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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005

SECTION TABLE OF CONTENTS

DIVISION 02 - SITE CONSTRUCTION

SECTION 02714

LIME TREATED SUBGRADE [LIME MODIFIED SOILS]

08/04

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 DELIVERY AND STORAGE
- 1.4 WEATHER LIMITATIONS
 - 1.4.1 Freeze Protection Method(s)
- 1.5 QUALITY ASSURANCE
 - 1.5.1 Required Data

PART 2 PRODUCTS

- 2.1 LIME TREATMENT REQUIREMENTS
 - 2.1.1 Hydrated Lime
 - 2.1.1.1 Type I
 - 2.1.1.2 Type II
 - 2.1.1.3 Type III
 - 2.1.1.4 Type IV
 - 2.1.2 Quicklime
 - 2.1.2.1 Type V
 - 2.1.2.2 Type VI
- 2.2 SOIL
- 2.3 WATER
- 2.4 BITUMINOUS CURING SEAL
 - 2.4.1 Emulsified Asphalt

PART 3 EXECUTION

- 3.1 SITE PREPARATION
 - 3.1.1 Grade Control
 - 3.1.2 Soil Testing
- 3.2 LIME TREATMENT AND SEQUENCE OF CONSTRUCTION OPERATIONS
 - 3.2.1 Application Requirements
 - 3.2.2 Scarification
 - 3.2.3 Dry Placing

- 3.2.4 Slurry Method
- 3.2.5 Preliminary Mixing and Watering
- 3.2.6 Preliminary Curing
- 3.2.7 Mixing, Uniformity Testing and Compaction
- 3.2.8 Two-Stage Pulverization and Mixing
- 3.2.9 Finishing
- 3.2.10 Limit of Daily Operations (Temporary Joints)
- 3.2.11 Final Curing
 - 3.2.11.1 Curing
- 3.3 TRAFFIC CONTROL, CURING MAINTENANCE AND DRAINAGE PROTECTION
- 3.4 EQUIPMENT LIMITATIONS
 - 3.4.1 General
 - 3.4.2 Spreading Equipment
 - 3.4.3 Additional Mixing Equipment Limitations
 - 3.4.4 Additional Compaction Equipment Limitations
- 3.5 SAFETY REQUIREMENTS
- 3.6 TESTS
 - 3.6.1 General
 - 3.6.2 Optimum Moisture, Maximum Density
 - 3.6.3 Uniformity Tests
 - 3.6.4 Compaction
 - 3.6.5 Thickness and Smoothness
 - 3.6.6 Field Application Rate Test
 - 3.6.7 Frequency of Tests

-- End of Section Table of Contents --

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SECTION 02714

LIME TREATED SUBGRADE [LIME MODIFIED SOILS]

08/04

NOTE: This guide specification covers the requirements for stabilization of subgrades by the application of lime.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

NOTE: Plant-mix operations and independent importation/placement of new lime base or sub-base courses are not included. Undefined simplifications of this guide specification may satisfy a secondary scope of "Lime Modified Soils." Optional sub-title "Lime Modified Soils" is intended for lime applications for less critical purposes than lime treated subgrade, such as drying excessively saturated construction sites during wet seasons. Considerable editing would be necessary when preparing project specification for this work.

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the

publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 216	(2002) Lime for Soil Stabilization
AASHTO T 102	(1983; R 2000) Spot Test of Asphaltic Materials
AASHTO T 219	(1987; R 1999) Testing Lime for Chemical Constituents and Particle Sizes
AASHTO T 27	(1999) Sieve Analysis of Fine and Coarse Aggregates

ASTM INTERNATIONAL (ASTM)

ASTM C 207	(2004) Hydrated Lime for Masonry Purposes
ASTM C 25	(1999) Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
ASTM C 977	(2003) Quicklime and Hydrated Lime for Soil Stabilization
ASTM D 1556	(2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2002e1) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.))
ASTM D 2397	(2002) Cationic Emulsified Asphalt
ASTM D 2922	(2004) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

ASTM D 3017	(2004) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 3551	(2002) Laboratory Preparation of Soil-Lime Mixtures Using a Mechanical Mixer
ASTM D 977	(2003) Emulsified Asphalt
NATIONAL LIME ASSOCIATION (NLA)	
NLA BUL 326	(2004) Lime-Treated Soil Construction Manual: Lime Stabilization and Lime Modification

1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-04 Samples

Cured lime-treated material

Lime

Submit a typical cured sample of on-site material with the required percent of lime content.

SD-05 Design Data

Job-mix formula

Mixing procedures

Analysis of equipment

SD-06 Test Reports

NOTE: Perform site preparation tests dependent upon
the criteria required, the condition of the existing
site and the purpose of the stabilization.

NOTE: Allow nuclear testing methods for site
preparation testing or final in place testing on
larger projects of over 3300 per square meter 4000
square yards.

Site preparation test

Final compaction report

[Field application rate test]

SD-07 Certificates

Bituminous curing seal

Lime

Contractor equipment list

Submit a list of construction equipment 7 days prior to bringing equipment on the job.

1.3 DELIVERY AND STORAGE

Deliver lime, bituminous materials in containers showing or including designated trade name, product identification, specification number, manufacturers name, and source. Store in a manner that will prevent moisture damage, overexposure, and contamination.

1.4 WEATHER LIMITATIONS

Do not construct subgrade when weather conditions detrimentally affect the quality of the materials. Do not apply lime unless the air temperature is

at least 5 degrees C 40 degrees F in the shade and rising. Do not apply lime to soils that are frozen or contain frost. If the air temperature falls below 2 degrees C 35 degrees F in the shade, protect completed lime-treated areas by approved methods against the detrimental effects of freezing. Remove and replace any damaged portion of the completed soil-lime treated area with new soil-lime material in accordance with this specification.

[1.4.1 Freeze Protection Method(s)

- a. Submit Contractor's plan(s) for freeze protection to Contracting Officer for approval.

]1.5 QUALITY ASSURANCE

1.5.1 Required Data

[Ten] [_____] days prior to the commencement of the work, a job-mix formula showing the amount of lime and water required per cubic meter cubic yard, and procedures for blending the lime/subgrade mixture for each type of existing soil. Include process type and number of: Lime applications, stages of mixing, slurry injection depths, mixing depths and depths of compaction lifts. Also, a list of equipment to be used and their relation to method of mixing proportioning, spreading, pulverizing and compacting subgrade, slurry injection, jet slurry mixing and other related work. The formula shall also contain amount of lime, either in sacks or kg per cubic meter pounds per cubic yard and the amount of water to be used, if slurry method is used. Use the following laboratory test method when applicable: ASTM D 3551.

PART 2 PRODUCTS

2.1 LIME TREATMENT REQUIREMENTS

NOTE: Allow the use of Type III lime for non-critical subgrade applications such as standard roads and parking areas. For primary roads and airfields consider the use of Type I or II first. Take into consideration availability of the lime chosen (including shipping/hauling charges). Type IV should be considered when Types I, II, III and quicklime are not available or not cost effective for project use.

NOTE: Add the A/E design criteria choice and percent of lime according to the chemical composition of the soil, (including the liability of excessive sand content) purpose of the lime stabilization and local site and climatic conditions. The percent of lime will also vary according to the type of lime chosen (hydrated or quicklime). The disadvantages of quicklime must be considered: (1) Dry quicklime produces a coarser material with poorer distribution in soil mass because field hydration is less effective than commercial hydrators. (2) Dry quicklime requires

more water than hydrate for stabilization which may be a problem for dry areas. (3) Dry quicklime or quicklime slurry requires careful handling due to greater susceptibility to skin and eye burns.

Perform lime treatment of subgrade. Scarify subgrade soil and mix uniformly with lime and water, spread, shape, compact and cure in accordance with these specifications and the following requirements:

- a. Lime requirement: The percent of [hydrated lime] [quicklime] by weight of dry soil material: [_____] percent.

2.1.1 Hydrated Lime

NOTE: For projects in Texas specify only AASHTO M 216, Type I, Grade A.

2.1.1.1 Type I

NOTE: Specifying a grade is optional, however, when no grade is specified the requirements of Grade A shall govern and when Grade B and C are used plan quantities for Grade A will be increased according to the "Basis of Purchase" paragraph within AASHTO M 216.

AASHTO M 216 [Grade A], [Grade B], [Grade C].

2.1.1.2 Type II

NOTE: Specifying a grade is optional, however, when no grade is specified the requirements of Grade A shall govern and when Grade B and C are used plan quantities for Grade A will be increased according to the "Basis of Purchase" paragraph within AASHTO M 216.

AASHTO M 216, [Grade A], [Grade B], [Grade C].

2.1.1.3 Type III

Magnesium or dolomitic lime containing magnesium, calculated as magnesium oxide no more than 41 percent by weight and in compliance with ASTM C 977.

[2.1.1.4 Type IV

By-Product, Waste, Salvaged or Specially Formulated Lime. ASTM C 207, Type N with the following modifications:

NOTE: For surface applications such as the drying of excessively wet ground surfaces at construction

sites, allow a minimum of 50 percent total calcium and magnesium oxide (nonvolatile basis).

- a. Total calcium and magnesium oxides (nonvolatile basis) equal 60 percent [_____] minimum.
- b. Available calcium hydroxide (rapid sugar test), ASTM C 25 plus total MgO content calculated to be an equivalent Ca (OH)₂ equal 30 percent minimum.
- c. Loss on ignition (carbon dioxide plus moisture, combined and free) as-received basis equal 35 percent maximum sampled at place of manufacture or 40 percent maximum, if sampled other than at place of manufacture.
- d. Free water (as received basis) equal 4 percent maximum.
- e. Residue: Sieve analysis of lime as follows:

<u>Sieve</u>	<u>Maximum Percent Retained</u>
4.75 mm	0
600 micrometers	5.0
150 micrometers	20.0

<u>Sieve</u>	<u>Maximum Percent Retained</u>
No. 4	0
No. 30	5.0
No. 100	20.0

- f. No requirements for plasticity, pops or pits, or water retention.

]2.1.2 Quicklime

2.1.2.1 Type V

High calcium quicklime containing at least 113 percent calcium hydroxide determined by AASHTO T 27 and AASHTO T 219 testing procedures.

<u>Sieve</u>	<u>Maximum Percent Retained</u>
9.5 mm	100
150 micrometers	15 max.

<u>Sieve</u>	<u>Maximum Percent Retained</u>
3/8 inch	100
No. 100	15 max.

2.1.2.2 Type VI

ASTM C 977.

2.2 SOIL

The inorganic natural material in the area to be stabilized[unless imported material, relocated material, or preliminary earthwork is

required: See Section 02300 EXCAVATION]. Remove stones retained on a 75 mm 3 inch sieve and deleterious substances such as sticks, debris, and vegetable matter.

2.3 WATER

Potable

2.4 BITUMINOUS CURING SEAL

2.4.1 Emulsified Asphalt

Conform to [ASTM D 977, Type SS-1] [or] [ASTM D 977 Type SS-1h]; [ASTM D 2397, Type CSS-1] [or] [ASTM D 2397 Type CSS-1h] [_____]. The base asphalt used to manufacture the emulsion shall show a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

PART 3 EXECUTION

3.1 SITE PREPARATION

Clean debris from area to be stabilized. Perform clearing and grubbing [to a depth of [_____] mm inches] [as specified in Section [02231 CLEARING AND GRUBBING] [02300 EXCAVATION]] [as required]. Remove rocks larger than 75 mm 3 inches. Inspect original ground for adequacy for the forthcoming compactive effort of lime treatment work. [Rough grade and shape the area to be stabilized to conform to the lines, grades, and cross sections indicated.] [Comply with subgrade requirements of Section 02300 EXCAVATION].

3.1.1 Grade Control

When stabilized course is to be constructed to meet a fixed grade, provide adequate line and grade stakes for control. Finished and completed stabilized areas shall conform to the lines, grades, cross section, and dimensions indicated. Locate grade stakes in lanes parallel to center line of areas under construction, and suitably placed for string lining. Maintain line and grade.

3.1.2 Soil Testing

NOTE: Perform site preparation tests dependent upon the criteria required, the condition of the existing site and the purpose of the stabilization.

Test original ground prior to scarification in accordance with ASTM D 1557.

3.2 LIME TREATMENT AND SEQUENCE OF CONSTRUCTION OPERATIONS

Comply with NLA BUL 326 and sequence of construction operations, unless specified otherwise hereinafter.

3.2.1 Application Requirements

NOTE: Specify double application of lime or two stage pulverization and mixing when the site

contains extremely plastic or heavy clays.

After site preparation, scarify subgrade and spread lime. Blend lime into subgrade to required depth as indicated. Apply lime and water only to those areas where mixing operations can be completed during the same working day. Accomplish application and mixing of lime by either the dry placing method or the slurry method. Use same method during any single days operation. [Double application of lime is required; percentage of lime for the initial application shall be between 2 and 3 percent. Apply curing seal as specified hereinafter and allow 6 to 7 days curing.]

3.2.2 Scarification

After obtaining required line and grade, scarify and partially pulverize the subgrade. Remove organic materials such as stumps and roots. Remove rocks larger than 75 mm 3 inches.

3.2.3 Dry Placing

Spread and distribute lime at a uniform rate with protection from wind as an important distribution and timing criteria. Prevent dry lime from blowing by adding water to lime or by other suitable means. Do not apply lime when wind conditions, in the opinion of the Contracting Officer, are objectionable.

3.2.4 Slurry Method

Apply or inject mixture of lime and water into the existing soil. Maintain the water content at 5 percent above optimum during application to lime/soil mixture. Prepare hydrate slurry either in a central mixing tank or tank trucks, with agitation provided for mixing or using a jet slurry maker. Prepare quicklime slurry using a portable batch slaking unit. Accurately weigh or meter lime and water. Standard water or asphalt trucks, properly cleaned, with or without pressure distributors, may be used to apply lime treatment. Spread or inject lime slurry evenly to yield uniform distribution of lime throughout soil. Distribute lime in successive passes over subgrade materials until proper amount of lime has been spread or injected to proper depth. Continually agitate slurry to keep mixture uniform. Keep pumps, distribution spray bars, slurry injection equipment and other equipment clean of excessive lime slurry. The Contractor's laboratory shall verify the specified amount and rate of application of lime for the various materials encountered.

3.2.5 Preliminary Mixing and Watering

Distribute lime uniformly by mixing and pulverizing subgrade. During mixing, add water to subgrade to provide a moisture content of 5 percent above optimum moisture content of material and to insure chemical action of lime and subgrade materials. Mixer shall continue making passes until it has produced a homogeneous, uniform mixture of lime, soil, and water. Continue mixing or remixing operations, until material is free of streaks or pockets of lime and mixture is uniform as indicated by testing. After initial mixing, shape and roll subgrade lightly to seal surface in order to reduce evaporation of moisture and lime carbonation.

3.2.6 Preliminary Curing

Moisture cure lime-soil mixture up to 48 hours until adhesive quality of

clay is reduced to almost normal soil consistency. Allow 7 days or more for curing heavy clays.

3.2.7 Mixing, Uniformity Testing and Compaction

After dry lime or lime slurry is uniformly applied to soil and mixture is pulverized and cured, continue mixing until individual agglomerates of soil do not exceed 25 mm one inch in maximum dimension (soil particles will pass a 25 mm one inch sieve with at least 60 percent passing the 4.75 mm No. 4 sieve). Continue mixing and re-mixing until material is uniformly mixed. Moisture shall be at approximately 2 percent over optimum for material other than rock. Compact lime-treated material immediately after final mixing and testing. Aerate or sprinkle as necessary to provide optimum moisture content during compaction. Compact lime-treated material in specified lifts to 95 percent of maximum density at optimum moisture content in accordance with ASTM D 1557, Method D. Base density value on a representative soil sample obtained from site and treated with required proportion of lime. As compaction progresses, maintain the shape of the lifts by blading. Surface upon completion shall be smooth and conform to indicated section and established lines and grades. Perform initial compaction with sheepsfoot roller or other suitable roller. Perform final rolling by means of sheepsfoot, steel-tired, or pneumatic rollers.

[3.2.8 Two-Stage Pulverization and Mixing

**NOTE: Specify double application of lime or two
stage pulverization and mixing when the site
contains extremely plastic or heavy clays.**

After curing, pulverize lime treated material until soil particles pass a 25 mm one inch sieve and 60 percent pass the 4.75 mm No. 4 sieve. If resultant mixture contains clods, reduce their size by scarifying, remixing, or pulverization to meet specified gradation.

]3.2.9 Finishing

Surface of finished lime-treated material after compaction shall be the established graded plane. At any point the surface shall not vary more than 15 mm 0.05 foot [] above or below established grade. Finish completed section by rolling with a pneumatic or suitable roller sufficiently light to prevent hairline cracking. Keep surface of each compacted layer of lime-treated material moist until covered by a subsequent layer of lime-treated material or curing seal.

3.2.10 Limit of Daily Operations (Temporary Joints)

At the end of each working day, prepare a temporary joint in fully compacted material normal to paved surface centerline. Construct a longitudinal temporary joint for partial width sections against which future material is to be placed. Remove temporary joints during next work period by trimming 75 mm 3 inches into treated material for continuity. Trimmed material may be incorporated in subsequent work. Temporary joints shall not coincide with any longitudinal or transverse temporary joint location of previous or subsequent construction. Remixing 100 mm 4 inches into the previous day's work may be substituted for joints providing the method and equipment is acceptable to the Contracting Officer.

3.2.11 Final Curing

3.2.11.1 Curing

Cure lime-treated material for 72 hours. During curing period, add [water] [bituminous curing seal] to surface to maintain moisture content of mixture at five percent above optimum water content. Lime that has been overexposed to open air shall be removed and disposed of off-station.

- a. Moist curing (water only): Keep surface damp by sprinkling and use light rollers to keep surface knitted together (preventing surface cracks) until following course of material is placed.
- b. Asphalt emulsion curing seal: Apply at least two applications uniformly to top (final) layer of lime-treated material at a rate of 0.68 to 0.9 liters per square meter 0.15 to 0.20 gallons per square yard of surface. Apply curing seal same day as soon as possible after completion of final rolling, before temperature falls below 5 degrees C 40 degrees F.

3.3 TRAFFIC CONTROL, CURING MAINTENANCE AND DRAINAGE PROTECTION

Keep traffic off surfaces freshly treated with bituminous material. Provide warning signs and barricades so that traffic will not travel over freshly treated surfaces. Do not permit equipment or traffic on lime-treated material until subgrade stability is assured. Maintain finished surface until work has been completed. Provide drainage during entire period of construction to prevent water from collecting or standing on area to be stabilized.

3.4 EQUIPMENT LIMITATIONS

3.4.1 General

The type of equipment to be used for each category of work shall conform to the NLA BUL 326 unless specified otherwise. Maintain equipment in satisfactory and safe operating condition.

3.4.2 Spreading Equipment

At windy locations use an approved screw type spreader box, mixer, or other semi-enclosed equipment which will offer protection from wind. Spreading hydrated lime by aggregate spreaders, dump trucks or agricultural spreaders is not allowed. Spreading by end-dumping, or tailgate control methods are not allowed. Change or alter equipment to be used in the event of non-uniform spreading of lime.

3.4.3 Additional Mixing Equipment Limitations

- a. Motor graders will not be allowed to mix lime with clays.
- b. Deep-lift rotary mixers may be used and may facilitate changes in specified depths of operation, providing equipment and method of operation sustains uniform distribution of lime with required compacted density throughout the deeper layer, with approval of Contracting Officer.

3.4.4 Additional Compaction Equipment Limitations

Unauthorized equipment, hauling or transportation vehicles will not be allowed for compaction purposes.

3.5 SAFETY REQUIREMENTS

In addition to the Contract Clause entitled "Accident Prevention", prevent employee eye or skin contact with quicklime during transport or application. Provide and require employees use the following:

- a. Protective clothing, high top boots, gauntlet-type gloves and protective headwear
- b. Splash-proof safety goggles and face shields
- c. Protective cream.

3.6 TESTS

3.6.1 General

Perform sampling and testing using a laboratory which has been inspected by the Cement and Concrete Reference Laboratory (of ASTM/CCRL) within the past 3 years or by a Government approved independent commercial testing laboratory. Frequency of sampling and testing of materials for conformance and quality control shall be as specified herein and shall be performed at such other times as necessary to document contract compliance. Test reports and results shall be certified by the laboratory and submitted together with Contractor's daily certification.

3.6.2 Optimum Moisture, Maximum Density

Perform optimum moisture, maximum density test on lime-treated material sampled after final mixing and prior to final compaction. Soil mixture shall be laboratory compacted within 3 hours of sampling and then moist-cured for 24 hours prior to optimum moisture-maximum density determination. Test in accordance with ASTM D 1557, Method D and the Job-Mix Formula.

3.6.3 Uniformity Tests

After placement and mixing of each lift perform a series of uniformity tests. Excavate a hole 250 mm 10 inches in diameter through full depth of lift and impregnate sides of hole with a standard phenolphthalein alcohol indicator. Non-conformity of color reaction, when material is treated as above, will be considered evidence of inadequate mixing.

3.6.4 Compaction

NOTE: Allow nuclear testing methods for site
preparation testing or final in-place testing on
larger projects of over 3300 square meters 4000
square yards. The required frequency of ASTM D 1556
check testing should vary according to the critical
nature and purpose of the project.

Perform in-place density test to determine degree of compaction between 24 and 72 hours after final compaction and 24 hour moist cure period. Test in accordance with ASTM D 1556. [Subject to approval of the Contracting Officer the following test methods may be included: ASTM D 2922, ASTM D 3017 and compatible meter methods providing one ASTM D 1556 check test is made after every [four] [_____] nuclear tests.]

3.6.5 Thickness and Smoothness

Thickness of final lime treated subgrade shall be not less than thickness shown. Final grade smoothness shall not deviate by more than 10 mm 3/8 inch, when tested with a 3 m 10 foot straightedge.

[3.6.6 Field Application Rate Test

Test for checking initial lime spreading rate.

]3.6.7 Frequency of Tests

The minimum number and type of quality control tests shall be as follows:

- a. Optimum moisture, maximum density. [Two] [_____] of each type or change of material with in-place density requirements.
 - b. Thickness, smoothness and uniformity. [Two] [_____] tests each day for every 850 square meters 1000 square yards [_____] or less mixed and placed.
 - c. Field density. One set of [3] [_____] tests for each lift for every 1650 square meters [2000] square yards [_____] or less.
 - [d. Field application rate test. One test for each lime spreading vehicle to be used on site.]
- End of Section --