

## CHAPTER 5 – MATERIALS

### MATERIALS

This sampling and testing program has been developed in accordance with the current Federal Highway Program Manual (FHPM), Volume 6, Chapter 4, Section 2, and Subsection 7. The program was designed with the purpose of providing assurance that the materials and workmanship incorporated in each highway construction project are in close conformity with the requirements of the approved plans and specifications, including approved changes.

The program provides for materials inspection and control; process control; acceptance and independent assurance certification by the producer; acceptance of small quantities; statistical methods for sampling and testing; inspection of project, district laboratory and central laboratory testing equipment; comparative testing by MnDOT; Cement and Concrete Reference Laboratory (CCRL) and AASHTO Materials Reference Laboratory (AMRL) inspection; retention of records; and training.

This chapter presents a general description of the program content. It includes the basic elements that the program should address from year to year. There are several sources of information that supplement this program as noted by the many references contained in this chapter. Some of these references are included as attachments.

### 5.1 Materials Sampling and Testing Program

All materials subject to definite specification requirements will be sampled, tested and inspected by the Department or its representative prior to being incorporated permanently into work. The project engineer is responsible for seeing that the material used in the work has been inspected, tested, and meets requirements in accordance with the specifications and Department policies and procedures.

#### 5.1.1 MATERIALS INSPECTION AND CONTROL

As soon as notice is received of an assignment to a construction project, the project engineer should develop a project schedule of tests utilizing the schedule of materials control contained in the special provisions of the contract document, and the statement of estimated quantities shown in the project plan. If practical, project inspectors responsible for materials sampling and testing should prepare this schedule of tests to become familiar with testing requirements prior to the start of construction. For special situations, a MnDOT materials testing engineer should be consulted.



Figure 5-1: Materials Inspection

Inspectors assigned to the testing of materials being incorporated into the work must be versed in the contract requirements and the correct method of taking samples, conducting tests, and recording the results and the procedures to be followed if a material failure occurs. The schedule of materials control located in the special provisions establishes minimum testing rates, however

the actual project testing frequencies may require additional testing, depending on the material and the construction operations.

Materials may be accepted on the basis of 1) visual inspection and check measurements on the job for minor quantities; 2) an inspection of materials at the producer's plant or in the supplier's warehouses; 3) certificates of compliance furnished by reputable suppliers for certain items; 4) representative sampling, testing, and inspection on the job, or 5) compliance with materials or products on MnDOT's Approved/Qualified Products List (APL).

Regardless of the basis of acceptance, final inspection and acceptance of any and all material must be made as it is incorporated into the work. This applies whether or not the material has been inspected elsewhere and bears a stamp denoting inspection. Materials and fabricated units may become contaminated or damaged in transit and in handling on the job. In addition, all testing and inspection is based on random or representative samples and very few fabricated units are completely inspected. Each section of pipe used in culvert or sewer construction, for example, will be covered by a fabricator's certificate of compliance and bear the manufacturer's stamp. However, the sections must be visually inspected for defects in manufacturing, as well as those resulting from handling, before installation.

### ***Material Certification***

A final certification must be made of all materials incorporated into the construction of a highway project. The certification attests that the materials incorporated into the construction work and the construction operations controlled by sampling and testing were in close conformity with the approved plans and specifications, and that the test results compare favorably with the results of the independent assurance sampling and testing. Exceptions to the certification must be explained as a part of the certification.

The exception certification summary form shall conform to the example shown in Attachment A-1 & A-2 Form TP-02171-04 at the end of this chapter and available at this link: <http://www.dot.state.mn.us/materials/index.html>

The project engineer will prepare the final material certification based on the individual certifications maintained in the project file. Other sections and units will be responsible for developing their parts of the overall certification, as appropriate. A MnDOT materials engineer will sign the certification.

FHWA requires MnDOT to furnish a certification (executed by project engineer) with the final billing for railroad and utility projects stating that the work is complete, acceptable, and in accordance with the terms of agreement. The certification that accompanies the final billing will fulfill the requirement for a materials certificate covering the railroad or utility work and no separate certificate will be necessary in accordance with Paragraph 5 a (6) of FHPM 6-2-2-7.

Material used on non-conventional federal aid projects and some emergency relief projects wherein the contract does not follow MnDOT specifications, or when the specifications are prepared by an architect or other engineer not using MnDOT specifications and acceptance procedures, will be certified by the project engineer on the form letter "Certification of Material on Non-Conventional Federal-Aid-Projects" (Attachment B). Contract Administration will submit

a standard certification to FHWA based on the project engineer's certification and materials testing.

### 5.1.2 PROCESS CONTROL, ACCEPTANCE, AND INDEPENDENT ASSURANCE CERTIFICATION BY THE PRODUCER

The verification of field-testing is considered an important aspect of MnDOT's overall quality assurance program. With the acceptance of most aggregate materials based on the field tests, it is essential that this testing and inspection function be monitored to assure that such acceptance test results are correct. Variations outside the tolerance indicated on the form suggest that some problem beyond normal testing precision, must be ascertained and resolved. The form then documents the resolution of excessive variations between field and laboratory test results.



Figure 5-2: Field Testing

Anytime the gradation results for routine or independent assurance sample exceed the tolerances shown, the form should be completed and distributed by the district materials engineer. To further clarify consider the two situations in more detail as follows:

#### ***Routine Samples***

A routine sample sent to the laboratory should be accompanied by the field test result. The lab test report will identify lab-field tolerances that are beyond acceptable limits. For an out-of-tolerance discrepancy on routine samples, the district materials engineer (DME) may fill out the attached form TP-02171-04 and notify the project engineer. Upon receipt of a failing test report, the project engineer may also start the process of lab-field tolerance resolution by using Form 24570 or other means. Using Form 24570, the project engineer should supply the required information for items two (2) and three (3). The DME can merely document under item four (4) the date he informed the project engineer and what is intended for further investigation. At this point, first occurrence, the DME would not necessarily have to actually make a field check or review unless requested by the project engineer.

The project engineer should be responsible for assuring that his inspection and testing personnel are sampling, testing, performing calculations correctly, and equipment is functioning properly. The DME on the other hand also has this same responsibility with his personnel in the laboratory. Upon completion of Form 24570, if used, the DME retains the original copy and distributes copies to the appropriate offices.

After additional sample(s) or subsequent routine laboratory samples have been submitted to the district laboratory and the out-of-tolerance variation still exists, equipment, etc., of both testing parties (field and district laboratory) shall be reviewed.

#### ***Independent Assurance Sampling and Testing***

As mentioned above, the same concepts apply. The only difference being that when the first out-of-tolerance gradation result occurs, it is the responsibility of the DME to check into the complete situation immediately, since the independent assurance sampler has supposedly checked sampling and testing procedures. A field check along with a laboratory check is warranted under this system immediately.

In the Twin Cities Metropolitan Area, where the Maplewood Materials Laboratory (MML) does the testing, the DME is still responsible for completing the form and investigation. The MML will perform the gradations and supply the results to the appropriate DME.

This does not imply that if discrepancies continue to occur, that the MML should be eliminated from investigation. The check system shall apply to the MML just as it does to district laboratories for equipment, procedures, testing, etc.

### **Process Control Samples and Tests**

Process control samples and tests are those samples taken and tested for the purpose of controlling the production of materials proposed for incorporation into the project. They are the responsibility of the contractor and/or manufacturer and form the basis for a contractor incorporating material into the work prior to acceptance sampling and testing. They are the basis of a manufacturer's certificate of compliance. Process control samples and tests are always subject to verification by MnDOT by means of acceptance and/or independent assurance samples and tests.

### **Acceptance Samples and Tests**

Acceptance samples and tests are those samples taken and tested for determining the quality and acceptability of the materials and workmanship which have been or are being incorporated into the project. They are the responsibility of the MnDOT (project engineer).

Acceptance samples and tests will be taken in accordance with the schedule of materials control contained in the special provisions of the contract document. See Section 5-692.211 of the Grading and Base Manual, Sections 5-693.910, .920 and .930 of the Bituminous Manual, and Sections 5-694.130-.136, Section .500 of the Concrete Manual, as appropriate for instructions and procedures for acceptance sampling and testing.

Acceptance samples and tests, in the case of materials manufactured and/or fabricated away from the project site, may be pre-sampled, tested and inspected by the appropriate district Materials Unit or the Materials Engineering Section. In this case, the materials will be identified as acceptable by inspections stamps or tags on, or affixed to, the material. Test reports and/or inspection reports will be submitted to the project engineer covering pre-inspected or tested material. The project engineer will determine that pre-inspected materials are acceptable at the time they are incorporated into the work.

### **Certification by Producer**

Certain manufactured products can be accepted on the basis of a manufacturer's certificate of compliance. The certificate is furnished with each shipment of material. Presently, bituminous materials, portland cements, fly ash, metal products, plastic products, concrete products, and seed are supplied on a certificate of compliance basis from certain producers. Producers must be approved by MnDOT before they can furnish materials on a certified basis. All concrete supplied on agency work shall come from a certified ready-mix plant meeting per the requirements of Specification 2461.4D7. Each year, the Department issues a technical memorandum listing the certified sources for asphalt. Other technical memorandums are issued periodically to cover certified sources for portland cement, fly ash, corrugated metal and pipe, and seed. More

detailed information on certification and producers is available from the Materials Engineering Section and the Materials Engineering website.

### **Independent Assurance Samples and Tests**

Independent assurance samples and tests are those samples, tests, or other procedures performed by personnel who do not have responsibility for process control or acceptance sampling and testing. They are used for the purpose of making independent checks on the reliability of the results obtained in acceptance sampling and testing of materials. Therefore, prompt comparisons of independent assurance and acceptance test results should be made so that any discrepancies can be evaluated and reconciled as soon as possible.

Independent assurance samples and tests are the responsibility of the district materials engineers. The materials engineers will inform the project engineer of the minimum number of samples and tests required. They may also be taken by representatives of the Office of Materials or engineering representatives of the FHWA.

Independent assurance samples and tests will be taken in accordance with the schedule of independent assurance sampling and testing. They can be a split sample from an acceptance sample. Independent assurance tests for concrete air content should be run at least 50 percent of the time on companion samples by the independent assurance inspector using test equipment other than that assigned to the project.

After completion of the work, the district materials engineer will submit a report (Form 24121 and/or 24141) recording the independent assurance samples taken on each contract. If for a valid reason, no independent assurance samples were taken or test performed, the report will still be completed and submitted with an appropriate explanation for the deficiency in sampling and testing.

### **Acceptance and Independent Assurance Samples**

Acceptance and independent assurance samples should be taken as close as possible to the location where the material is to be incorporated into the work or mixed with other materials. The locations where acceptance and independent assurance samples are to be taken are identified in the Construction, Bituminous, Concrete, and Grading & Base Manuals.

Sampling locations and references are as follows:

1. Aggregate base gradation: taken from blended windrow or behind box spreader (5-692.211).
2. Bituminous aggregate gradation: taken from conveyor belt (5-693.910).
3. Bituminous mixture: taken from behind the paver (5-593.930).
4. Concrete coarse aggregate gradation: take sample from discharge belt, chute or loading hopper at a producing plant (5-693-131) and take sample from the discharge gates of the hopper at a batch plant (5-694.132) and fine aggregate gradation taken from trucks or stockpile (5-694-133).
5. Concrete: take sample from the discharge stream of a stationary mixer (5-694.503) and take the sample from the discharge stream of the chute from ready-mix concrete trucks (5-694.504). When pumping concrete, acceptance samples should be obtained

at the truck discharge. Correlation samples should be obtained at the point of final placement at the state of pumping and midway into the concrete pour to assure that slump, air and other mix properties do not change significantly.

### **5.1.3 ACCEPTANCE OF SMALL QUANTITIES**

When the quantity of a material used on a job site is significantly less than that indicated in the field testing rate column of the schedule for material control, the project engineer may accept such small quantities without sampling or testing. To qualify for small quantity acceptance, the material shall be from a known reliable source and judged by the project engineer to be capable of performing satisfactorily and meeting the requirements for the intended purpose. Where small quantity items are used in critical locations or have the effect of significantly influencing the performance, strength or durability of major items, prior approval for their use without testing must be obtained from the material engineer.

Acceptance of small quantities of materials shall be documented on Form 2415 or Form 2403. Guidelines for small quantity acceptance are included in the schedule for material control. A sample of these forms is included in the Appendix.

### **5.1.4 STATISTICAL METHODS FOR SAMPLING AND TESTING**

Statistically-based specifications now being used for the quality assurance and acceptance of bituminous density and aggregate base gradation and density require special sampling and testing methods. Procedures for sampling and testing materials relating to these statistically based specifications are given in the Bituminous Manual (5-692.700) as appropriate.

### **5.1.5 INSPECTION OF PROJECT, DISTRICT LABORATORY, AND CENTRAL LABORATORY TESTING EQUIPMENT**

Tests made by field personnel for the acceptance or rejection of materials are a part of the contract and, as such, the testing equipment used to make these tests must be accurate within the tolerances specified for each piece of equipment used. In order to obtain uniformity of calibration in all districts, procedures for calibrating/checking field test equipment have been developed by the Material Engineering Section. Procedures for calibrating balances, scales, moisture-density equipment, box sieves and a method of evaluating the serviceability of 8-inch round test sieves are located in the laboratory manual at:

<http://www.dot.state.mn.us/materials/materialscertification.html>

Calcium carbide moisture testers (Speedy Moisture testers) are sent to the Maplewood Materials Laboratory for calibration. DO NOT SHIP ANY CALCIUM CARBINE WHEN SENDING MOISTURE TESTER IN FOR CALIBRATION TO THE MAPLEWOOD LABORATORY. Air meters are calibrated at the district materials laboratories.

Calibration of field test equipment is made by personnel under the supervision of the district materials engineer. All field test equipment shall be calibrated and inspected each year before using on construction projects. Because of the hard usage this equipment receives, it will be necessary to examine the equipment and recalibrate, if necessary, during the progress of the work. Inspected and calibrated equipment should have an identifying mark and the date of

inspection or calibration on it. Maintain a document log that shows what was done, by whom, and the date.

#### **5.1.6 COMPARATIVE TESTING BY STATE**

Verification of most material tests conducted in field laboratories will be done under a program of comparative testing of companion samples. The laboratory samples submitted in accordance with the schedule of materials control for materials accepted by field testing and should be companion samples. Comparison of the field and laboratory results will assure that the test equipment in use is in good condition and accurate, and that the test procedure is being followed correctly. Comparisons should be made promptly. Permissible tolerances between field and laboratory test results have been established by the Office of Materials. Comparisons will be made by the district materials engineer or the Materials Engineering Section as applicable. Any variations in excess of the tolerances established will be investigated by the district materials engineer and the resolution of problems with test equipment or testing procedures causing wide variations in the comparative test results documented on Form 24355, Verification of Field Testing.

#### **5.1.7 CEMENT AND CONCRETE REFERENCE LABORATORY (CCRL) AND AASHTO MATERIALS REFERENCE LABORATORY (AMRL) INSPECTION**

The Maplewood Materials Laboratory will be included in each regular reference laboratory inspection tour and will regularly participate in the testing of proficiency samples submitted by AMRL and CCRL. The district materials laboratories will be included in each regular reference laboratory inspection tour and will regularly participate in the testing of proficiency samples submitted by AMRL. AMRL inspects State Materials Laboratory in Maplewood and district laboratories test equipment and review of test procedures for standard tests on soil, aggregate, bituminous material, and bituminous mixtures. CCRL inspects agencies for standard tests on cement, concrete and reinforcing steel. Any deficiencies noted in these inspections must be corrected or otherwise satisfied.

#### **5.1.8 RETENTION OF RECORDS**

Records of materials tests and inspection will be retained as specified in the Department's record retention schedule. Retention will generally be for three years after FHWA final payment on a federal aid project, or seven years after completion of a state funded project. Some records are retained for longer periods (refer to schedule) if they have historical reference value for later evaluation of material sources.

#### **5.1.9 TRAINING**

Project inspectors will be adequately trained in the sampling, testing and inspection duties to which they are assigned. Training courses for inspectors will be provided periodically by the district to assure that project inspectors are adequately trained and that sampling and testing procedures are performed correctly and reported promptly.

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### **5.2 Sampling and Testing by Consultants and Independent Laboratories**

Consultants and independent laboratories that are AMRL accredited can be employed to conduct the acceptance sampling and testing on a project. In such instances, they are considered representatives of MnDOT and are to be paid by and directly accountable to the agency

employing them, be it MnDOT, county, a municipality, or some other contract agency. Employees of consultants and independent laboratories that are performing the sampling and testing must be qualified for such work, consultants and independent laboratories must be AMRL accredited for the testing performed prior to being used on a project.

Being certified or accredited under an acceptable national program is a means of demonstrating qualifications.

Consultants and independent laboratories are only authorized to perform acceptance sampling and testing.

Consultants and independent laboratories are not authorized to perform any independent assurance sampling and testing without prior approval. This sampling and testing can only be conducted by state or agency designated personnel who do not have direct responsibility for acceptance sampling and testing, and, are not assigned or directly related to the project. Normally, the independent assurance inspector obtains the independent assurance samples for testing at the district laboratory or the Maplewood Materials Laboratory.

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### 5.3 Sampling and Testing of Electrical Equipment

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Every MnDOT contract proposal has a schedule of materials control document within it. Contractors and inspectors must adhere to the sampling and testing requirements contained in this document.

Electrical cables with a jacket are usually inspected at the distributor. Documentation showing project number, reel number(s), and MnDOT test number(s) will be included with each project shipment. If such documentation is not received from the contractor, submit a sample for testing along with material certification from the manufacturer. Pre-inspected materials will not be tagged; an inspection report will be sent by the MnDOT inspector for each shipment. Project inspectors should verify that the shipping documents agree with this inspection report.

MnDOT Materials Lab Testing Contact information:

*Steve Grover at 651-366-5540,  
Cindy Schellack at 651-366-5543, or  
James Ferry at 651-366-5536 with any questions.  
<http://www.dot.state.mn.us/materials/lab.html>*

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### 5.4 MnDOT's Approved/Qualified Products List (APL)

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MnDOT's APL is a list of products that the Department has pre-approved or pre-qualified for use on a project. The Department uses this list to verify the acceptability of products used in the performance of the work. The contract documents will direct the contractor to MnDOT's APL when an approved product is specified for use on the project.

The website address for the MnDOT's APL is as follows: <http://www.dot.state.mn.us/products/index.html>

**A.6 MnDOT’s Approved/Qualified Products List**

Access lighting system materials listed on MnDOT’s Approved/Qualified Products List.

**A.7 Shop Drawing Submittals**

Prepare shop drawing submittals in accordance with 1502 for all products not on MnDOT’s Approved/Qualified Products List (APL).

Submit products as specified in the Contract. Review shop drawings for accuracy and completeness before submittal.

**A.8 MnDOT Approved Products Materials List**

Before performing the Work, submit to the Engineer, in accordance with 1502, a Signals and Lighting product materials list of the products selected from MnDOT’s Approved/Qualified Products List to be used on the Project for Signals and Lighting. Ensure the products selected meet the requirements of this section.

For MnDOT’s approved products, see MnDOT’s Approved/Qualified Products website.

In the Signals and Lighting product materials list submitted to the Engineer, provide the following information:

- (1) Title the document “MnDOT’s Approved/Qualified Products List for Signals and Lighting,” centered at the top of the document,
- (2) Directly under the title include the Trunk Highway, County, and State Project number, and
- (3) For each product listed from MnDOT’s Approved/Qualified Products List, provide a separate line that includes the following:
  - (3.1) Name of the manufacturer,
  - (3.2) Name of the product,
  - (3.3) Catalog number, and
  - (3.4) Quantity ordered for the Project.

This submittal and the Engineer’s review of the submitted list do not relieve the responsibility for providing products that comply with MnDOT’s Approved/Qualified Products List.

**A.9 Cut Sheets, Catalog Sheets, or Specification Sheets**

Provide cut sheets, catalog sheets, or specification sheets for MnDOT’s Approved/Qualified Products List products to the Engineer upon request.

Figure 5-3: Standard Specification 2545.2A.8

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## 5.5 Shop Drawing Submittals for Signals and Lighting

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Prepare shop drawing submittals for projects in accordance with 1502 for all products not on the APL.

Be sure to submit products showing compliance with contract documents. Review shop drawings for accuracy, completeness, and compliance with contract documents prior to submittal.

The engineer’s review and approval of shop drawing submittals does not relieve the responsibility for providing products that comply with the contract documents.

MnDOT defines a shop drawing as a “detailed document showing how a specific product will be fabricated and constructed. This document will also include required material specifications and requirements.”

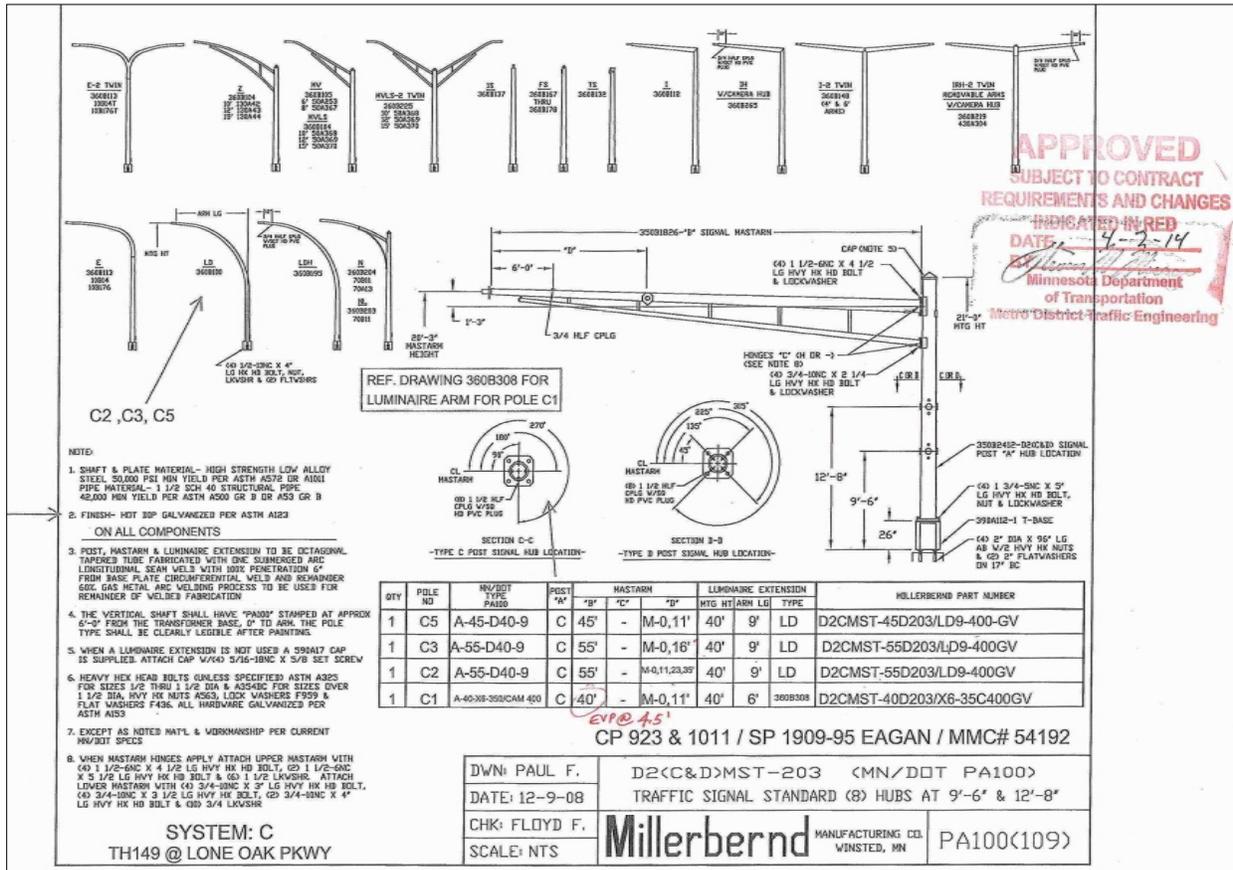


Figure 5-4: Shop Drawing



## ATTACHMENT “A-2”

Exceptions include all of the following situations:

**Failing Tests** Any failure of a field test, quality control test, or verification test. Corrections or deducts resulting from failing tests must be listed as resolutions of exceptions.

**Missing Tests** Any missed field test, quality control test, or verification test. Tests include required observations of quality control tests.

**Test Tolerance** Any tolerance failure between an acceptance test and the corresponding companion proficiency or Independent Assurance sample test. Companion sample tests are performed between:

- ✓ Field and laboratory samples
- ✓ Quality control and quality assurance samples
- ✓ Verification and verification companion samples
- ✓ Field and IA samples
- ✓ Quality control and IA samples
- ✓ Plant observer’s quality assurance or verification samples and IA samples

**Non-Certified Testers** Any acceptance samples taken or tests performed by non-certified or under-certified testers. This includes contractor quality control tests when used for acceptance and agency verification tests. Tests not performed in a qualified laboratory are also exceptions.

### Other Exceptions

- ✓ Material accepted from a non-approved source, missing certificates of compliance, incomplete small quantity documentation, etc.
- ✓ Paving without a Mixture Design Report and/or recommendation
- ✓ Individual test out of tolerance, but moving average is within limits, is an exception for the individual test out of tolerance
- ✓ Bituminous test results in warning band (year 2000 and older specifications) is an exception, reduce payment in accordance with specifications

**ATTACHMENT “B”**

**CERTIFICATION OF MATERIALS ON NONCONVENTIONAL FEDERAL AID PROJECT**

Memorandum to:                   Materials Engineer

  Minnesota Department of Transportation  
  Materials and Research Laboratory  
  1400 Gervais Avenue  
  Maplewood, MN 55109

Subject:                            Certification of Materials on  
  Non-conventional Federal Aid Project

  Project No:  
  Contact No:  
  Type of Work:

This is to certify that the materials used on the above project were in close conformity with the specification requirements of the contract and are properly covered by tests in accordance with the Contract Agency’s plan for acceptance testing or were determined to be acceptable for their intended use on the basis of small quantity visual inspection.

Dated: \_\_\_\_\_ Project Engineer: \_\_\_\_\_

This schedule is revised periodically. The current revision is sent to the project engineer after contract award.

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**5.7 Chapter 5 Resources**

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- Federal Highway Program Manual, Volume 6, Chapter 4, Section 2, and Subsection 7
- MnDOT’s Approved/Qualified Products List
- MnDOT Materials Engineering Section
- Construction, Bituminous, Concrete, and Grading & Base Manuals
- MnDOT Standard Specifications for Construction 2461.4D7, 2545.2A.8

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