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USACE / NAVFAC / AFCESA UFGS-02160 (August 2004)  
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Preparing Activity: USACE Superseding  
UFGS-02160A (October 2000)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005

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### SECTION 02160

#### SOLIDIFICATION/STABILIZATION (S/S) OF CONTAMINATED MATERIAL 08/04

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NOTE: This guide specification covers the requirements for solidification/stabilization (S/S) of contaminated materials.

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.

\*\*\*\*\*

## PART 1 GENERAL

### 1.1 REFERENCES

\*\*\*\*\*

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

\*\*\*\*\*

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.

ASTM INTERNATIONAL (ASTM)

ASTM D 1556	(2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1633	(2000) Compressive Strength of Molded Soil-Cement Cylinders
ASTM D 4832	(2002) Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D 5084	(2003) Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods
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U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 268	Land Disposal Restrictions
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1.2 UNIT PRICES

\*\*\*\*\*  
**NOTE: This paragraph should be deleted if the work is in one lump sum contract or there is a separate Measurement and Payment Section. Batch processing is likely to use weight as the method of measurement. In situ processes are more likely to use volume as the method of measurement.**  
\*\*\*\*\*

Payment shall be based on the Contract unit price schedule for each [in situ] [metric ton ton] [cubic meter cubic yard] of contaminated material entering the S/S process. This unit price shall include the cost for materials, equipment, waste feed processing, S/S operations, stockpiles, testing, and all other work associated with the S/S process.

1.2.1 Reprocessing

No payment will be made for materials or labor required to reprocess any processed material not meeting the physical and chemical testing requirements outlined in this section. Reprocessed material shall be deducted from the daily production rate.

1.3 SYSTEM DESCRIPTION

\*\*\*\*\*  
**NOTE: The Contractor is sometimes required to provide treatability study test results prior to performing work at the site. Treatability study test results should include the proposed reagents and mix ratios to be used during full scale treatment. The test results submitted should verify**

that the mix design proposed meets the post-treatment criteria listed in Table 1. Consideration should also be given to the need to monitor off-gas and dust emissions during the treatability study. Detailed information on testing requirements, test methods, detection limits, and off-gas and dust emission testing requirements should be presented in the appropriate section and referenced here.

At projects where strict testing protocols are required to adequately determine the effectiveness of the process being tested, the Contractor should be required to provide a "Treatability Study Work Plan" for approval prior to performing the treatability study.

Prior to performing any treatability study, the untreated samples should be tested to verify that they contain the contaminants of concern at high enough concentrations and these contaminants leach at levels which are representative of the materials found on-site. Additional testing may be needed to verify that physical properties of the samples are also representative of site conditions.

The last two sentences of this paragraph should be omitted if a specific method of treatment (in situ or ex-situ) is desired.

\*\*\*\*\*

An [in situ] [pug mill] [ex-situ] [\_\_\_\_\_] S/S system shall be used which provides a safe, reliable method to treat contaminated material so that the treated material conforms to paragraph PERFORMANCE REQUIREMENTS. A system or procedure, other than described in this section, may be used if the approved SUBMITTALS demonstrate equivalent capabilities. Such approval does not relieve the Contractor of responsibility for meeting specified requirements for safety, reliability, and performance.

#### 1.4 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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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-03 Product Data

Work Plan  
Qualifications  
Equipment  
Quality Control Tests

An S/S Work Plan within [60] [\_\_\_\_\_] days after notice to proceed. No S/S of contaminated material shall be performed until the work plan is approved. A period of [30] [\_\_\_\_\_] days shall be allowed in the schedule for Government review and approval of the work plan. The work plan shall address the technical requirements listed in this section and shall include, but is not limited to the following:

a. Contractor Experience: Information to demonstrate that the S/S Contractor meets the qualification requirements outlined in Paragraph QUALIFICATIONS.

b. Mix Design: The proposed mix design and method of mixing to be used in treating the contaminated material. The proposed source of water to be used for the S/S process shall also be identified.

c. Equipment: Specifications for the proposed homogenization and mixing equipment, batching equipment, and process control instrumentation. Process flow diagrams, mixing times, and processing rates shall be included. Anticipated pretreatment of the contaminated material shall be identified.

d. Drawings: Drawings indicating dimensions and layout of the S/S system on the site. Drawings shall be to scale.

e. Emissions: Air emissions, dust, and noise from the system shall be identified and estimated. Control systems

required to maintain compliance with local, state, and federal regulations shall be described as appropriate. Air emissions, dust, and noise testing protocol to be performed during the test run and full scale operations shall also be described.

f. Quality Control: A quality control plan which addresses control and documentation of batch proportions, mixing time, mixing speed, sample collection, sample curing, and post-treatment testing.

g. Demobilization: A post-treatment cleanup and sampling plan for the treatment area.

h. Stockpile Design: A proposed stockpile design which meets the criteria outlined in this section.

#### Key Personnel

Resumes of key personnel at least [5] [\_\_\_\_\_] working days prior to the personnel assuming duties on site.

#### Batch Proportions

Daily batch proportion and mixing quality control data.

#### SD-06 Test Reports

##### Post Treatment Testing

Results of post-treatment tests performed.

##### Field Demonstration

The field demonstration report shall include pre-treatment and post-treatment test results, and shall document other relevant field demonstration data including but not limited to: batch proportions, mixing time, and mixing speed. Off-gas, dust, and noise test results shall also be included.

#### SD-07 Certificates

##### Reagents

Reagent composition, certificates of analysis, and MSDS documentation. A confidentiality agreement may be requested if proprietary reagents are being used.

### 1.5 PERFORMANCE REQUIREMENTS

\*\*\*\*\*  
NOTE: The post-treatment testing criteria listed in Table 1 are only examples. Chemical and physical test criteria should be determined on a site specific basis. Post-treatment criteria may be based on federal regulatory criteria, site specific risk analyses, or site specific criteria based on state and local regulations.  
\*\*\*\*\*

The [Toxicity Characteristic Leaching Procedure as specified in EPA SW-846.3-3] [\_\_\_\_\_] shall be performed on representative samples of treated material. The extract shall meet the chemical post-treatment testing criteria listed in Table 1. Chemical testing required in this section shall be conducted in accordance with Section [01450A CHEMICAL DATA QUALITY CONTROL] [\_\_\_\_\_]. The treated material shall also meet the physical testing criteria listed in Table 1. The tests listed in Table 1 shall be performed on samples that have been cured for [3] [\_\_\_\_\_] days.

Table 1. POST-TREATMENT TEST CRITERIA

TEST	TEST VALUE
Arsenic	[_____] mg/L
Cadmium	[_____] mg/L
Chromium (Total)	[_____] mg/L
Lead	[_____] mg/L
Min. Unconfined Compressive Strength ASTM D 1633	[_____] kPa
Max. Permeability ASTM D 5084	[_____] cm/s
Maximum Volume Increase	[_____] percent.

#### 1.5.1 Disposal of Treated Material

\*\*\*\*\*  
**NOTE: Reference the appropriate section which describes requirements for disposal of treated material, including manifests for off-site disposal. Identify onsite disposal locations on the drawings.**  
 \*\*\*\*\*

The treated material, upon meeting the physical and chemical testing criteria, shall be disposed of as required by Section [02120 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS] [\_\_\_\_\_].

#### 1.5.2 Emission Controls

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**NOTE: Site specific requirements should be added to this paragraph.**  
 \*\*\*\*\*

The S/S system shall include control apparatus necessary to meet local, state, and/or federal regulations for air emissions and dust.

#### 1.5.3 Noise Control

\*\*\*\*\*  
**NOTE: Different day and night noise restrictions may be appropriate.**  
 \*\*\*\*\*

The S/S system shall [meet state and local noise pollution control regulations] [not exceed [\_\_\_\_\_] decibels at any site boundary].

## 1.6 QUALIFICATIONS

### 1.6.1 Contractor Experience

The Contractor shall have successfully completed at least [5] [\_\_\_\_\_] S/S projects of comparable size and scope in accordance with local, state, and federal requirements using the proposed system or a similar system.

### 1.6.2 Key Personnel

Key personnel shall have a minimum of [3] [\_\_\_\_\_] years of S/S field experience. Key personnel shall include system operators, quality control personnel, and supervisory engineering and technical staff involved with the S/S system operation.

## 1.7 PROJECT/SITE CONDITIONS

\*\*\*\*\*  
**NOTE: Pertinent site characterization data should be placed in the appendix of the specifications or on the drawings and referenced here. Indicate the detail to which site characterization has been performed and indicate where obvious data gaps exist.**  
\*\*\*\*\*

The physical conditions indicated on the drawings and in the specifications are the result of site investigations. While the site investigation data is representative of subsurface conditions at a specific location, variations in the contaminated materials are expected to exist.

## 1.8 EQUIPMENT

### 1.8.1 Mixing Equipment

The mixing equipment shall have a minimum capacity adequate to meet performance and schedule requirements and shall be equipped with positive means for controlling the mix proportions, maintaining the time of mixing constant, and maintaining the appropriate speed of rotation of the mixer.

### 1.8.2 Reagent Feed Units

Satisfactory means, incorporating weighing, metering or volumetric measurement shall be provided to separately batch the required amount of each reagent. Silos and feeders shall be equipped and operated so that no caking of material or variation in feed occurs. Provision shall be made so that each reagent can be easily sampled.

### 1.8.3 Accuracy of Measurement Equipment

Scales, meters, and volumetric measuring devices used for measuring contaminated material, reagents, and water for S/S processing shall be accurate to plus or minus [0.1] [\_\_\_\_\_] percent of the quantity being measured. A check of calibration of measuring equipment shall be performed once every [5] [\_\_\_\_\_] working days.

## 1.9 MIX DESIGN

\*\*\*\*\*  
NOTE: In most instances, the Government will have conducted treatability studies prior to advertisement for bids. Results of these treatability studies are generally provided to bidders and included in the contract documents.  
\*\*\*\*\*

The Contractor shall select a mix design which meets the performance criteria listed in Table 1 for use during full scale treatment. [A preliminary treatability study has been performed on the contaminated materials. Results of this study are provided in Appendix [\_\_\_\_\_] for information only.] [No Government treatability studies were performed.]

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Water

\*\*\*\*\*  
NOTE: It may be appropriate to require chemical testing of the proposed water source when the water is of questionable quality.  
\*\*\*\*\*

Water shall not contain concentrations of oil, acid, salt, alkali, organic matter, or other deleterious substances which will be detrimental to the successful execution of the S/S treatment process. Potable water shall be used where available. The Government may require the Contractor to perform chemical analyses on representative water samples if the water appears to be of questionable quality.

#### 2.1.2 Reagents

The chemical composition of reagents used shall be provided to the Government. A certificate of analysis supplied by the vendor shall accompany each shipping unit of reagent. Reagents shall be shipped in properly labeled containers with instructions for handling and storage. The instructions shall be strictly adhered to.

## PART 3 EXECUTION

### 3.1 STOCKPILES

\*\*\*\*\*  
NOTE: Delete this paragraph if stockpiles are not required. More elaborate stockpile requirements may be needed based on site-specific regulatory criteria.  
  
In addition to leachate collected from stockpiles, water from other sources (decontamination water, surface runoff, etc.) is also sometimes used in the S/S process.  
\*\*\*\*\*

Stockpiles shall be constructed for storing contaminated material [prior

to] [and] [following] treatment. Stockpiles shall be constructed to include:

a. A geomembrane liner with a minimum thickness of 1.0 mm (40 mils) 40 mils. The liner shall be protected from vehicles by a [540] [\_\_\_\_\_] g/square m [16] [\_\_\_\_\_] ounce/square yard geotextile and a traffic surface layer consisting of gravel, concrete, or other material which will not damage the geomembrane. The ground surface on which the geomembrane is placed shall be smooth and free of rocks greater than 12.5 mm 0.5 inches in diameter or any other object that could damage the geomembrane.

b. The liner shall be sloped to a low point to allow leachate to be collected. Leachate collected from the stockpile shall be analyzed and, if necessary, treated to meet applicable local, state, and federal regulations. Leachate collected from the stockpile may be used in the S/S process provided the treated material to which the leachate was added meets the physical and chemical post-treatment test criteria.

c. A geomembrane cover with a minimum thickness of 0.25 mm (10 mils) 10 mils to prevent precipitation from entering the stockpile.

d. Berms surrounding the stockpile that are a minimum of 300 mm 12 inches in height.

### 3.2 OPERATION

#### 3.2.1 Weather Conditions

\*\*\*\*\*  
**NOTE: Site specific conditions should be considered when determining allowable temperatures at which S/S and curing may take place. Treatability studies can be used to address this issue.**  
\*\*\*\*\*

S/S shall not take place in an ambient temperature below [4] [\_\_\_\_\_] degrees C [40] [\_\_\_\_\_] degrees F without approval. Provisions shall be made to maintain the temperature of the treated material above freezing while curing. Contaminated material shall not be treated if it contains any frozen material. The temperature of the S/S material immediately after treatment shall not exceed [32] [\_\_\_\_\_] degrees C [90] [\_\_\_\_\_] degrees F without approval. S/S shall not be performed during periods of heavy rainfall if this will result in the addition of excess water to the mixture.

#### 3.2.2 Dissimilar Materials

Dissimilar materials that testing has indicated need different mix ratios, shall not be mixed together.

#### 3.2.3 Oversize Material

\*\*\*\*\*  
**NOTE: Indicate the method and location of disposal of treated oversize material.**  
\*\*\*\*\*

Contaminated material that exceeds the maximum allowable particle size of the S/S mixing unit and that is amenable to treatment shall be reduced to a size that the mixing unit can accept. Oversize material that cannot be

reduced to an allowable size for the S/S unit shall be treated in accordance with [40 CFR 268] [\_\_\_\_]. After treatment, the material shall be disposed of [\_\_\_\_]. Hazardous residual produced in treating the oversize material shall be disposed of in accordance with applicable local, state and federal regulations.

### 3.3 FIELD DEMONSTRATION

Prior to full-scale operations, a field demonstration shall be performed. At least [500] [\_\_\_\_] cubic meters cubic yards of contaminated material shall be processed and the tests listed in Table 2 shall be performed on [5] [\_\_\_\_] representative samples of the treated material. A field demonstration shall be performed on each distinctive type of material or contaminant to be treated.

#### 3.3.1 Full-Scale Processing Equipment

The full-scale processing equipment shall be used for the field demonstration. Reagents, mix ratios, and mixing procedures used during the field demonstration shall be the same as those used for the remainder of the work.

#### 3.3.2 Sampling Locations

\*\*\*\*\*  
NOTE: Sampling protocols for the field demonstration should be the same as the sampling protocols used for full scale treatment. Specify the method, location and depth at which samples for the field demonstration will be obtained. Chemical testing should generally be performed to verify that the materials to be used for the test run, contain the contaminants of concern at high enough concentrations to adequately test the system. Additional testing may be warranted to verify that the physical properties of the materials are also representative of site conditions.  
\*\*\*\*\*

Contaminated material used for the field demonstration shall be obtained from [\_\_\_\_]. Prior to performing the field demonstration, contaminated material to be used for the field demonstration shall be tested to verify it contains the following minimum levels of contamination: [\_\_\_\_].

#### 3.3.3 Testing

\*\*\*\*\*  
NOTE: Consideration should be given to the need for monitoring off-gas, dust, and noise generation during the field demonstration to ensure compliance with local, state, and federal regulations.  
\*\*\*\*\*

Testing shall be performed to verify that the treated material from the field demonstration meets the specified physical and chemical criteria. If the treated material produced during the field demonstration does not pass the testing requirements, an equal quantity of the same type of material which failed shall be treated using a new mix design or procedure.

### 3.3.4 Volume Increase

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NOTE: The excessive addition of reagents during treatment can result in a greater than anticipated volume increase. Limiting volume increase is important if the treated material is to be placed in an onsite landfill with limited storage space. For this reason, monitoring of volume increase is often done during the treatability study, field demonstration, and/or full-scale treatment.

The excessive addition of reagents can also result in higher treatment and off-site disposal costs.

\*\*\*\*\*

The estimated increase in volume resulting from treatment shall be determined and reported with the field demonstration test results. Volume increase shall be determined by comparing the volume of in situ contaminated material to be treated to the volume of treated material using the following formula:

$B = 100 \times [(1+R) \times (D \text{ in situ}/D \text{ treated}) - 1]$ , where

B= Volume increase in percent.

R= Dry weight ratio of solidifying agent to waste.

D in situ = Dry unit weight of in situ waste.

D treated = Dry unit weight of compacted treated material.

### 3.3.5 Field Demonstration Test Results

\*\*\*\*\*

NOTE: While two options of the field demonstration test results paragraph are provided, it is preferable to force the Contractor to stop processing contaminated material until results from the field demonstration indicate that the Contractor's proposed mix design can successfully treat the contaminated material.

\*\*\*\*\*

After completion of the field demonstration, [no additional contaminated material shall be processed until test results from the field demonstration verify that the treated material meets the physical and chemical criteria listed in Table 1] [contaminated material may continue to be processed. However, if test results from the field demonstration do not pass the criteria listed in Table 1, the contaminated material treated with the failing mix design shall be reprocessed with a working mix design at no additional cost to the Government].

### 3.4 QUALITY CONTROL PROCEDURES

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NOTE: Leaching and hydraulic conductivity tests are not amenable to real time quality control because of the time required to perform the tests; therefore, it is preferable to minimize the number of leaching and hydraulic conductivity tests performed and to maintain quality control of the S/S process by

verifying that the mix design works during the field demonstration and maintaining quality control by monitoring batch proportions and mixing time. Real time indicator tests such as pH, specific conductance, mix temperature, and water content can also be used as quality control tools.

\*\*\*\*\*

#### 3.4.1 Batch Proportions

Mixing time, mixing speed, and amounts of contaminated material, reagents, and water added to each batch shall be recorded. Mixing time, mixing speed, and batch proportions shall be maintained within the limits specified in the approved Work Plan and as modified during the field demonstration.

#### 3.4.2 Segregation

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NOTE: To prevent double handling, it is preferable to place treated material directly into the permanent storage area rather than stockpiling it until post-treatment testing is completed.

\*\*\*\*\*

Treated material shall be [separated into units (stockpiles) for post-treatment testing. Table 2 lists the frequency at which post-treatment testing shall be performed. Unit size shall be equal to or less than the quantity pertaining to the most frequent quality control test] [placed directly into the permanent storage site after treatment. Treated material shall be placed such that the material from specific batches/runs can be defined and removed if it fails post-treatment testing].

#### 3.4.3 Quality Control Tests

\*\*\*\*\*

NOTE: Samples for post-treatment testing should generally be collected immediately after treatment. This eliminates the need to remove samples from the treated mass after it has cured.

If the treated material exhibits soil-like properties, moisture content and density criteria may also need to be specified for the post-treatment test samples.

The values shown in Table 2 for frequency of testing are only examples and need to be determined on a site specific basis. If required, site specific testing requirements for off-gas emissions, dust, and noise should also be included in the table.

\*\*\*\*\*

The tests listed in Table 2 shall be performed on representative samples of treated material. Samples for quality control and quality assurance testing shall be collected immediately after treatment and allowed to cure as specified in ASTM D 4832 or by another approved method. Samples shall meet the post-treatment testing criteria listed in Table 1.

Table 2. POST-TREATMENT QUALITY CONTROL TESTING FREQUENCY

Standard Test Procedure	Frequency/Cubic [Meters] [yards]
TCLP EPA SW-846.3-3	1 per [500] [_____]
Unconfined Compressive Strength ASTM D 1633	1 per [500] [_____]
Permeability ASTM D 5084	1 per [500] [_____]
Volume Increase ASTM D 1556	1 per [500] [_____]

#### 3.4.4 Retesting and Reprocessing

Retesting and reprocessing shall be performed, at no additional cost to the Government, for treated material that does not meet the physical and chemical requirements listed in Table 1.

##### 3.4.4.1 Retesting

Any unit that fails post-treatment quality control or quality assurance testing shall be retested or reprocessed. If the Contractor elects to retest the unit, two additional samples shall be collected and tested for the failed parameter. If both tests pass, reprocessing of the unit will not be required. If either sample fails, the unit shall be reprocessed.

##### 3.4.4.2 Reprocessing

If the Contractor reprocesses a unit of material, the unit shall be sampled and tested as described in paragraph Quality Control Tests after reprocessing.

##### 3.4.5 Adjustments to Mix Design

Subject to approval, the mix design may be changed based on the characteristics of the material being treated. An additional field demonstration may be required by the Contracting Officer prior to implementation of the new mix design.

##### 3.4.6 Quality Assurance Testing

Duplicate samples shall be submitted to the Government's quality assurance laboratory at a frequency of one set of samples per [10] [\_\_\_\_\_] sets of quality control tests performed. Quality assurance samples will be tested for the parameters listed in Table 2. The Contracting Officer may require additional quality assurance tests as a result of failed quality assurance or quality control tests. The Contracting Officer may also require additional quality assurance tests due to changes in the mix design or physical appearance of the contaminated material.

-- End of Section --