FIELD SAMPLING AND TESTING MANUAL

SECTION 200

EARTHWORK

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SECTION 200
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Reference Forms:

DOT 13942 Conversion Chart for Speedy Tester
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SFN 9987 Aggregate Sample Worksheet
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SFN 59724 Sand Cone Correction Factor
SFN 59725 Density Test Worksheet – Sand Cone Method

All test procedures used within and referred to in this section can be found under "Testing Procedures" of this manual.

Form examples at end of section are for "Reference Only." Use the most current available forms on the NDDOT website only.

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Section 203
Excavation and Embankment

203.01 Description.

This work consists of the excavation, haul, placement, disposal, and compaction of embankment material.

203.02 Excavation.

No testing required.

203.03 Embankment – Acceptance Samples and Tests.

A. Engineer Responsibility.

The Engineer will collect material and conduct testing to verify the material meets the requirements of 'Compaction Control' in Section 203.04.E.2 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

1. Compaction Control, Type A.

   Table 203-1 shows test method and frequency for embankment compaction control.

Table 203-1	
Test	Frequency
ND T 180 or ND T 99, "Moisture-Density Relations of Soils (Multi-Point)"	1 compaction curve for each change in soil.
ND D 2167, "Density and Unit Weight of Soil in Place by the Rubber Balloon Method," or ND T 191, "Density of Soil In-Place by the Sand Cone Method"	1 test per 1,500 feet of compacted roadway per 12" lift.
ND T 265, "Laboratory Determination of Moisture Content of Soils;" or ND T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy);" or ND D 4643, "Microwave Method of Drying Soils"	1 test per 1,500 feet of compacted roadway per 12" lift.

   Sample locations will be randomly selected by the Engineer.

The results of the in-place density and moisture tests are compared to the appropriate moisture density curve derived from the ND T 180 or ND T 99 testing.

Compute the ND T 180 or ND T 99 on SFN 10063, “Moisture-Density Relationship Tests” worksheet. The in-place density and moisture tests are recorded on SFN 2454, “Density Test Worksheet – Volume Measure,” or SFN 59725, “Density Test Worksheet – Sand Cone Method.”

2. Compaction Control, Type B.

   No testing required.

3. Compaction Control, Type C.

   No testing required.

B. District Materials Coordinator Responsibility.

Reserved.

C. Materials and Research Responsibility.

Reserved.

203.04 Independent Assurance (IA) Samples and Tests.

A. Engineer Responsibility.

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. **District Materials Coordinator Responsibility.**

The District Materials Coordinator will obtain these samples and conduct these tests. Soils or soil-aggregates tested for moisture-density relations will be an equal split sample from the Engineer. In-field IA testing will be conducted next to the field test using the same method.

Table 203-2 shows test method and frequency for embankment compaction control, Type A, for IA.

Table 203-2	
Test	Frequency
ND T 180 or ND T 99, “Moisture-Density Relations of Soils (Multi-Point)”	1 compaction curve for each three miles of roadway, or a minimum of 1 test per 200,000 C.Y.
ND D 2167, “Density and Unit Weight of Soil in Place by the Rubber Balloon Method,” or ND T 191, “Density of Soil In-Place by the Sand Cone Method”	1 density test for each three miles of roadway, or a minimum of 1 test per 200,000 C.Y.
ND T 265, “Laboratory Determination of Moisture Content of Soils,” or ND T 217, “Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy),” or ND D 4643, “Microwave Method of Drying Soils”	1 moisture test for each three miles of roadway, or a minimum of 1 test per 200,000 C.Y.

Compute the ND T 180 or ND T 99 on SFN 10063, “Moisture-Density Relationship Tests” worksheet. The in-place density and moisture tests are recorded on SFN 2454, “Density Test Worksheet – Volume Measure,” or SFN 59725, “Density Test Worksheet – Sand Cone Method.”

Engineer and District Materials Coordinator will compare the test results for IA tolerance in Table 203-3.

Table 203-3	
Test	Tolerance
ND T 180 or ND T 99, “Moisture-Density Relations of Soils (Multi-Point)”	± 4 lbs. cu. ft. (MDD) ± 1.5 (OM)
ND D 2167, “Density and Unit Weight of Soil in Place by the Rubber Balloon Method,” or ND T 191, “Density of Soil In-Place by the Sand Cone Method”	± 5 lbs. cu. ft.
ND T 265, “Laboratory Determination of Moisture Content of Soils,” or ND T 217, “Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy),” or ND D 4643, “Microwave Method of Drying Soils”	± 2.0

If the initial IA testing is not within specified tolerances, the Engineer shall obtain an additional sample for testing under the observation of the District Materials Coordinator.

The Engineer and District Materials Coordinator shall conduct equipment checks and review testing procedures. This will continue until the differences are resolved.

C. Materials and Research Responsibility.

Reserved.

Section 210
Structural and Channel Excavation, Foundation Fill and Preparation

210.01 Description.

This work consists of excavation as defined in the plans.

210.02 Excavation.

No testing required.

210.03 Acceptance Samples and Tests.

A. Engineer Responsibility.

The Engineer will collect material and conduct testing to verify material meets the requirements of Section 210.03.B and 714.04.A.7, 8 of the NDDOT *Standard Specifications for Road and Bridge Construction*.

Table 210-1 shows test methods and frequency for compaction control.

Table 210-1	
Tests	Frequency
ND T 180 or ND T 99, “Moisture-Density Relations of Soils (Multi-Point)”	1 compaction curve for each change in material.
ND D 2167, “Density and Unit Weight of Soil in Place by the Rubber Balloon Method,” or ND T 191, “Density of Soil In-Place by the Sand Cone Method”	1 test per 1 foot in elevation.
ND T 265, “Laboratory Determination of Moisture Content of Soils,” or ND T 217, “Determination of Moisture in Soil by Mean of Calcium Carbide Gas Pressure Tester (Speedy),” or ND D 4643, “Microwave Method of Drying Soils”	1 test per 1 foot in elevation.

Sample locations will be randomly selected by the Engineer.

The results of the in-place density and moisture tests are compared to the appropriate moisture density curve derived from the ND T 180 or ND T 99 testing.

Compute the ND T 180 or ND T 99 on SFN 10063, “Moisture-Density Relationship Tests” worksheet. The in-place density and moisture tests are

recorded on SFN 2454, “Density Test Worksheet – Volume Measure,” or SFN 59725, “Density Test Worksheet – Sand Cone Method.”

Table 210-2 shows test method and frequency for aggregate placed.

Table 210-2	
Test	Frequency
ND T 27, “Sieve Analysis of Fine and Coarse Aggregates**”**	1 test result per 2,500 C.Y.
ND T 11, “Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing”	1 test result per 2,500 C.Y.
NDDOT 4, “Percentage of Fracture Particles in Coarse Aggregate”	1 test result per 2,500 C.Y.
ND T 113, “Lightweight Pieces in Aggregate”	1 test result per 2,500 C.Y.

Compute the sieve analysis results on SFN 9987, “Aggregate Sample Worksheet.” Results are recorded on SFN 10072, “Aggregate Quality Test Summary.”

B. District Materials Coordinator Responsibility.

Reserved.

C. **Materials and Research Responsibility.**

Reserved.

210.04 Independent Assurance (IA) Samples and Tests.

A. Engineer Responsibility.

Conduct IA tests on split samples taken by the District Materials Coordinator.

Testing performed will be as directed by the District Materials Coordinator.

B. District Materials Coordinator Responsibility.

The District Materials Coordinator will obtain these samples and conduct these tests. These samples will be an equal split sample from the Engineer.

Samples will be obtained and split according to ND T 2, “Sampling of Aggregates,” and ND T 248, “Reducing Samples of Aggregate to Testing Size.”

Soils or soil-aggregates tested for moisture-density relations will be an equal split sample from the Engineer. In-field IA testing will be conducted next to the field test, using the same method.

Table 210-3 shows test method and frequency for IA.

Table 210-3	
Test	Frequency
ND T 180 or ND T 99, “Moisture-Density Relations of Soils (Multi-Point)”	1 compaction curve for each three miles of roadway, or a minimum of 1 test per 200,000 C.Y.
ND D 2167, “Density and Unit Weight of Soil in Place by the Rubber Balloon Method,” or ND T 191, “Density of Soil In-Place by the Sand Cone Method”	1 density test for each three miles of roadway, or a minimum of 1 test per 200,000 C.Y.
ND T 265, “Laboratory Determination of Moisture Content of Soils,” or ND T 217, “Determination of Moisture in Soil by Mean of Calcium Carbide Gas Pressure Tester (Speedy),” or ND D 4643, “Microwave Method of Drying Soils”	1 moisture test for each three miles of roadway, or a minimum of 1 test per 200,000 C.Y.
ND T 27, “Sieve Analysis of Fine and Coarse Aggregates”	Minimum 1 test result per project.
ND T 11, “Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing”	Minimum 1 test result per project.
NDDOT 4, “Percentage of Fracture Particles in Coarse Aggregate”	Minimum 1 test result per project.
ND T 113, “Lightweight Pieces in Aggregate”	Minimum 1 test result per project.

Compute the ND T 180 or ND T 99 on SFN 10063, “Moisture-Density Relationship Tests” worksheet. The in-place density and moisture tests are recorded on SFN 2454, “Density Test Worksheet – Volume Measure,” or SFN 59725, “Density Test Worksheet – Sand Cone Method.”

The Engineer and District Materials Coordinator will compare the test results for IA tolerance in Table 210-4.

Table 210-4	
Test	Tolerance
ND T 180 or ND T 99, “Moisture-Density Relations of Soils (Multi-Point)”	± 4 lbs. cu. ft. (MDD) ± 1.5 (OM)
ND D 2167, “Density and Unit Weight of Soil in Place by the Rubber Balloon Method,” or ND T 191, “Density of Soil In-Place by the Sand Cone Method”	± 5 lbs. cu. ft.
ND T 265, “Laboratory Determination of Moisture Content of Soils,” or ND T 217, “Determination of Moisture in Soil by Mean of Calcium Carbide Gas Pressure Tester (Speedy),” or ND D 4643, “Microwave Method of Drying Soils”	± 2.0
ND T 27, “Sieve Analysis of Fine and Coarse Aggregates,” and ND T 11, “Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing”: No. 4 sieve and larger No. 30 sieve No. 200 sieve	 ±5 ±3 ±2
NDDOT 4, “Percentage of Fracture Particles in Coarse Aggregate”	±5
ND T 113, “Lightweight Pieces in Aggregate”	±2

If the initial IA testing is not within specified tolerances, the Engineer shall obtain an additional sample for testing under the observation of the District Materials Coordinator.

The Engineer and District Materials Coordinator shall conduct equipment checks and review testing procedures. This will continue until the differences are resolved.

C. Materials and Research Responsibility.

Reserved.

SECTION 230

RESHAPING ROADWAY AND SUBGRADE PREPARATION

230 DESCRIPTION

This work consists of scarifying, shaping, compacting, and maintaining the subgrade, or reshaping an existing roadway before constructing a base, or surface course.

230.1 ACCEPTANCE SAMPLES AND TESTS

Field Laboratory Testing: The Engineer or Representative conducts a minimum of one moisture and density test for each compacted lift per 1500 feet of roadway. Conduct moisture test according to AASHTO T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy)."* Conduct the density test according to ASTM D 2167, "Density and Unit Weight of Soil in Place by the Rubber-Balloon Method," or AASHTO T 191, "Density of Soil In-Place by Sand-Cone Method." Record information on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method." Conduct additional tests at locations as directed by the Engineer or Representative.

If work consists of embankment widening, then testing shall be conducted on each side of roadway or embankment that is widened. Each widened portion shall be considered a separate roadway.

230.2 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

District Laboratory Testing: The District Materials Coordinator or Representative conducts a minimum of one moisture and density test, including a proctor test, for each three miles of roadway. Conduct these tests according to AASHTO T 217, "Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy)," ASTM D 2167, "Density and Unit Weight of Soil in Place by the Rubber-Balloon Method," or AASHTO T 191, "Density of Soil In-Place by Sand-Cone Method," and AASHTO T 99 or T 180, "Moisture-Density Relations of Soils." Record information on SFN 2454, "Density Test Worksheet – Volume Measure," or SFN 59725, "Density Test Worksheet – Sand Cone Method," and SFN 10063, "Moisture-Density Relationship Test."

For Type C subgrade preparation, perform proctor tests for each soil change encountered with a minimum of one test for every three miles of roadway.

Frequency of testing shall not differ when conducting embankment widening.

- Field applications typically require the use of the “Speedy” to determine soils moisture content, but it may be practical to use AASHTO T 265, “Laboratory Determination of Moisture Content,” or ASTM D 4643, “Microwave Method of Drying Soils,” in its place. However, acceptance testing and Independent Assurance (IA) testing must be completed using the same soils moisture determination method.

Materials and Research Division Testing: No specified number of tests is required. The Materials and Research Division will perform moisture-density relationship tests according to AASHTO T 99 or T 180, “Moisture-Density Relations of Soils,” if requested to do so by the District Materials Coordinator.

SECTION 234

STABILIZED SUBGRADE

234 DESCRIPTION

This work consists of treating the top layer of subgrade with lime or lime-fly ash.

234.1 ACCEPTANCE SAMPLES AND TESTS

Field Laboratory Testing: The Engineer or Representative conducts moisture-density relationship tests for all soil types encountered on the project after the complete mixing of the lime and/or fly ash with the soil.

Conduct a minimum of one moisture and density test for every 1500 feet, or fraction thereof. Perform the moisture-density relationship tests, proctor, and all related density tests on the same day.

The Engineer or Representative conducts a minimum of one moisture and one density test, including a proctor test, for every 1500 feet of roadway. Conduct tests according to AASHTO T 217, “Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy),”* ASTM D 2167, “Density and Unit Weight of Soil in Place by the Rubber-Balloon Method,” or AASHTO T 191, “Density of Soil In-Place by Sand-Cone Method,” and AASHTO T 99 or T 180, “Moisture-Density Relations of Soils.” Record information on SFN 2454, “Density Test Worksheet – Volume Measure,” or SFN 59725, “Density Test Worksheet – Sand Cone Method,” and SFN 10063, “Moisture-Density Relationship Tests.”

234.2 INDEPENDENT ASSURANCE (IA) SAMPLES AND TESTS

District Laboratory Testing: The District Materials Coordinator or Representative conducts a minimum of one moisture and density test, including a proctor test, for each three miles of roadway. Stagger the test locations on a four-lane facility. Complete the proctor and density tests on the same day. Conduct tests according to AASHTO T 217, “Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Moisture Tester (Speedy),”* ASTM D 2167, “Density and Unit Weight of Soil in Place by the Rubber-Balloon Method,” or AASHTO T 191, “Density of Soil In-Place by Sand-Cone Method,” and AASHTO T 99 or T 180, “Moisture-Density Relations of Soils.” Record the information on SFN 2454, “Density Test Worksheet - Volume Measure,” or SFN 59725, “Density Test Worksheet - Sand Cone Method,” and SFN 10063, “Moisture-Density Relationship Test.”

The District Materials Coordinator or Representative performs one random width and depth check for each two miles of roadway, or fraction thereof. Record results on SFN 13889, “Project Records Samples/Tests Reports.” If an NHS system project, submit a copy of SFN 13889, “Project Records Samples/Test Reports,” to the FHWA at the completion of the project.

* Field applications typically require the use of the “Speedy” to determine soils moisture content, but it may be practical to use AASHTO T 265, “Laboratory Determination of Moisture Content,” or ASTM D 4643, “Microwave Method of Drying Soils,” in its place. However, acceptance testing and Independent Assurance (IA) testing must be completed using the same soils moisture determination method.

CONSULTANT USE OF NUCLEAR GAUGES FOR COMPACTION CONTROL

1. General Requirements

Consulting firms may use nuclear gauges under the following conditions:

- The use of the gauges shall be limited to soil and aggregate density testing only. Testing must be conducted according to AASHTO T 310, “In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).”

- The firm providing the testing maintains accreditation under the AASHTO Accreditation Program (AAP).

    - Included in the scope must be AASHTO Standard R18, “Establishing and Implementing a Quality System for Construction Materials Laboratories,” and AASHTO Test Method T 310, “In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).”

    - The firm providing the testing shall provide calibration data for the nuclear gauges they are using. The nuclear gauges are to be calibrated according to Annex A1, A2, and A3 of AASHTO T 310.

- Nuclear gauges contain radioactive materials. Users must follow all applicable safety regulations and protocol required by the North Dakota State Health Department.

2. Correlation Requirements

- A series of five (5) side-by-side comparisons shall be conducted at the beginning of each project on a location determined by the Engineer.

- The data acquired from each gauge will be correlated to conventional methods of determining dry density on the same materials tested on the project. The conventional density tests are the following:

    In-Place Density Tests:

    ND D 2167, “Density and Unit Weight of Soil In-Place by the Rubber Balloon Method”
    ND T 191, “Density of Soil In-Place by the Sand Cone Method”

In-Place Moisture Tests:

ND T 265, “Laboratory Determination of Moisture Content of Soils”
ND T 217, “Determination of Moisture in Soil by Means of Calcium Carbide Gas Pressure Tester (Speedy)”
ND D 4643, “Microwave Method of Drying Soils”

- Personnel conducting the nuclear density testing must also conduct the comparison testing in the field. These personnel must also be certified to provide conventional density and moisture testing according to NDDOT *Standard Specification for Road and Bridge Construction* Section 106.10.

- All correlation results are provided to the Engineer within 24 hours of the completion of the testing.

- The average of the moisture content tests shall be compared to the nuclear gauge results. If the average differentiates by less than 1.0% or 1.0 lbs./cu.ft., the nuclear gauge is used without correction.

- If the gauge results differ by more than 1.0%, a correction factor will be applied. If the in-place wet density results differ by more than 1.0 lbs./cu.ft., a correction will be applied.

3. Validation of Results

- This correlation will be verified in the field with a single test for every ten (10) nuclear gauge tests for the first 30 tests. Testing can be reduced to a single validation test per 50 nuclear gauge tests thereafter.

- If a correction factor has been applied and the verification differentiates by over 0.5% or 0.5 lbs./cu.ft., a new correction factor shall be established as previously described in Section 2. Correlation testing would also revert to a single test for every ten (10) nuclear gauge tests for the first 30 tests.

4. Independent Assurance (IA)

- Independent assurance is required and conducted using the conventional in-place density methods used for the comparison testing.

- The District Materials Coordinator directs frequency and testing of the IA.

SECTION 200

FORMS

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CONVERSION CHART FOR SPEEDY TESTER

North Dakota Department of Transportation, Materials & Research

DOT 13942 (Rev. 01-2009)

WET WT. %	DRY WT. %	WET WT. %	DRY WT. %	WET WT. %	DRY WT. %	WET WT. %	DRY WT. %	WET WT. %	DRY WT. %
1.0	1.0	7.0	7.5	13.0	14.9	19.0	23.5	25.0	33.3
1.1	1.1	7.1	7.6	13.1	15.1	19.1	23.7	25.1	33.5
1.2	1.2	7.2	7.7	13.2	15.2	19.2	23.8	25.2	33.7
1.3	1.3	7.3	7.9	13.3	15.3	19.3	23.9	25.3	33.9
1.4	1.4	7.4	8.0	13.4	15.5	19.4	24.1	25.4	34.0
1.5	1.5	7.5	8.1	13.5	15.6	19.5	24.2	25.5	34.2
1.6	1.6	7.6	8.2	13.6	15.7	19.6	24.4	25.6	34.4
1.7	1.7	7.7	8.3	13.7	15.9	19.7	24.5	25.7	34.6
1.8	1.8	7.8	8.5	13.8	16.0	19.8	24.7	25.8	34.8
1.9	1.9	7.9	8.6	13.9	16.1	19.9	24.8	25.9	35.0
2.0	2.0	8.0	8.7	14.0	16.3	20.0	25.0	26.0	35.1
2.1	2.1	8.1	8.8	14.1	16.4	20.1	25.2	26.1	35.3
2.2	2.2	8.2	8.9	14.2	16.6	20.2	25.3	26.2	35.5
2.3	2.4	8.3	9.1	14.3	16.7	20.3	25.5	26.3	35.7
2.4	2.5	8.4	9.2	14.4	16.8	20.4	25.6	26.4	36.9
2.5	2.6	8.5	9.3	14.5	17.0	20.5	25.8	26.5	36.1
2.6	2.7	8.6	9.4	14.6	17.1	20.6	25.9	26.6	36.2
2.7	2.8	8.7	9.5	14.7	17.2	20.7	26.1	26.7	36.4
2.8	2.9	8.8	9.6	14.8	17.4	20.8	26.3	26.8	36.6
2.9	2.9	8.9	9.8	14.9	17.5	20.9	26.4	26.9	36.8
3.0	3.1	9.0	9.9	15.0	17.6	21.0	26.6	27.0	37.0
3.1	3.2	9.1	10.0	15.1	17.8	21.1	26.7	27.1	37.2
3.2	3.3	9.2	10.1	15.2	17.9	21.2	26.9	27.2	37.4
3.3	3.4	9.3	10.3	15.3	18.1	21.3	27.1	27.3	37.6
3.4	3.5	9.4	10.4	15.4	18.2	21.4	27.2	27.4	37.7
3.5	3.6	9.5	10.5	15.5	18.3	21.5	27.4	27.5	37.9
3.6	3.7	9.6	10.6	15.6	18.5	21.6	27.6	27.6	38.1
3.7	3.8	9.7	10.7	15.7	18.6	21.7	27.7	27.7	38.3
3.8	4.0	9.8	10.9	15.8	18.8	21.8	27.9	27.8	38.5
3.9	4.1	9.9	11.0	15.9	18.9	21.9	28.0	27.9	38.7
4.0	4.2	10.0	11.1	16.0	19.0	22.0	28.2	28.0	38.9
4.1	4.3	10.1	11.2	16.1	19.2	22.1	28.4	28.1	39.1
4.2	4.4	10.2	11.4	16.2	19.3	22.2	28.5	28.2	39.3
4.3	4.5	10.3	11.5	16.3	19.5	22.3	28.7	28.3	39.5
4.4	4.6	10.4	11.6	16.4	19.6	22.4	28.9	28.4	39.7
4.5	4.7	10.5	11.7	16.5	19.8	22.5	29.0	28.5	39.9
4.6	4.8	10.6	11.9	16.6	19.9	22.6	29.2	28.6	40.1
4.7	4.9	10.7	12.0	16.7	20.0	22.7	29.4	28.7	40.3
4.8	5.0	10.8	12.1	16.8	20.2	22.8	29.5	28.8	40.4
4.9	5.2	10.9	12.2	16.9	20.3	22.9	29.7	28.9	40.6
5.0	5.3	11.0	12.3	17.0	20.5	23.0	29.9	29.0	40.8
5.1	5.4	11.1	12.5	17.1	20.6	23.1	30.0	29.1	41.0
5.2	5.5	11.2	12.6	17.2	20.8	23.2	30.2	29.2	41.2
5.3	5.6	11.3	12.7	17.3	20.9	23.3	30.4	29.3	41.4
5.4	5.7	11.4	12.9	17.4	21.1	23.4	30.5	29.4	41.6
5.5	5.8	11.5	13.0	17.5	21.2	23.5	30.7	29.5	41.8
5.6	5.9	11.6	13.1	17.6	21.4	23.6	30.9	29.6	42.0
5.7	6.0	11.7	13.3	17.7	21.5	23.7	31.1	29.7	42.2
5.8	6.2	11.8	13.4	17.8	21.7	23.8	31.2	29.8	42.5
5.9	6.3	11.9	13.5	17.9	21.8	23.9	31.4	29.9	42.7
6.0	6.4	12.0	13.6	18.0	22.0	24.0	31.6	30.0	42.9
6.1	6.5	12.1	13.8	18.1	22.1	24.1	31.8	30.1	43.1
6.2	6.6	12.2	13.9	18.2	22.2	24.2	31.9	30.2	43.3
6.3	6.7	12.3	14.0	18.3	22.4	24.3	32.1	30.3	43.5
6.4	6.8	12.4	14.2	18.4	22.5	24.4	32.3	30.4	43.7
6.5	7.0	12.5	14.3	18.5	22.7	24.5	32.5	30.5	43.9
6.6	7.1	12.6	14.4	18.6	22.9	24.6	32.6	30.6	44.1
6.7	7.2	12.7	14.5	18.7	23.0	24.7	32.8	30.7	44.3
6.8	7.3	12.8	14.7	18.8	23.2	24.8	33.0	30.8	44.5
6.9	7.4	12.9	14.8	18.9	23.3	24.9	33.2	30.9	44.7

DENSITY TEST WORKSHEET - VOLUME MEASURE

North Dakota Department of Transportation, Materials & Research
SFN 2454 (5-2017)

Project Number	PCN	Date	Tested By

TEST IDENTIFICATION		**Test Number**					
		Time					
		Lot					
		Station					
		Offset from centerline					
		Lane					
		Depth below finished grade ft.					
IN-PLACE TEST VOLUME MEASURE	a	Final volume reading cu. ft.					
	b	Initial volume reading cu. ft.					
	c	Volume of hole = (a - b) cu. ft.					
	d	Wet weight of soil lbs.					
	e	Wet density = (d/c) lbs./cu.ft.					
	f	Moisture %					
	g	Dry density=(e x 100)/(100 + f) lbs./cu.ft.					
MOISTURE-DENSITY RELATIONSHIP TEST		ND Procedure					
		Test Number (Proctor test)					
		Station					
		Offset from centerline					
		Depth below finished grade ft.					
	h	Maximum dry density lbs./cu.ft.					
	i	Optimum moisture %					
REQUIRED MOIS.-DENS.	k	Required % maximum dry density					
	l	% Maximum dry density = (g/h) x 100					
	m	Required moisture %					
	n	Moisture = f %					
MOISTURE DETERMINATION		Container ID					
	p	Wet weight + container g					
	q	Dry weight + container g					
	r	Moisture loss = (p - q) g					
	s	Tare weight of container g					
	t	Dry weight of soil = (q - s) g					
	f	Moisture = (r/t) x 100 %					

Remarks

AGGREGATE SAMPLE WORKSHEET

North Dakota Department of Transportation, Materials & Research

SFN 9987 (Rev. 08-2015)

PCN
Laboratory No.
Field Sample No.
Pit Location
Owner
Project
County
Material/Specification
Date Received
Date Sampled
Sampled From
Submitted By

Sieve Size		Wt. Ret. Non-Cum.	Wt. Ret. Cum.	% Ret.	% Pass	ND Spec.
100 mm	4"					
90 mm	3 1/2"					
75 mm	3"					
63 mm	2 1/2"					
50 mm	2"					
37.5 mm	1 1/2"					
25.0 mm	1"					
19.0 mm	3/4"					
16.0 mm	5/8"					
12.5 mm	1/2"					
9.5 mm	3/8"					
4.75 mm	No. 4					
Minus No. 4						
Wt.Check						
Original Wt.						

ND T-27 Tested By: _____

FRACTURED FACES
FF = % of particles w/ frac. faces
WF = Wt. of frac. particles
WQ = Wt. of questionable frac. particles
WA = Wt. of total sample
FF = [WF + (WQ/2)]/WA X 100
FF =
ND Spec.

NDDOT 4 Tested By: _____

Sieve Size		Wt. Ret. Non-Cum.	Wt. Ret. Cum.	% Ret.	% Pass	% Pass Tot. Smpl.	ND Spec.
2.36 mm	No. 8						
2.00 mm	No. 10						
1.18 mm	No. 16						
600µm	No. 30						
425µm	No. 40						
300µm	No. 50						
150µm	No. 100						
75µm	No. 200						
Minus No. 200							
Original Wt.							
Wt. After Wash							
Wash Loss							
Wt.Check							

ND T-27 Tested By: _____ ND T-11 Tested By: _____

LIGHTWEIGHT PIECES

+ No. 4 Material				– No. 4, + No. 30 Material			
(A) % Retained on No.4 Sieve	=		%	(I) Weight of Lt Wt Pieces, -No. 4, + No. 30 Mtrl.	=		g
(B) % Passing No. 30, Total Sample	=		%	(J) Weight of – No. 4, + No. 30 Material	=		g
(C) % Pass No. 4 – % Pass No. 30, [100–(A+B)]	=		%	(K) Lt Wt Pieces, – No. 4, + No. 30 (I/J)x100	=		%
(D) Total Sample A+B+C	=	100.0	%	(L) Lt Wt Pieces, – No. 4, + No. 30 Material % of Total Sample (KxC)/100	=		%
(E) Weight of Lt Wt Pieces in + No. 4 Mtrl.	=		g				
(F) Weight of + No. 4 Material	=		g				
(G) Lt Wt Pieces, + No. 4 Mtrl (E/F)x100	=		%				
(H) Lt Wt Pieces, + No. 4 Mtrl., % of Total Sample (GxA)/100							%
				(M) Lightweight Pieces in Total Sample (H+L)	=		%
					ND Spec.		

ND T-113 Tested By: _____

Distribution:

☐ _____ District

☐ Central Lab.

Date	Testing Lab Supervisor

SFN 9987

Laboratory Number

Liquid Limit, Plastic Limit, and Plasticity Index

Liquid Limit

A. Can no. tare weight	
B. Can and wet soil	
C. Can and dry soil	
D. Moisture loss (B - C)	
E. Dry soil weight (C - A)	
F. Moisture at blows (D/E) x 100	
Moisture corrected (F x K)	
G. Liquid Limit	

ND T 89 tested by: _____

#Blows

Number of blows N	Factor for Liquid Limit K
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014

Plastic Limit

H. Can No. tare weight	
I. Can and wet soil	
J. Can and dry soil	
L. Moisture loss (I - J)	
M. Dry soil weight (J - H)	
Moisture content (L/M) x 100	
O. Plastic Limit	
Plastic Index (G - O)	

ND T 90 tested by: _____

LA Abrasion

Grading Used: ☐ A ☐ B ☐ C ☐ D		
Weight of original sample	(A) =	grams
Weight of sample retained on No. 12	(B) =	grams
Loss	(C) =	grams
LA Abrasion = C/A x 100	=	% Loss

AASHTO T-96 Tested By: _____

Unit Weight

Wt. Loose, lbs	lbs/cf
Wt. Rodded, lbs	lbs/cf

AASHTO T-19 Tested By: _____

MOISTURE-DENSITY RELATIONSHIP TESTS

North Dakota Department of Transportation, Materials & Research
SFN 10063 (6-2018)

Project Number	PCN	Station	Depth Below Grade
Offset From Centerline		Type of Soil	
ND Test Designation	Date	Test Number	

Density

Determination No.		Test Count 1	2	3	4	5	6
A. Volume of Mold	cu. ft.						
B. Weight of Mold + Compacted Soil	lbs.						
C. Weight of Mold	lbs.						
D. Weight of Compacted Soil = B - C	lbs.	0.00	0.00	0.00	0.00	0.00	0.00
E. Wet density = D / A	lbs./cu. ft.						
F. Dry density = (E x 100) / (100 + L)	lbs./cu. ft.	0.0	0.0	0.0	0.0	0.0	0.0

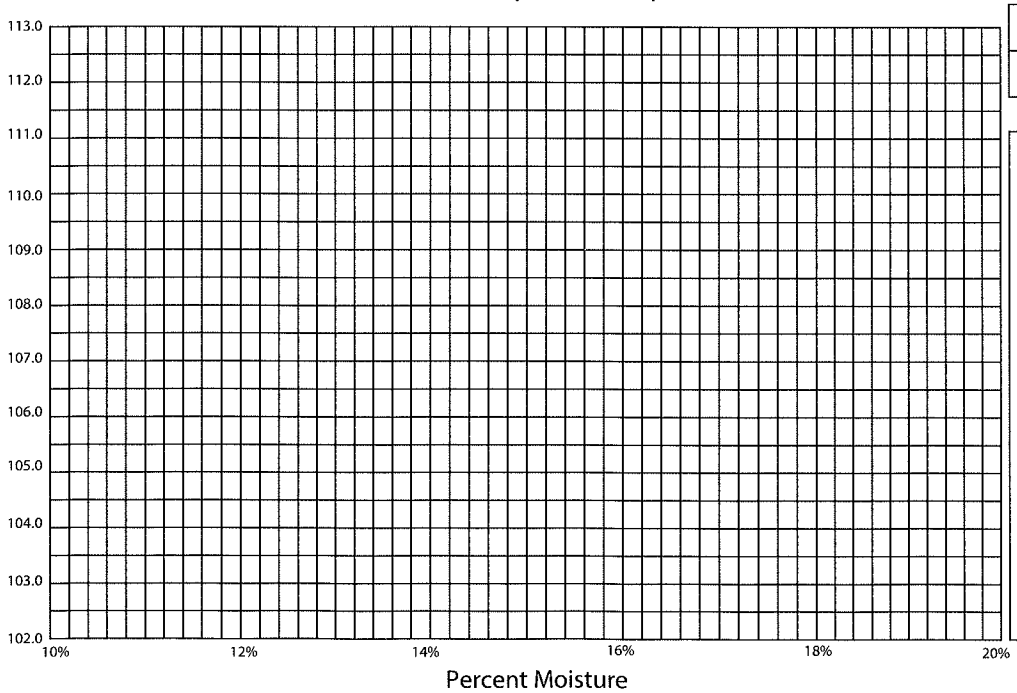
ND T99 or T180 Tested by

Moisture Content

Container No.							
G. Wet Weight + Container	gms.						
H. Dry Weight + Container	gms.						
I. Moisture Loss = G - H	gms.	0.0	0.0	0.0	0.0	0.0	0.0
J. Weight of Container	gms.						
K. Tare Dry Weight of Soil = H - J	gms.	0.0	0.0	0.0	0.0	0.0	0.0
L. % Moisture (I / K) x 100							

ND D4643, ND T217 or T-265 Tested by

Moisture Density Relationship



Max. Dry Density	lbs./cu. ft.
Optimum Moisture	%

Remarks:

SAND CONE CORRECTION FACTOR

North Dakota Department of Transportation, Materials and Research Division
SFN 59724 (2-2018)

Project Number	PCN	Date	Tested By

Trial	1	2	3
A Wt. of jar, cone, and sand (before) lbs.			
B Wt. of jar, cone and sand (after) lbs.			
Trial	C^1	C^2	C^3
C Wt. of sand in cone and ring (A-B)			

Cone Correction Factor (Cc) = $\frac{(C^1 + C^2 + C^3)}{3}$

Cc =

Note: all weights shall be recorded to the nearest .001 lbs. Three weights should not vary by more than 0.01 lbs.

SAND BULK DENSITY DETERMINATION

Trial	1	2	3
D Wt. of jar, cone, and sand (before) lbs.			
E Wt. of jar, cone and sand (after) lbs.			
F Wt. of sand in cone, ring, and density apparatus (D-E)			
G Wt. of sand in density apparatus (F-Cc)			
Trial	D^1	D^2	D^3
H Density apparatus volume			
Bulk Density = (G / H)			

Bulk Density Sand (Db) = $\frac{(D^1 + D^2 + D^3)}{3}$

Db =

DENSITY TEST WORKSHEET - SAND CONE METHOD

North Dakota Department of Transportation, Materials & Research
SFN 59725 (5-2016)

Project Number	PCN	Date	Tested By

TEST IDENTIFICATION		**Test Number**					
		Time					
		Lot					
		Station					
		Offset from centerline					
		Lane					
		Depth below finished grade ft.					
IN-PLACE DRY DENSITY DETERMINATION	a	Unit Weight of Sand (pcf) SFN 59724					
	b	Wt. material removed from test hole-lbs.					
	c	Initial sand weight - lbs.					
	d	Final sand weight - lbs.					
	e	Wt. sand in funnel and hole = c - d					
	f	Cone calibration factor- lbs. SFN 59724					
	g	Wt. sand in hole = e - f (lbs.)					
	h	Volume of test hole = g/a (cu. ft.)					
	I	Wet Density = b/h/(lbs./cu. ft.)					
	j	Dry Density = i/(100+p) x 100(lbs./cu.ft.)					
		Moisture Determination					
	k	Wet weight + container					
	l	Dry weight + container					
	m	Moisture loss = k - l					
	n	Tare weight of container					
	o	Dry weight of soil = l - n					
	p	Moisture Percentage = (m/o) x 100 (%)					
MOISTURE-DENSITY RELATIONSHIP TEST		ND Procedure					
		Test Number (Proctor Test)					
		Station					
		Offset from centerline					
		Depth below finished grade					
	q	Maximum Dry Density					
		Optimum Moisture					
REQUIRED MOIS-DENS.		Required % maximum Dry Density					
		% Maximum Dry Density = (j/q) x 100					
		Required Moisture					
		Moisture = p					

Remarks

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