according to WSDOT FOP for AASHTO T 248, and conduct the quality tests specified in Section 9-03.8(2) subsections 1, 2, 3, and 4 of the Standard Specifications to confirm that the aggregate in the trial blends meets the minimum quality requirements specified in Section 9-03.8(2) of the Standard Specifications.

Note 6: The designer has an option of performing the quality tests on each stockpile instead of the trial aggregate blend. The test results from each stockpile can be used to estimate the results for a given combination of materials.

Evaluation of the Gradations of Three Trial Blends (Example)
7. Determining an Initial Trial Binder Content for Each Trial Aggregate Gradation

7.1 Designers can either use their experience with the materials or the procedure given in Appendix A1 to determine an initial trial binder content for each trial aggregate blend gradation.

*Note 7:* When using RAP, the initial trial asphalt content should be reduced by an amount equal to that provided by the RAP.

8. Compacting Specimens of Each Trial Gradation

8.1 Prepare replicate mixtures (Note 8) at the initial trial binder content for each of the chosen trial aggregate trial blend gradations. From Table 1, determine the number of gyrations based on the design ESALs for the project. On WSDOT projects the ESAL level will be indicated in the Contract Special Provisions.

*Note 8:* At least two replicate specimens are required, but three or more may be prepared if desired. Generally, 4500 to 4700 g of aggregate is sufficient for each compacted specimen with a height of 110 to 120 mm for aggregates with combined bulk specific gravities of 2.550 to 2.700, respectively.

8.2 Condition the mixtures according to R 30, and compact the specimens to \( N_{\text{design}} \) gyrations in accordance with WSDOT FOP for AASHTO T 312. Record the specimen height to the nearest 0.1 mm after each revolution.

8.3 Determine the bulk specific gravity (\( G_{mb} \)) of each of the compacted specimens in accordance with WSDOT FOP for AASHTO T 166 or T 275 as appropriate. The bulk specific gravity results of the replicate specimens shall not differ by more than 0.020.

<table>
<thead>
<tr>
<th>Design ESALs (^a) (million)</th>
<th>Compaction Parameters</th>
<th>Typical Roadway Application (^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N_{\text{initial}} )</td>
<td>( N_{\text{design}} )</td>
</tr>
<tr>
<td>&lt; 0.3</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Applications include roadways with very light traffic volumes such as local roads, county roads, and city streets where truck traffic is prohibited or at a very minimal level. Traffic on these roadways would be considered local in nature, not regional, intrastate, or interstate. Special purpose roadways serving recreational sites or areas may also be applicable to this level.</td>
<td></td>
</tr>
<tr>
<td>0.3 to &lt; 3</td>
<td>7</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Applications include many collector roads or access streets. Medium-trafficked city streets and the majority of county roadways may be applicable to this level.</td>
<td></td>
</tr>
<tr>
<td>3 to &lt; 30</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Applications include many two-lane, multilane, divided, and partially or completely controlled access roadways. Among these are medium to highly trafficked city streets, many state routes, U.S. highways, and some rural Interstates.</td>
<td></td>
</tr>
<tr>
<td>( \geq 30 )</td>
<td>9</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Applications include the vast majority of the U.S. Interstate system, both rural and urban in nature. Special applications such as truck-weighing stations or truck-climbing lanes on two-lane roadways may also be applicable to this level.</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)The anticipated project traffic level expected on the design lane over a 15-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 15 years.

\(^b\)As defined by *A Policy on Geometric Design of Highways and Streets, 2001*, AASHTO.

**Superpave Gyratory Compaction Effort**

*Table 1*
8.4 Determine the theoretical maximum specific gravity ($G_{mm}$) according to WSDOT FOP for AASHTO T 209 of separate samples representing each of these combinations that have been mixed and conditioned to the same extent as the compacted specimens.

**Note 11:** The maximum specific gravity for each trial mixture shall be based on the average of at least two tests. The maximum specific gravity results of the replicate specimens shall not differ by more than 0.011.

9. Evaluating Compacted Trial Mixtures

9.1 Determine the volumetric requirements for the trial mixtures in accordance with Section 9-03.8(2) of the *Standard Specifications*.

9.2 Calculate $V_a$ and VMA at $N_{design}$ for each trial mixture using equations 2 and 3:

$$V_a = 100 \times \left(1 - \frac{G_{mb}}{G_{mm}}\right)$$  \hspace{1cm} (2)

$$VMA = 100 - \frac{G_{mb}P_s}{G_{sb}}$$  \hspace{1cm} (3)

Where:

- $G_{mb}$ = Bulk specific gravity of the extruded specimen
- $G_{mm}$ = Theoretical maximum specific gravity of the mixture
- $P_s$ = Percent of aggregate in the mixture (100-$P_b$)
- $G_{sb}$ = Bulk specific gravity of the combined aggregate

**Note 12:** Although the initial trial binder content was estimated for a design air void content of 4.0%, the actual air void content of the compacted specimen is unlikely to be exactly 4.0%. Therefore, the change in binder content needed to obtain a 4.0% air void content, and the change in VMA caused by this change in binder content, is estimated. These calculations permit the evaluation of VMA and VFA of each trial aggregate gradation at the same design air void content, 4.0%.

9.3 Estimate the volumetric properties at 4.0 percent air voids for each compacted specimen. On WSDOT projects, the gyration level will be specified in the Contract Provisions.

9.3.1 Determine the difference in average air void content at $N_{design}$ ($\Delta V_a$) of each aggregate trial blend from the design level of 4.0% using Equation 4:

$$\Delta V_a = 4.0 - V_a$$  \hspace{1cm} (4)

9.3.2 Estimate the change in binder content ($\Delta P_b$) needed to change the air void content to 4.0% using Equation 5:

$$\Delta P_b = -0.4 \left(\Delta V_a\right)$$  \hspace{1cm} (5)
9.3.3 Estimate the change in VMA ($\Delta VMA$) caused by the change in the air void content ($\Delta V_a$) determined in Section 9.3.1 for each trial aggregate blend gradation, using Equations 6 or 7.

$$\Delta VMA = 0.2(\Delta V_a) \text{ if } V_a > 4.0$$  \hspace{1cm} (6)

$$\Delta VMA = -0.1(\Delta V_a) \text{ if } V_a < 4.0$$  \hspace{1cm} (7)

Note 13: A change in binder content affects the VMA through a change in the bulk specific gravity of the compacted specimen ($G_{mb}$).

9.3.4 Calculate the VMA for each aggregate trial blend at $N_{design}$ gyrations and 4.0% air voids using Equation 8:

$$VMA_{design} = VMA_{trial} + \Delta VMA$$  \hspace{1cm} (8)

Where:

- $VMA_{design}$ = VMA estimated at a design air void content of 4.0%
- $VMA_{trial}$ = VMA determined at the initial trial binder content

9.3.5 Using the values of $\Delta V_a$ determined in Section 9.3.1 and Equation 9, estimate the relative density of each specimen at $N_{initial}$ when the design air void content is adjusted to 4.0 percent at $N_{design}$:

$$%G_{mm_{initial}} = 100 \times \left( \frac{G_{mb}h_d}{G_{mm}h_i} \right) - \Delta V_a$$  \hspace{1cm} (9)

Where:

- $%G_{mm_{initial}}$ = relative density at $N_{initial}$ gyrations at the adjusted design binder content
- $h_d$ = Height of the specimen after $N_{design}$ gyrations, from the Superpave gyratory compactor, mm
- $h_i$ = Height of the specimen after $N_{initial}$ gyrations, from the Superpave gyratory compactor, mm
9.3.6 Estimate the percent of effective binder ($P_{be}$) and calculate the Dust/Asphalt Ratio ($P_{200}/P_{be}$) for each trial blend using Equations 10 and 11:

\[
P_{beest} = - (P_s \times G_b) \left( \frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} \right) + P_{best}
\]

Where:
- $P_{beest}$ = Estimated effective binder content
- $P_s$ = Percent of aggregate in the mixture (100-$P_b$)
- $G_b$ = Specific gravity of the binder
- $G_{se}$ = Effective specific gravity of the aggregate
- $G_{sb}$ = Bulk specific gravity of the combined aggregate
- $P_{best}$ = Estimated binder content

\[
\text{Dust/Asphalt Ratio} = \frac{P_{200}}{P_{be}}
\]

Where:
- $P_{200}$ = Percent passing the No. 200 (0.075 mm) sieve

9.3.7 Compare the estimated volumetric properties from each trial aggregate blend gradation at the adjusted design binder content with the criteria specified in Section 9-03.8(2) of the Standard Specifications. Choose the trial aggregate blend gradation that best satisfies the volumetric criteria.

**Note 14:** Table 2 presents an example of the selection of a design aggregate structure from three trial aggregate blend gradations.

**Note 15:** Many trial aggregate blend gradations will fail the VMA criterion. Generally, the % criterion will be met if the VMA criterion is satisfied. Section 12.1 gives a procedure for the adjustment of VMA.

**Note 16:** If the trial aggregate gradations have been chosen to cover the entire range of the gradation controls, then the only remaining solution is to make adjustments to the aggregate production or to introduce aggregates from a new source. The aggregates that fail to meet the required criteria will not produce a quality mix and should not be used. One or more of the aggregate stockpiles should be replaced with another material which produces a stronger structure. For example, a quarry stone can replace a crushed gravel, or crushed fines can replace natural fines.
### Volumetric Property

#### Trial Mixture (¾ Inch Nominal Maximum Aggregate) 15 Year Project Design ESALs = 5 million

<table>
<thead>
<tr>
<th>Volumetric Property</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_b$ (trial)</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>$G_{mm, initial}$ (trial)</td>
<td>88.1</td>
<td>87.8</td>
<td>87.1</td>
<td></td>
</tr>
<tr>
<td>$G_{mm, design}$ (trial)</td>
<td>95.9</td>
<td>95.3</td>
<td>94.7</td>
<td></td>
</tr>
<tr>
<td>$V_a$ at $N_{design}$</td>
<td>4.1</td>
<td>4.7</td>
<td>5.3</td>
<td>4.0</td>
</tr>
<tr>
<td>VMA$_{trial}$</td>
<td>12.9</td>
<td>13.4</td>
<td>13.9</td>
<td></td>
</tr>
</tbody>
</table>

#### Adjustments to Reach Design Binder Content ($V_a = 4.0\%$ at $N_{design}$)

<table>
<thead>
<tr>
<th>Adjustment</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta V_a$</td>
<td>−0.1</td>
<td>−0.7</td>
<td>−1.3</td>
</tr>
<tr>
<td>$\Delta P_b$</td>
<td>0.0</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>$\Delta$VMA</td>
<td>0.0</td>
<td>−0.1</td>
<td>−0.3</td>
</tr>
</tbody>
</table>

#### At the Estimated Design Binder Content ($V_a = 4.0\%$ at $N_{design}$)

<table>
<thead>
<tr>
<th>Property</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated $P_b$ (design)</td>
<td>4.4</td>
<td>4.7</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>VMA (design)</td>
<td>12.9</td>
<td>13.3</td>
<td>13.6</td>
<td>≥ 13.0</td>
</tr>
<tr>
<td>$G_{mm, initial}$ (design)</td>
<td>88.2</td>
<td>89.5</td>
<td>88.4</td>
<td>≤ 89.0</td>
</tr>
</tbody>
</table>

### Notes:

1. The top portion of this table presents measured densities and volumetric properties for specimens prepared for each aggregate trial blend at the initial trial binder content.
2. None of the specimens had an air void content of exactly 4.0 percent. Therefore, the procedures described in Section 9 must be applied to:
   - (1) estimate the design binder content at which $TV_a = 4.0\%$, and
   - (2) obtain adjusted VMA and relative density values at this estimated binder content.
3. The middle portion of this table presents the change in binder content ($\Delta P_b$) and VMA ($\Delta$VMA) that occurs when the target air void content ($TV_a$) is adjusted to 4.0 percent for each trial aggregate blend gradation.
4. A comparison of the VMA and densities at the estimated design binder content to the criteria in the last column shows that trial aggregate blend gradation No. 1 does not have sufficient VMA (12.9% versus a requirement of ≥ 13.0%). Trial blend No. 2 exceeds the criterion for relative density at $N_{initial}$ gyrations (89.5% versus requirement of ≤ 89.0%). Trial No. 3 meets the requirement for relative density and VMA and, in this example, is selected as the design aggregate structure.

### Selection of a Design Aggregate Structure (Example)

#### Table 2

10. Selecting the Design Binder Content

10.1 Prepare replicate mixtures (Note 8) containing the selected design aggregate structure at each of the following three binder contents: (1) the estimated design binder content, $P_b (design)$; (2) 0.5% below $P_b (design)$; and (3) 0.5% above $P_b (design)$.

10.1.1 Use the number of gyrations previously determined in Section 8.1.

10.2 Condition the mixtures according to R 30, and compact the specimens to $N_{design}$ gyrations according to WSDOT FOP for AASHTO T 312. Record the specimen height to the nearest 0.1 mm after each revolution.
10.3 Determine the bulk specific gravity of each of the compacted specimens in accordance with WSDOT FOP for AASHTO T 166 or AASHTO T 275 as appropriate.

10.4 Determine the theoretical maximum specific gravity \((G_{mm})\) according to WSDOT FOP for AASHTO T 209 of each of the three mixtures using companion samples which have been conditioned to the same extent as the compacted specimens (Note 8).

10.5 Determine the design binder content which produces a target air void content of 4.0 percent at \(N_{\text{design}}\) gyrations using the following steps:

10.5.1 Calculate \(V_a\), VMA, and VFA at \(N_{\text{design}}\) using Equations 2, 3 and 12: The volumetric properties are determined for each specimen and then averaged for each replicate mixture.

\[
VFA = 100 \times \left( \frac{VMA - V_a}{VMA} \right) \tag{12}
\]

10.5.2 Calculate the Dust/Asphalt Ratio, using Equation 13.

\[ \text{Dust/Asphalt Ratio} = \frac{P_{200}}{P_{be}} \tag{13} \]

Where:

\[ P_{be} = \text{Effective binder content} \]

10.5.3 For each of the three mixtures, determine the average corrected specimen relative densities at \(N_{\text{initial}}\) (%), using Equation 14.

\[
\%G_{mm_{\text{initial}}} = 100 \times \left( \frac{G_{mb} h_d}{G_{mm} h_i} \right) \tag{14}
\]

10.5.4 Plot the average \(V_a\), VMA, VFA, and relative density at \(N_{\text{design}}\) for replicate specimens versus binder content.

\textbf{Note 17:} All plots are generated automatically by the Superpave software. Figure 2 presents a sample data set and the associated plots.

10.5.5 By graphical or mathematical interpolation (Figure 2), determine the binder content to the nearest 0.1 percent at which the target \(V_a\) is equal to 4.0 percent. This is the design binder content \((P_b)\) at \(N_{\text{design}}\).

10.5.6 By interpolation (Figure 2), verify that the volumetric requirements specified in Section 9-03.8(2) of the \textit{Standard Specifications} are met at the design binder content.

10.6 Compare the calculated percent of maximum relative density with the design criteria at \(N_{\text{initial}}\) by interpolation, if necessary. This interpolation can be accomplished by the following procedure.

10.6.1 Prepare a densification curve for each mixture by plotting the measured relative density at \(x\) gyrations, \(%G_{mm_x}\), versus the logarithm of the number of gyrations (see Figure 3).
10.6.2 Examine a plot of air void content versus binder content. Determine the difference in air voids between 4.0 percent and the air void content at the nearest, lower binder content. Determine the air void content at the nearest, lower binder content at its data point, not on the line of best fit. Designate the difference in air void content as \( \Delta V_a \).

10.6.3 Using Equation 14, determine the average corrected specimen relative densities at \( N_{\text{initial}} \). Confirm that satisfies the design requirements in Section 9-03.8(2) of the Standard Specifications at the design binder content.

10.7 Prepare replicate (Note 8) specimens composed of the design aggregate structure at the design binder content to confirm that \( \%G_{\text{mm max}} \) satisfies the design requirements in Section 9-03.8(2) of the Standard Specifications.

10.7.1 Condition the mixtures according to R-30, and compact the specimens according to WSDOT FOP for AASHTO T312 to the maximum number of gyrations, \( N_{\text{max}} \), from Section 9-03.8(2) of the Standard Specifications.

10.7.2 Determine the average specimen relative density at \( N_{\text{max}} \), \( \%G_{\text{mm max}} \), by using Equation 15, and confirm that satisfies the volumetric requirement in Section 9-03.8(2) of the Standard Specifications.

\[
\%G_{\text{mm max}} = 100 \times \frac{G_{\text{mb}}}{G_{\text{mm}}}
\]

Where:
\( \%G_{\text{mm max}} \) = Relative density at \( N_{\text{max}} \) gyrations at the design binder content

<table>
<thead>
<tr>
<th>( P_b(%) )</th>
<th>( V_a(%) )</th>
<th>VMA (%)</th>
<th>VFA (%)</th>
<th>Maximum Density at ( N_{\text{design}} (G_{\text{mm}}) )</th>
<th>Density at ( N_{\text{design}} ) lbs/ft(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3</td>
<td>9.9</td>
<td>17.0</td>
<td>41.8</td>
<td>2.660</td>
<td>165.6</td>
</tr>
<tr>
<td>4.8</td>
<td>8.2</td>
<td>16.7</td>
<td>50.9</td>
<td>2.636</td>
<td>164.1</td>
</tr>
<tr>
<td>5.3</td>
<td>6.9</td>
<td>16.6</td>
<td>58.5</td>
<td>2.617</td>
<td>162.9</td>
</tr>
<tr>
<td>5.8</td>
<td>5.2</td>
<td>16.5</td>
<td>68.5</td>
<td>2.585</td>
<td>160.9</td>
</tr>
<tr>
<td>6.3</td>
<td>3.9</td>
<td>16.2</td>
<td>76.0</td>
<td>2.574</td>
<td>160.2</td>
</tr>
</tbody>
</table>

In this example, the estimated design binder content is 4.8 percent; the minimum VMA requirement for the design aggregate structure (¾ in nominal maximum size) is 13.0 percent, and the VFA requirements is 65 to 78 percent.

Entering the plot of percent air voids versus percent binder content at 4.0 percent air voids, the design binder content is determined as 6.2 percent.

Entering the plots of percent VMA versus percent binder content and percent VFA versus percent binder content at 6.2 percent binder content, the mix meets the VMA and VFA requirement.

Sample Volumetric Design Data at \( N_{\text{des}} \)

---

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Sample Densification Curve

*Figure 3*
11. Evaluating Moisture Susceptibility

11.1 Prepare six mixture specimens composed of the design aggregate structure at the design binder content. Prepare the specimens according to WSDOT T 726, and compact the specimens to approximate 4.0% air voids in accordance to WSDOT FOP for AASHTO T 312. The WSDOT State Materials Laboratory will evaluate the HMA for moisture susceptibility.

11.2 Test the specimens and calculate the tensile strength ratio in accordance with WSDOT T 718.

12. Adjusting the Mixture to Meet Properties

12.1 Adjusting VMA – If a change in the design aggregate skeleton is required to meet the specified VMA, there are three likely options: (1) change the gradation (Note 18); (2) reduce the minus No. 200 (0.075 mm) fraction (Note 19); or (3) change the surface texture and/or shape of one or more of the aggregate fractions (Note 20).

Note 18: Changing gradation may not be an option if the trial aggregate blend gradation analysis includes the full spectrum of the gradation control area.

Note 19: Reducing the percent passing the No. 200 (0.075 mm) sieve of the mix will typically increase the VMA. If the percent passing the No. 200 (0.075 mm) sieve is already low, this is not a viable option.

Note 20: This option will require further processing of existing materials or a change in aggregate sources.
12.2 Adjusting VFA – The lower limit of the VFA range should always be met at 4.0% air voids if the VMA meets the requirements. If the upper limit of the VFA is exceeded, then the VMA is substantially above the minimum required. If so, redesign the mixture to reduce the VMA. Actions to consider for redesign include: (1) changing to a gradation that is closer to the maximum density line; (2) increasing the minus No. 200 (0.075 mm) fraction, if room is available within the specification control points; or (3) changing the surface texture and shape of the aggregates by incorporating material with better packing characteristics, e.g., less thin, elongated aggregate particles.

13. Report

13.1 The report shall include the identification of the project number, mix class designation, and mix design number.

13.2 The report shall include information on the design aggregate structure including the source of aggregate, and gradation, including the blending ratios.

13.3 The report shall contain information about the design binder including the source of binder and the performance grade.

13.4 The report shall contain information about the HMA including the percent of binder in the mix; the relative density; the number of initial, design, and maximum gyrations; and the VMA, VFA, $V_a$, and Dust/Asphalt Ratio $P_{bc}$, $G_{mm}$, $G_{mb}$, $G_{sb}$ and $G_{sc}$ of the aggregate blend, $G_{sb}$ of the fine aggregate, and $G_b$.

13.5 The report shall contain the results of the moisture susceptibility testing and the required level of anti-strip additive needed.

14. Keywords

14.1 HMA mix design; Superpave; volumetric mix design.
Appendix

A1. Calculating an Initial Trial Binder Content for Each Aggregate Trial Blend

Nonmandatory Information

A1.1 Calculate the bulk and apparent specific gravities of the combined aggregate in each trial blend using the specific gravity data for the aggregate fractions obtained in Section 6.6 and Equations 16 and 17:

\[
G_{sb} = \frac{P_1 + P_2 + \cdots + P_n}{G_1 + G_2 + \cdots + G_n}
\]

(16)

\[
G_{sa} = \frac{P_1 + P_2 + \cdots + P_n}{\left(\frac{G_1}{P_1} + \frac{G_2}{P_2} + \cdots + \frac{G_n}{P_n}\right)}
\]

(17)

Where:

- \(G_{sb}\) = Bulk specific gravity for the combined aggregate
- \(G_{sa}\) = Apparent specific gravity for the combined aggregate
- \(P_1, P_2, P_n\) = Percentages by mass of aggregates 1, 2, n
- \(G_1, G_2, G_n\) = Bulk specific gravities (Equation 16) or apparent specific gravities (Equation 17) of aggregates 1, 2, n.

A1.2 Estimate the effective specific gravity of the combined aggregate in the aggregate trial blend using Equation 18:

\[
G_{se} = G_{sb} + 0.8(G_{sa} - G_{sb})
\]

(18)

Where:

- \(G_{se}\) = Effective specific gravity of the combined aggregate
- \(G_{sb}\) = Bulk specific gravity of the combined aggregate
- \(G_{sa}\) = Apparent specific gravity of the combined aggregate

**Note 21:** The multiplier, 0.8, can be changed at the discretion of the designer. Absorptive aggregates may require values closer to 0.6 or 0.5.

**Note 22:** The Superpave mix design system includes a mixture conditioning step before the compaction of all specimens; this conditioning generally permits binder absorption to proceed to completion. Therefore, the effective specific gravity of Superpave mixtures will tend to be close to the apparent specific gravity in contrast to other design methods where the effective specific gravity generally will lie near the midpoint between the bulk and apparent specific gravities.
A1.3 Estimate the volume of binder absorbed into the aggregate, \( V_{ba} \), using Equations 19 and 20:

\[
V_{ba} = W_s \left( \frac{1}{G_{sb}} - \frac{1}{G_{se}} \right) 
\]

(19)

Where:

\( W_s = \) The mass of aggregate in 1 cm\(^3\) of mix, g, is calculated as

\[
W_s = \frac{P_b (1 - V_a)}{G_b + P_s \frac{G_{se}}{G_b}} 
\]

(20)

and Where:

\( P_b = \) Percent of binder, in decimal equivalent, assumed to be 0.05

\( P_s = \) Percent of aggregate in mixture, in decimal equivalent, assumed to be 0.95

\( G_b = \) Specific gravity of the binder

\( V_a = \) Volume of air voids, assumed to be 0.04 cm\(^3\) in 1 cm\(^3\) of mix

Note 23: This estimate calculates the volume of binder absorbed into the aggregate, \( V_{ba} \), and subsequently, the initial, trial binder content at a target air void content of 4.0%.

A1.4 Estimate the volume of effective binder using Equation 21:

\[
V_{be} = 0.176 - (0.0675 \log (S_n)) 
\]

(21)

Where:

\( V_{be} = \) Volume of effective binder, cm\(^3\)

\( S_n = \) Nominal maximum sieve size of the largest aggregate in the aggregate trial blend, mm.

Note 24: This regression Equation is derived from an empirical relationship between:

1. VMA and \( V_{be} \) when the air void content, \( V_a \), is equal to 4.0 percent: \( V_{be} = \) VMA - \( V_a \) = VMA - 4.0; and
2. the relationship between VMA and the nominal maximum sieve size of the aggregate in MP 2. For WSDOT projects, see contract provisions.

A1.5 Calculate the estimated initial trial binder \((P_{bi})\) content for the aggregate trial blend gradation using Equation 22:

\[
P_{bi} = 100 \times \left( \frac{G_b (V_{be} + V_{ba})}{(G_b (V_{be} + V_{ba})) + W_s} \right) 
\]

(22)

Where:

\( P_{bi} = \) Estimated initial trial binder content, percent by weight of total mix
WSDOT SOP 735
Standard Operating Procedure for Longitudinal Joint Density

1. General Scope
   a. This procedure describes the method for determining the location of a longitudinal joint density test.
   b. Longitudinal joint density tests are performed in addition to Quality Assurance (QA) density tests.
   c. One longitudinal joint density test will be performed on the confined or unconfined edge at each longitudinal joint.

2. Longitudinal Joint Testing
   a. The longitudinal joint density test will be conducted in accordance with WSDOT FOP for WAQTC TM 8, except “Test Site Location, Section 1, subsection c, which is modified by this procedure to read “No closer than 18 in (450mm) to any vertical mass, or less than 6 in (152 mm) from a vertical pavement edge,” making sure the gauge will sit flush with the hot-mix asphalt (HMA). See Figure 1.
   b. A longitudinal joint density will be required on the lane edge side of a shoulder if the shoulder is required to meet the same QA density requirements as the traveled lane.

   Note: Hot lap joints are not included in longitudinal joint testing.

3. Number of Longitudinal Joint Tests
   a. For projects requiring 400 tons sublot with 5 sublots – One reading, at each longitudinal joint to be tested, will be taken within each compaction lot at the same station location as the third sublot.
   b. For projects requiring 80 ton sublots – One reading, at each longitudinal joint to be tested, will be taken every four hundred tons or at every fifth sublot tested.

4. Calculation of Results
   a. Calculate the Longitudinal Joint density in accordance WSDOT SOP 729.

5. Report
   a. Report the results using one or more of the following:
      • Materials Testing System (MATS)
      • WSDOT Form 350-095
      • Form approved in writing by the State Materials Engineer

   Note: Lot Number corresponds to the lot where the set of longitudinal joint readings were taken. The station corresponds to the station within the lot (i.e., third sublot) where the set of longitudinal joint readings were taken.
Longitudinal Test Location Examples

Figure 2
1. Scope

1.1 This test method covers the determination of slump flow of self-consolidating concrete.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. (Warning - Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.)

1.4 The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 ASTM Standards

C 143/C 143M – Test Method for Slump of Hydraulic-Cement Concrete

C 172 – Practice for Sampling Freshly Mixed Concrete

C 173/C 173M – Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

C 670 – Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

2.2 AASHTO Standards

T 119M/T 119 – Standard Test Method for Slump of Hydraulic-Cement Concrete

TP 73-09 – Slump Flow of Self-Consolidating Concrete (SCC)

2.3 WAQTC Standards

TM 2 – Sampling Freshly Mixed Concrete

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1This Test Method is based on ASTM C 1611/C 1611M and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *halo, n* – An observed cement paste or mortar ring that has clearly separated from the coarse aggregate, around the outside circumference of concrete after flowing from the slump cone.

3.1.2 *spread, n* – The distance of lateral flow of concrete during the slump-flow test.

3.1.3 *stability, n* – The ability of a concrete mixture to resist segregation of the paste from the aggregates.

3.1.4 *viscosity, n* – Resistance of a material to flow under an applied shearing stress.

4. Summary of Test Method

4.1 A sample of freshly mixed concrete is placed in a mold shaped as the frustum of a cone. The concrete is placed in one lift without tamping or vibration. The mold is raised, and the concrete allowed to spread. After spreading ceases, two diameters of the concrete mass are measured in approximately orthogonal directions, and slump flow is the average of the two diameters.

5. Significance and Use

5.1 This test method provides a procedure to determine the slump flow of self-consolidating concrete in the laboratory or the field.

5.2 This test method is used to monitor the consistency of fresh, unhardened self-consolidating concrete and its unconfined flow potential.

5.3 It is difficult to produce self-consolidating concrete that is both flowable and nonsegregating using coarse aggregates larger than 1 in (25 mm). Therefore, this test method is considered applicable to self-consolidating concrete having coarse aggregate up to 1 in (25 mm) in size.

6. Apparatus

6.1 *Mold* – The mold used in this test method shall conform to that described in FOP for AASHTO T 119.

6.2 *Base Plate* – The base plate on which the mold rests shall be nonabsorbent, smooth, rigid, and have a minimum diameter of 36 in (915 mm).

*Note 1:* Field experience and results from the round robin test program have shown that base plates made from sealed/laminated plywood, acrylic plastic, or steel are suitable for performing this test.

6.3 *Strike-off Bar* – As described in FOP for WAQTC T 152.

7. Sample

7.1 The sample of concrete from which test specimens are made shall be representative of the entire batch. Sample in accordance with FOP for WAQTC TM 2.
8. Procedure

8.1 The slump-flow test shall be performed on a flat, level, nonabsorbent base plate. Position and shim the base plate so it is fully supported, flat, and level.

8.2 Filling the Mold – WSDOT requires the use of Procedure B.

8.2.1 Filling Procedure B (Inverted Mold) – Dampen and place the mold, with the smaller opening of the mold facing down, in the center of a flat, moistened base plate or concrete surface. Using a suitable container, fill the entire mold continuously. The mold shall be held firmly in place during filling. Do not rod or tamp the SCC. Slightly overfill the mold.

8.3 Strike off the surface of the concrete level with the top of the mold by a sawing motion of the strike-off bar. Remove concrete from the area surrounding the base of the mold to preclude interference with the movement of the flowing concrete. Remove the mold from the concrete by raising it vertically. Raise the mold a distance of 9 ± 3 in (225 ± 75 mm) in 3 ± 1 seconds by a steady upward lift with no lateral or torsional motion. Complete the entire test from start of the filling through removal of the mold without interruption within an elapsed time of 2½ minutes.

8.4 Wait for the concrete to stop flowing and then measure the largest diameter of the resulting circular spread of concrete to the nearest ¼ in (5 mm). When a halo is observed in the resulting circular spread of concrete, it shall be included as part of the diameter of the concrete. Measure a second diameter of the circular spread at an angle approximately perpendicular to the original measured diameter.

8.5 If the measurement of the two diameters differs by more than 2 in (50 mm), the test is invalid and shall be repeated.

9. Calculation

9.1 Calculate the slump flow using Eq 1:

\[
\text{Slump flow} = \frac{(d^1 + d^2)}{2}
\]

where:

\[d^1 = \text{the largest diameter of the circular spread of the concrete, and}\]

\[d^2 = \text{the circular spread of the concrete at an angle approximately perpendicular to } d^1\]

9.2 Record the average of the two diameters to the nearest ¼ in (5 mm).

10. Report

10.1 Report the slump flow to the nearest ¼ in (5 mm).

11. Precision and Bias

See ASTM C1611/C 1611M for precision and bias.
Performance Exam Checklist  
WSDOT FOP for ASTM C 1611/C 1611M  
Standard Test Method for Slump Flow of Self-Consolidating Concrete

Participant Name _______________________________ Exam Date ___________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required.</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>Has the current calibration/verification tags present?</td>
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<td>☐</td>
</tr>
<tr>
<td>3. Sample was taken per WSDOT FOP for WAQTC TM 2?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>4. Molds and base plate dampened and base plate is flat, level and fully supported?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>5. Mold filled completely in one lift (slightly overfilled)?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>6. Mold struck off level with top opening?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>7. Excess material removed from base plate and mold raised 9 ± 3 inches, in 3 ± 1 seconds?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>8. After flow stabilized, measured largest diameter (including halo if necessary)?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>9. Second measurement taken approximately perpendicular to first measurement?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>10. First and second measurements agree within 2″?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>11. Slump flow was reported as an average of the two measurements?</td>
<td>☑</td>
<td>☐</td>
</tr>
<tr>
<td>12. Slump flow reported to the nearest ¼”?</td>
<td>☑</td>
<td>☐</td>
</tr>
</tbody>
</table>

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Signature of Examiner _______________________________

Comments:
1. Scope

1.1 This test method covers determination of the passing ability of self-consolidating concrete by using the J-Ring in combination with a slump cone mold. The test method is limited to concrete with maximum size of aggregate of 1 in (25 mm).

1.2 The values stated in either inch-pounds or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3 The text of this standard references notes that provide explanatory material. These notes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.4 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. (Warning – Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.)

2. Referenced Documents

2.1 ASTM Standards

C 125 – Terminology Relating to Concrete and Concrete Aggregates
C 143/C 143M – Test Method for Slump of Hydraulic-Cement Concrete
C 172 – Practice for Sampling Freshly Mixed Concrete
C 173/C 173M – Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C 1611/C 1611M – Test Method for Slump Flow of Self-Consolidating Concrete

3. Terminology

3.1 Definitions

3.1.1 For definitions of terms used in this test method, refer to Terminology C 125.

3.2 Definitions of Terms Specific to This Standard

3.2.1 *Halo* – An observed cement paste or mortar ring that has clearly separated from the coarse aggregate, around the outside circumference of concrete after flowing from the slump cone.

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1This Test Method is based on ASTM C 1621/C 1621M and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
3.2.2 *J-ring* – An apparatus consisting of a rigid ring supported on sixteen ⅝ in (16 mm) diameter rods equally spaced on a 12 in (300 mm) diameter circle 4 in (100 mm) above a flat surface as shown in Figure 1.

3.2.3 *J-ring flow* – The distance of lateral flow of concrete using the J-Ring in combination with a slump cone.

3.2.4 *Passing ability* – The ability of self-consolidating concrete to flow under its own weight (without vibration) and fill completely all spaces within intricate formwork, containing obstacles, such as reinforcement.

4. **Summary of Test Method**

4.1 A sample of freshly mixed concrete is placed in a slump mold (inverted position) that is concentric with the J-Ring (Figure 2). The concrete is placed in one lift without tamping or vibration. The mold is raised, and the concrete is allowed to pass through J-Ring and subside (Figure 3).

The diameters of the concrete, in two directions approximately perpendicular to each other, are measured and averaged to obtain the J-Ring flow. The test is repeated without the J-Ring to obtain the slump flow.

The difference between the slump flow and J-Ring flow is an indicator of the passing ability of the concrete.

5. **Significance and Use**

5.1 This test method provides a procedure to determine the passing ability of self-consolidating concrete mixtures. The difference between the slump flow and J-Ring flow is an indication of the passing ability of the concrete. A difference less than 1 in (25 mm) indicates good passing ability and a difference greater than 2 in (50 mm) indicates poor passing ability. The orientation of the slump cone for the J-Ring test and for the slump flow test without the J-Ring shall be the same.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>in</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12.0 ± 0.13</td>
<td>300 ± 3.3</td>
</tr>
<tr>
<td>B</td>
<td>1.5 ± 0.06</td>
<td>38 ± 1.5</td>
</tr>
<tr>
<td>C</td>
<td>0.625 ± 0.13</td>
<td>16 ± 3.3</td>
</tr>
<tr>
<td>D</td>
<td>2.36 ± 0.06</td>
<td>58.9 ± 1.5</td>
</tr>
<tr>
<td>E</td>
<td>1.0 ± 0.06</td>
<td>25 ± 1.5</td>
</tr>
<tr>
<td>F</td>
<td>4.0 ± 0.06</td>
<td>200 ± 1.5</td>
</tr>
</tbody>
</table>

*Figure 1*
5.2 This test method is applicable for laboratory use in comparing the passing ability of different concrete mixtures. It is also applicable in the field as a quality control test.

6. Apparatus

6.1 **J-Ring** – The apparatus shall consist of a steel (or equivalent nonabsorbent, rigid material) ring measuring 12 in (300 mm) in diameter at the center of the ring and 1 in (25 mm) in thickness, and sixteen ⅛ in (16 mm) diameter smooth steel rods spaced evenly around the ring measuring 4 in (100 mm) in length (see Figure 1).

6.2 **Mold** – The mold (slump cone) used in this test method is as described in FOP for AASHTO T 119.

6.3 **Base Plate** – A nonabsorbent, rigid plate having a diameter of at least 36 in (915 mm).

*Note 1:* Field experience has shown that base plates made from sealed or laminated plywood, rigid plastic, or steel are suitable for performing this test.

6.4 **Strike Off Bar** – As described in FOP for WAQTC T 152.

6.5 **Measuring Device** – A ruler, metal roll-up measuring tape, or similar rigid or semi-rigid length measuring instrument marked in increments of ¼ in (5 mm) or less.

7. Sample

7.1 The sample of concrete from which test specimens are made shall be representative of the entire batch. It shall be obtained in accordance with FOP for WAQTC TM 2.

8. Procedure

8.1 Perform the test on a flat, level, and nonabsorbent base plate. Position and shim the base plate so that it is fully supported and level. Pre-moisten base-plate with a damp towel, rag, or sponge. Rest the J-Ring at the center of the base plate.
8.2 WSDOT uses only Procedure B.

8.1.2 Filling Procedure B (Inverted Mold) – Dampen the mold, and place it on the base plate with the smaller opening facing down and concentric with the J-Ring. Support the mold and fill the mold in one lift. Heap the concrete above the top of the mold.

8.3 Strike off the surface of the concrete level with the top of the mold by a sawing motion of the strike off bar. Remove concrete from the area surrounding the mold to preclude interference with the movement of the flowing concrete. Raise the mold a distance of 9 ± 3 in (230 ± 75 mm) in 3 ± 1 s by a steady vertical lift with no lateral or torsional motion. Complete the entire procedure from start of the filling through removal of the mold without interruption within an elapsed time of 2½ min.

8.4 Wait for the concrete to stop flowing and then measure the largest diameter \(d_1\) of the resulting circular flow of concrete. When a halo is observed in the resulting circular flow of concrete, it shall be included as part of the diameter of the concrete. Measure a second diameter \(d_2\) of the circular flow at approximately perpendicular to the first measured diameter \(d_1\). Measure the diameters to the nearest \(\frac{1}{4}\) in (5 mm). Determine the J-Ring flow in accordance with Section 9 of this test method.

8.5 Conduct a slump flow test without the J-Ring in accordance with Test Method C 1611/ C 1611M. Use the same filling procedure as used with the J-Ring. Complete the tests with and without the J-Ring within 6 min.

9. Calculation

9.1 Calculate J-Ring flow according to the following equation:

\[
\text{J-Ring flow} = \frac{d_1 + d_2}{2}
\]

9.2 Calculate the slump flow according to the following equation:

\[
\text{Slump flow} = \frac{d_1 + d_2}{2}
\]

9.3 Calculate the difference between slump flow and J-Ring flow to the nearest \(\frac{1}{2}\) in (10 mm). This number represents the passing ability of the concrete.

10. Blocking Assessment

10.1 Identify blocking assessment according to Table 1.

<table>
<thead>
<tr>
<th>Difference Between Slump Flow and J-Ring Flow</th>
<th>Blocking Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1 in (0 to 25 mm)</td>
<td>No visible blocking</td>
</tr>
<tr>
<td>&gt; 1 to 2 in (&gt;25 to 50 mm)</td>
<td>Minimal to noticeable blocking</td>
</tr>
<tr>
<td>&gt; 2 in (&gt;50 mm)</td>
<td>Noticeable to extreme blocking</td>
</tr>
</tbody>
</table>

Blocking Assessment

Table 1
11. Report

11.1 Report the filling procedure (A or B) that was used.

11.2 Report the J-Ring flow as the average of the two measured diameters to the nearest ½ in (10 mm).

11.3 Report the slump flow (without the J-Ring) as the average of the two measured diameters to the nearest ½ in (10 mm).

11.4 Report the passing ability as the difference between the slump flow and J-Ring flow to the nearest ½ in (10 mm). Identify the blocking assessment.

12. Precision and Bias

See ASTM C 1621/C 1621M for Precision and bias.
Performance Exam Checklist

WSDOT FOP for ASTM C 1621/C 1621M

Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring

Participant Name ________________________________ Exam Date ________________

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has the current calibration/verification tags present?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sample was taken per WSDOT FOP for WAQTC TM 2?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Molds and base plate dampened and base plate is flat, level and fully supported?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Mold is centered in J-Ring and centered on base plate?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mold filled completely in one lift (slightly overfilled)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Mold struck off level with top opening?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Excess material removed from base plate and mold raised 9 ± 3 inches, in 3 ± 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>seconds?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. After flow has stabilized, measure largest diameter (including halo)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Second measurement taken approximately perpendicular to first measurement?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Measurements made to nearest ¼&quot;?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Test performed within 6 minutes of FOP for ASTM C 1611?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. All calculations performed correctly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Results reported to the nearest ½&quot;?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First Attempt: Pass ☐ Fail ☐        Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ____________________________________________

Comments:
WSDOT FOP for ASTM D 4791

Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

1. Scope

1.1 This test method covers the determination of the percentages of flat particles, elongated particles, or flat and elongated particles in coarse aggregates.

1.2 The values stated in inch-pound units are to be regarded as the standard except in regard to sieve size and the size of aggregate, which are given in SI units in accordance with Specification E 11. The SI units in parentheses are for information purposes only.

1.3 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Note: WSDOT will be determining flat and elongated particles in accordance with Section 8.4.

2. Referenced Documents

2.1 WSDOT Standards

T 2 – FOP for AASHTO for the Sampling of Aggregates
T 248 – FOP for AASHTO for Reducing Field Samples of Aggregates to Testing Size

2.2 WAQTC Standards

T 27/11 – FOP for AASHTO for the Sieve Analysis of Fine and Coarse Aggregates and Materials Finer Than 75 mm (No. 200) in Mineral Aggregates by Washing

3. Terminology

3.1 Definitions

3.1.1 flat or elongated particles of aggregate – Those particles of aggregate having a ratio of width to thickness or length to width greater than a specified value (see Terminology C 125).

3.1.2 flat and elongated particles of aggregate – Those particles having a ratio of length to thickness greater than a specified value.

3.1.3 length – Maximum dimension of the particle.

3.1.4 width – Maximum dimension in the plane perpendicular to the length.

3.1.5 thickness – Maximum dimension perpendicular to the length and width.

---

1This Test Method is based on ASTM D 4791-05 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.
4. Summary of Test Method

4.1 Individual particles of aggregate of specific sieve sizes are measured to determine the ratios of width to thickness, length to width, or length to thickness.

5. Significance and Use

5.1 Flat or elongated particles of aggregates, for some construction uses, may interfere with consolidation and result in harsh, difficult to place materials.

5.2 This test method provides a means for checking compliance with specifications that limit such particles or to determine the relative shape characteristics of coarse aggregates.

6. Apparatus

6.1 The apparatus used shall be equipment suitable for testing aggregate particles for compliance with the definitions in 3.1, at the dimensional ratios desired.

6.1.1 Proportional Caliper Device – The proportional caliper devices illustrated in Figures 1, 2, and 3 are examples of devices suitable for this test method. The device illustrated in Figures 1 and 2 consists of a base plate with two fixed posts and a swinging arm mounted between them so that the openings between the arms and the posts maintain a constant ratio. The axis position can be adjusted to provide the desired ratio of opening dimensions. Figure 1 illustrates a device on which ratios of 1:2, 1:3, 1:4, and 1:5 may be set. The device illustrated in Figure 3 contains several fixed posts and has the capability of measuring various ratios simultaneously.

6.1.1.1 Verification of Ratio – The ratio settings on the proportional caliper device shall be verified by the use of a machined block, micrometer, or other appropriate device.

6.1.2 Balance – The balance or scales used shall be accurate to 0.5 percent of the mass of the sample.
5. Significance and Use

5.1 Flat or elongated particles of aggregates, for some construction uses, may interfere with consolidation and result in harsh, difficult to place materials.

5.2 This test method provides a means for checking compliance with specifications that limit such particles or to determine the relative shape characteristics of coarse aggregates.

6. Apparatus

6.1 The apparatus used shall be equipment suitable for testing aggregate particles for compliance with the definitions in 3.1, at the dimensional ratios desired.

6.1.1 Proportional Caliper Device—The proportional caliper devices illustrated in Fig. 1, Fig. 2, and Fig. 3 are examples of devices suitable for this test method. The device illustrated in Fig. 1 and Fig. 2 consists of a base plate with two fixed posts and a swinging arm mounted between them so that the openings between the arms and the posts maintain a constant ratio. The axis position can be adjusted to provide the desired ratio of opening dimensions. Fig. 1 illustrates a device on which ratios of 1:2, 1:3, 1:4, and 1:5 may be set. The device illustrated in Fig. 3 contains several fixed posts and has the capability of measuring various ratios simultaneously.

6.1.1.1 Verification of Ratio—The ratio settings on the proportional caliper device shall be verified by the use of a machined block, micrometer, or other appropriate device.

6.1.2 Balance—The balance or scales used shall be accurate to 0.5% of the mass of the sample.

7. Sampling

7.1 Sample the coarse aggregate in accordance with in FOP for AASHTO T2. The mass of the field sample shall be the mass shown in FOP for AASHTO T2.

7.2 Thoroughly mix the sample and reduce it to an amount suitable for testing using the applicable procedures described in FOP for AASHTO T 248. The sample for test shall be approximately the mass desired when dry and shall be the end result of the reduction. Reduction to an exact predetermined mass shall not be permitted. The mass of the test sample shall conform to the following:
### Nominal Maximum Size* Square Openings, in (mm)

<table>
<thead>
<tr>
<th>Square Openings, in (mm)</th>
<th>Nominal Maximum Size*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMS</td>
<td>Test Sample, lb (kg.)</td>
</tr>
<tr>
<td>⅜ (9.5)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>⅝ (12.5)</td>
<td>4 (2)</td>
</tr>
<tr>
<td>¾ (19)</td>
<td>11 (5)</td>
</tr>
<tr>
<td>1 (25.0)</td>
<td>22 (10)</td>
</tr>
<tr>
<td>1⅛ (37.5)</td>
<td>33 (15)</td>
</tr>
<tr>
<td>1½ (37.5)</td>
<td>44 (20)</td>
</tr>
<tr>
<td>2 (50)</td>
<td>77 (35)</td>
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<td>2½ (63)</td>
<td>130 (60)</td>
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<tr>
<td>3 (75)</td>
<td>220 (100)</td>
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<td>3½ (90)</td>
<td>330 (150)</td>
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<tr>
<td>4 (100)</td>
<td>440 (200)</td>
</tr>
<tr>
<td>4½ (112)</td>
<td>660 (300)</td>
</tr>
<tr>
<td>5 (125)</td>
<td>1100 (500)</td>
</tr>
<tr>
<td>6 (150)</td>
<td></td>
</tr>
</tbody>
</table>

*For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

**Note:** For an aggregate specification having a generally unrestrictive gradation (i.e., wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5% of the materials.

### Procedure

#### 8.1  
If determination by mass is required, oven dry the sample in accordance with FOP for AASHTO T 255. If determination is by particle count, drying is not necessary.

#### 8.2  
Sieve the sample to be tested in accordance with FOP for AASHTO T 27/11. If the material retained on each required size (⅜ and larger) is more than 5 percent of the sample, reduce the material in accordance with FOP for AASHTO T 248 until approximately 100 particles are obtained for each required size.

#### 8.3  
Flat and Elongated Particle Test – Test each of the particles in each size fraction and place in one of two groups: (1) flat and elongated or (2) not flat and elongated.

**8.3.1** Use the proportional caliper device, set at the desired ratio.

**8.3.2 Measurement**

**8.3.2.1** On proportional caliper devices similar to the devices shown in Figure 1 and Figure 2, set the larger opening equal to the length of the particle. The particle is flat and elongated if the particle, (biggest to smallest) when oriented to measure its thickness (biggest), can pass completely through the smaller opening of the caliper when it is rotated in any direction.
Use of Proportional Caliper

*Figure 2*

<table>
<thead>
<tr>
<th>in</th>
<th>mm</th>
<th>in</th>
<th>mm</th>
<th>in</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>⅛</td>
<td>3.2</td>
<td>⅞</td>
<td>21.2</td>
<td>2⅛</td>
<td>64.0</td>
</tr>
<tr>
<td>3/16</td>
<td>4.8</td>
<td>1</td>
<td>25.4</td>
<td>2⅞</td>
<td>72.0</td>
</tr>
<tr>
<td>¼</td>
<td>6.3</td>
<td>1⅛</td>
<td>27.0</td>
<td>3¾</td>
<td>96.0</td>
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<tr>
<td>5/16</td>
<td>7.9</td>
<td>1½</td>
<td>38.0</td>
<td>8</td>
<td>207.0</td>
</tr>
<tr>
<td>¾</td>
<td>9.5</td>
<td>1⅛</td>
<td>41.0</td>
<td>16</td>
<td>414.0</td>
</tr>
</tbody>
</table>

**Metric Equivalents**

Proportional Caliper

*Figure 3*
8.4.2.2 On calipers similar to the one described in Figure 3, set the minimum dimension of the proportional caliper device such that the particle, when oriented to measure its thickness, passes snugly between the post and swing arm. The particle is flat and elongated if the particle, when oriented to measure its length, fails to pass the desired large opening of the proportional caliper device.

8.4.3 After the particles have been classified into the groups described in 8.4, determine the proportion of the sample in each group by count or mass, as required.

*Note:* WSDOT performs this test by weight.

9. Calculation

9.1 Calculate the percentage of flat and elongated particles to the nearest 1 percent for each sieve size than ⅜ in and larger (9.5 mm), as required.

10. Report

10.1 Include the following information in the report:

10.1.1 Identification of the coarse aggregate tested, and

10.1.2 Grading of the aggregate sample, showing percentage retained on each sieve.

10.1.3 For flat and elongated particle tests:

10.1.3.1 Percentages, calculated by number or by mass, or both, for flat and elongated particles for each sieve size tested,

10.1.3.2 The dimensional ratio used in the tests, and

10.1.4 When required, weighted average percentages based on the actual or assumed proportions of the various sieve sizes tested. Report the grading used for the weighted average if different from that in 10.1.2.

10.2 Report results using one or more of the following:

- Materials Testing System (MATS)
- WSDOT Form 350-161
- Form approved in writing by the State Materials Engineer

11. Precision and Bias

See ASTM D 4791 for precision and bias statements.
### Performance Exam Checklist

**Flat and Elongated Particles in Coarse Aggregate**  
**FOP for ASTM D 4791**

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The tester has a copy of the current procedure on hand?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Field sample obtained per AASHTO T 2?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Sample thoroughly mixed prior to reducing to testing size?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Sample reduced to testing size per AASHTO T 248?</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Mass of the test sample conforms to the table in Section 7.2, ASTM D 4791?</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Procedure**

1. If determination by mass, sample oven dried to a constant weight prior to mass determination?  
2. Sample sieved per AASHTO T 27/T 11?  
3. Proportional caliper device positioned at proper ratio?  
4. Each size fraction ¾ inch and larger retaining more than 5% of the original sample reduced per AASHTO T 248 until approximately 100 particles are obtained for each size fraction required?  
5. Each particle of each size fraction tested for FLAT and ELONGATED using the proportional caliper device put in the appropriate group classification? (Flat and Elongated or Not Flat and Elongated)  
6. Proportion of the sample of each sieve size determined by Mass?  
7. Percent of Flat and Elongated particles figured to the nearest 1% for each sieve size?  
8. Record number of particles in each sieve size tested?  
9. Record percentages calculated by Mass?  
10. All calculations performed correctly?  

First Attempt: Pass ☐ Fail ☐  
Second Attempt: Pass ☐ Fail ☐

Signature of Examiner ________________________________

---

**Participants Name** ________________________________  
**Exam Date** ___________________
Comments:
• Contaminated Material Disposal Bills – Book Number 7
• Miscellaneous Records – Book Number 8
• Full size As Built Plans and Completed Contractor Provided Shop Drawings, in rolls (not in books/not bound)

10-3.1B Temporary Final Records

All records designated as Temporary Final Records are to be retained within the Region for a period of three years after which they may be destroyed. If a claim, lawsuit, or other circumstance is found to be pending at the end of this three year period, the Region should further retain those pertinent records until the issues have been resolved. The Region should ensure that those records designated as Temporary Final Records are also assembled as a portion of the overall project final records. The date for the beginning of this three-year retention period for State-funded projects is the Acceptance Date; the date the State Construction Engineer signs the Final Contract Voucher Certification accepting the project. If Federal funds are involved in the project, the date for the beginning of this three-year retention period is the date that FHWA accepts the final payment voucher. The Headquarters Accounting and Financial Services Division will send a Retention of Records on Federal Aid Projects letter to the Region that specifically indicates the retention period.

The following list contains some of the items that may be kept as Temporary Final Records. This listing is not a complete listing of all the possible items that could be grouped into this category. In short, Temporary Final Records consist of all project records that are not kept as Permanent Final Records. If Temporary Final Records are kept in numbered books then, in order to eliminate confusion with Permanent Final Records, these books are to be numbered consecutively beginning with Book Number 9. Examples of Temporary Final Records include:

• Item Quantity Tickets
• Project Engineer’s Copy of Estimates
• Project Correspondence
• Inspector’s Record of Field Tests
• Scaleman’s Diary and Scale Checks
• Scale Test Reports
• Concrete Pour Records
• Record of Field Audits
• Approval of Source of Materials
• Quantity Computation Sheets
• Surfacing Depth Check Records
• Copies of Shop Drawings
• Contractor’s Payrolls (Federal Aid Projects)
• FHWA Form 1589 (ARRA Projects)
• Source document files
• Alignment (Transit) Book
• Grade Book
• Cross-Section Notes
• Drainage Notes
• Photographs
• Mass Diagrams
• Computer Summary Sheets
• Computer Listings
• Falsework and Form Plans
• Daily Report of Force Account Worked
• Quarterly Report of Amounts Credited DBE Participation
• Quarterly Report of Amounts Paid MBE/WBE Participants
• Washington State Patrol Field Check list

10-3.1C  Electronic Documents Filed With Temporary/Permanent Records

Documents created electronically that do not require an original signature may be kept in an electronic file cabinet during the life of the contract, and if they are not part of the permanent records, they may be placed on a CD and included in the temporary files. No hard copies are necessary.

Documents created electronically that require an original signature and which are to be included in the permanent final records package may be kept in an electronic file cabinet during the life of the contract; however, original hard copies must be provided as part of the permanent records package. CDs are not acceptable.

Documents created electronically that require an original signature and which are not part of the permanent final records package may be kept in an electronic file cabinet during the life of the contract, placed on a CD for the temporary files and the original hard copies destroyed at contract Acceptance or at the end of the three-year retention period.

10-3.2  Contracts

The original signed contract documents are maintained in the Contract Processing Section of the State Accounting Services Office during the active stage of a contract. After final payment has been made, Accounting sends these documents to Records Services for permanent filing.

10-3.3  Change Orders

Approved change orders are a legal part of the contract documents and are treated just like the original contract documents. For a complete discussion of change orders, see Construction Manual M 41-01, Section 1-2.4C.
10-3.7 Record of Collisions and Traffic Control

10-3.7A Record of Collisions and Traffic Surveillance

In the past, all Record of Accidents (now known as Record of Collisions) received by the Project Engineer’s office used to be included as part of the Permanent Records. Since collisions recorded by the WSP are now part of WSDOT’s Transportation Data Office records (TDO), there is no need for a project office to keep Record of Collisions in either the Temporary or Final Records. If it is necessary to change traffic control as a result of a collision, the project office only needs to reference the record of collision report in either the Project Engineer’s diary or Inspector’s Daily Report. The Record of Collisions should only be used during the life of the project to augment decisions on changing traffic control plans during construction. It should be noted that Construction Manual M 41-01, Section 1-2.3E does not require a collision report be obtained for every collision that may occur within the project limits.

A separate file should also contain the records of traffic control surveillance prepared in accordance with Construction Manual M 41-01, Section 1-2.3E. Information in this file should be kept current and upon completion of the contract, submitted to Headquarters Engineering Records as a part of the project’s Permanent Final Records. When the Washington State Patrol provides the Project Engineer with traffic control assistance they also provide the engineer with a WSP Traffic Control Checklist (WSDOT Form 421-045). While this form is a part of the traffic control operations, it can be kept separately and made part of the Temporary Final Records.

10-3.7B Contractor’s Daily Report of Traffic Control

The Contractor’s Daily Report of Traffic Control (WSDOT Forms 421-040A and 421-040B), completed by the Contractor’s Traffic Control Supervisor, should also be included as part of the project’s Permanent Final Records. The Contractor’s Daily Report of Traffic Control is discussed in more detail in Construction Manual M 41-01, Section 1-2.3.

10-3.8 Pile Driving Records

The Pile Driving Record Book (WSDOT Form 450-004) should be included and made a part of the Permanent Final Records. The requirements for pile driving and pile driving records are further detailed in Chapter 6.

10-3.9 Post Tensioning Records

The Post Tensioning Record Book (WSDOT Form 450-005) should be included and made a part of the Permanent Final Records. The requirements for post tensioning and post tensioning records are further detailed in Chapter 6.

10-3.10 Miscellaneous Records

Miscellaneous Records are, in general, optional records and may be included in the permanent records at the Project Engineer’s discretion. This part of the records is intended for items that might be considered of added importance. This might include photographs of special features or construction methods, information regarding
opening to traffic, dedication activities, or other documentation of particular importance. Placing these in the Permanent Final Records will make them a matter of permanent record where they will be retained for future reference.

Records of environmental contamination issues, except records of disposal of contaminated materials which are placed in Book 7, are not optional and should be included in Miscellaneous Records.

10-3.11 As-Built Plans and Shop Drawings

As-Built Plans are a record of changes made to the originally intended physical product of the contract. As-Built drawings should reflect the same degree of detail as the original plan drawings. As-Built Plans are necessary as a way of preserving the historical detail of what occurred on the project. As-Built Plans can also be used as a basis to plan and design future projects in the same location and to make repairs to damaged structural components or other non-functioning facilities. In addition, state law requires that owners of “underground facilities” be able to locate these facilities within 24 inches (600 millimeters) of the outside dimensions. As-Built Plans offer a convenient means for recording these facilities.

Within two weeks after a contract has been awarded, the State Pre-Contract Administration Office or Printing Services Office will furnish the Region Office with one set of large size black line prints of the contract plans which will be marked “For As Constructed Plans Only.” These plans shall be used by the Project Engineer solely for the purpose of preparing “As-Built Plans.” All corrections, revisions, and additional sketches, necessary to depict the work as it was constructed should be shown on these plans. Corrections are to be made by lining out quantities or features that were changed during construction, then noting the correction or change in red ink. These corrections and revisions are to be noted on the plans in a manner that results in neat and legible sheets. A red pen that writes sharp, clear, and dark with a medium width line shall be used to mark these notations. Fine lined pens do not reproduce well when scanned and are not to be used. If electronic versions of these plans are available, corrections noted electronically and plotted in a manner that produces these same results are acceptable.

Special care must be taken to ensure that changes in construction are noted on all contract plan sheets affected by the change. For instance, the change in location of a catch basin or manhole may affect the location listed in the structure note sheet, the drainage plan view sheet, and the drainage profile sheet.

If concrete foundations are partially removed, the remaining portions of the foundations should be shown on the As-Built Plans. It is not required that the As-Built, Summary of Quantities sheets be revised to reflect final estimate quantities. Summary of Quantity sheets are to be marked identifying them as original plan quantities which are shown as preliminary estimates of work. It should also be noted that final As-Built quantities for individual unit bid items can be obtained from the final CAPS ledger for the project.

In order to help identify significant changes in work location or significant changes in the work completed at a particular location, the Quantity Tabulation sheets must be updated to show the actual physical feature items or the locations of installations where significant changes were made. Types of significant changes may include...
### 11-2A  Project Office

<table>
<thead>
<tr>
<th>Form No.</th>
<th>Revised Date</th>
<th>Form Name</th>
</tr>
</thead>
<tbody>
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<td></td>
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<tr>
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## Alphabetical Listing of Forms

### Forms Requiring an Original Hand Written Signature

(X) = Contractor’s signature is desirable but not necessary to make payment.

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### Forms Suitable for Printed Signature

(X)* = Contractor’s signature is desirable but not necessary.

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