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USACE / NAVFAC / AFCESA / NASA UFGS-33 56 13.14 (April 2006)  
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Preparing Activity: NAVFAC Replacing without change  
UFGS-13217 (August 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2009

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SECTION 33 56 13.14

FIBERGLASS-PLASTIC LINING FOR STEEL TANK BOTTOMS (FOR PETROLEUM)  
04/06

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NOTE: This guide specification covers the requirements for a fiberglass reinforced plastic lining system intended for use in lining the bottoms of severely corroded steel tanks used for storage of all types of petroleum fuels.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

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).

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NOTE: This lining is for use where substantial amounts of steel have been lost by corrosion; that is, where up to one-half the original thickness is lost or an average of four or more pits 3 mm 1/8 inch deep or greater occur within a circle of 900 mm 3 feet radius or in so many locations that repair by welding steel plates over bad areas becomes uneconomical. The lining system should be used only on bottoms which are resting on a firm foundation to prevent internal cracking of the lining and subsequent leakage. The lining is not intended for use over concrete false bottoms in steel tanks. Questions concerning the repair of concrete false bottoms should be referred to NAVFACENGCOMHQ, Code 04B3. Do not use fiberglass lining to repair

leaking tanks. Do not use fiberglass lining over "oil canning" tank bottoms. On a previous project, lining a leaking tank with fiberglass could not correct the leakage. Defects in the lining which allowed the leakage were impossible to locate and repair. Oil canning tank bottoms will allow sufficient deflection in the lining to result in cracks even if most of the tank bottom appears to be firmly supported.

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**NOTE:** The following information shall be shown on the project drawings:

1. Tank in plan and elevation including major appurtenances.
2. Surrounding areas which affect the works.
3. Surface to be lined and other repair work.

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PART 1 GENERAL

1.1 REFERENCES

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**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.

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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 INDUSTRIAL HYGIENE ASSOCIATION (AIHA)

AIHA Z9.4

(1997) Abrasive Blasting Operations:  
Ventilation and Safe Practices for Fixed  
Location Enclosures

ASTM INTERNATIONAL (ASTM)

- ASTM C 33/C 33M (2008) Standard Specification for Concrete Aggregates
- ASTM C 881/C 881M (2002) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

- SSPC SP 5 (2007) White Metal Blast Cleaning
- SSPC SP 7 (2007) Brush-Off Blast Cleaning
- SSPC SSPM (2000) SSPC Painting Manual, Volume 2, Systems and Specifications

U.S. DEPARTMENT OF DEFENSE (DOD)

- MIL-A-22262 (Rev B; Am 2) Abrasive Blasting Media Ship Hull Blast Cleaning
- MIL-P-24441 (Rev C; Supp 1; INT Am 1) Paint, Epoxy-Polyamide
- MIL-PRF-4556 (Rev F; Am 1) Coating Kit, Epoxy, for Interior of Steel Fuel Tanks
- MIL-PRF-680 (Rev B) Degreasing Solvent

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

- FS O-D-1276 (Rev B) Disinfectant-Detergent, General Purpose (Pine Oil)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

- 29 CFR 1910.1200 Hazard Communication
- 40 CFR 260 Hazardous Waste Management System: General
- 40 CFR 261 Identification and Listing of Hazardous Waste
- 40 CFR 262 Standards Applicable to Generators of Hazardous Waste
- 40 CFR 263 Standards Applicable to Transporters of Hazardous Waste
- 40 CFR 264 Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
- 40 CFR 265 Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

1.2 SUBMITTALS

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**NOTE:** Review submittal description (SD) definitions in Section 01 33 00 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.

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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 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Primer

Polyester resin system

Fiberglass mat

Fiberglass cloth

Epoxy resin binder

Blast cleaning abrasive

Submit data for the materials to be used. The data shall include brand names, catalog numbers, names and addresses of

manufacturers.

#### SD-06 Test Reports

##### Blast cleaning abrasive

Submit report on type, size, and hardness of abrasive selected for blast cleaning together with laboratory test data to verify that the abrasive to be used conforms to the size and hardness requirements.

#### SD-07 Certificates

Primer

Fiberglass mat

Fiberglass cloth

Epoxy resin binder

Sand

Detergent

Solvent

Qualifications of contractor's representatives

Qualifications of manufacturer's representatives

Equipment list

#### SD-08 Manufacturer's Instructions

Primer

Polyester resin system

Fiberglass mat

Fiberglass cloth

Epoxy resin binder

Blast cleaning abrasive

Submit detailed mixing and application procedures. Submit material safety data sheets for materials to be used at the job site in accordance with 29 CFR 1910.1200.

#### SD-11 Closeout Submittals

Abrasive treatment or disposal manifest

1.3 DELIVERY AND STORAGE

1.3.1 Delivery

Deliver materials to the job site in the original packages or containers with each bearing the brand name, applicable standard designation, catalog number, and name of manufacturer.

1.3.2 Storage

Keep materials dry and protected from extreme temperatures by storage under cover and away from direct exposure to rain, heat, or other extreme weather conditions.

1.4 QUALITY ASSURANCE

1.4.1 Contractor's Representatives

Submit names and qualifications of each Contractor's representative who will be in charge of the work and who will be present at the job site when the work is being accomplished.

1.4.2 Manufacturer's Representatives

Submit the name and qualifications of the resin manufacturer's representative who shall be present during the initial phase of the lining application to insure that the manufacturer's mixing and application procedures are understood and are being followed. The manufacturer shall certify in writing that the representative is a regular employee and is qualified and experienced in the type of lamination work to be performed.

1.5 EQUIPMENT

1.5.1 Equipment List

Submit a complete list of equipment, with adequate description by item, that will be used at the job site.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Primer

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**NOTE: Composition L is intended for use in geographic areas with regulations controlling the emission of solvents into the atmosphere. However, Composition L may not meet some local environmental requirements for volatile organic compound (VOC) emissions. The specific primer selected for use should be in compliance with any applicable VOC limits contained in air quality standards established for the region where the primer will be used.**  
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Green epoxy-polyamide, MIL-P-24441, epoxy-polyimide green primer or epoxy primer, MIL-PRF-4556, Composition [G] [L].

## 2.1.2 Polyester Resin System

### 2.1.2.1 Polyester Resin

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**NOTE: The listed resins are those which have produced suitable liner systems. The use of proprietary materials specified in this paragraph has been approved by NAVFACENGCOM HQ (Code 021) in accordance with the requirements of NAVFAC P-68. The paragraph may be used without further NAVFACENGCOM HQ approval or request for waiver.**  
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One of the following chemical resistant polyester (including vinyl ester) resins, or equal: Derakane 411-45 (Dow Chemical Company), Atlac 4010A (Koppers Company, Inc.), Dion Cor-Res 7000A (Koppers Company, Inc.).

### 2.1.2.2 Catalyst and Promoter

Use the catalyst and promoter solutions and proportions of each recommended by the resin manufacturer.

### 2.1.2.3 Additives

Thixotropic materials, paraffin wax for the air-exposed surface coat only, and other additives recommended by the resin manufacturer, in the amounts specified by the resin manufacturer.

### 2.1.3 Fiberglass Mat

Type E glass, Silane sized chopped strand reinforcing mat with a high solubility binder, 0.46 kg per square meter 1 1/2 ounces per square foot.

### 2.1.4 Fiberglass Cloth

Type E glass, plain weave cloth with a Silane finish, 0.34 kg per square meter 10 ounces per square yard, 16 x 14 thread count, 150-4/2 warp and filling yarn.

### 2.1.5 Epoxy Resin Binder

ASTM C 881/C 881M, Type III (for surfaces subject to thermal or mechanical movements), Grade 2 (Medium viscosity) or Grade 3 (Non-sagging consistency), [Class B, for use between 5 to 15.6 degrees C 40 and 60 degrees F] [or,] [Class C, for use above 15.6 degrees C 60 degrees F], with filler.

### 2.1.6 Sand for Mortar or Putty

ASTM C 33/C 33M, uniformly graded from coarse to fine with no more than 5 percent passing the 150 micrometers No. 100 sieve.

### 2.1.7 Blast Cleaning Abrasive

MIL-A-22262. Select abrasive material, particle size, and hardness in accordance with SSPC SSPM Volume 2, Surface Preparation Commentary to produce the required surface condition. Do not use sand or organic

abrasives such as walnut shells.

#### 2.1.8 Detergent

FS O-D-1276.

#### 2.1.9 Solvent

MIL-PRF-680, Type II, minimum flashpoint of 60 degrees C 140 degrees F.

### 2.2 MIXES

#### 2.2.1 Polyester Putty

Catalyzed polyester resin, thixotropic material, and sand. Use proportions recommended by the manufacturer of the polyester resin to form a putty consistency.

#### 2.2.2 Epoxy Resin Mortar

Epoxy resin binder adhesive system and sand. Mix small trial batches to determine proper mortar consistency.

## PART 3 EXECUTION

### 3.1 SAFETY, FUEL REMOVAL, AND TANK CLEANING

Safety procedures, fuel removal, and tank cleaning shall be in accordance with Section 33 65 00 CLEANING PETROLEUM STORAGE TANKS. Insure that personnel are advised of the information contained in the Material Safety Data Sheets (MSDS) for the products to be used for protection against toxic and hazardous chemical effects. Blank-off or disconnect incoming fuel lines. Follow the applicable precautions in AIHA Z9.4 during abrasive blasting.

### 3.2 INSPECTION

Prior to starting any work, verify that the tank and connecting lines have been emptied of fuel and that the tank has been adequately cleaned.

### 3.3 VENTILATION

Throughout the course of the work, provide ventilation as required for producing a vapor-free condition, for adequate removal of solvent vapors and toxic hazards, and for curing the coatings. Use exhaust-type fans, either explosion-proof electrically operated or air-driven, and of sufficient capacity to hold the vapor concentration below 4 percent of the lower explosive limit. Attach noncollapsible, noncombustible flexible ducts to the fans. The ducts shall be of sufficient length to reach the bottom of the tank and extend to the work areas. Keep fans in operation whenever workmen are in the tank and whenever necessary for proper cure of the lining system materials.

### 3.4 WEATHER CONDITIONS

Perform abrasive blasting, surface repair, and lining application only when the ambient temperature is between 10 and 32 degrees C 50 and 90 degrees F and the steel surface temperature is more than 3 degrees C 5 degrees F above the dew point temperature of the surrounding air. Surface repair and

lining work shall not be done on damp or wet surfaces or while there is any precipitation.

### 3.5 TEST PANELS

After the tank is cleaned, inspect the tank walls and select steel plate with similar characteristics and surface profile for use as test panels. Abrasive blast one or more 0.093 square meter one foot square test panels to white metal in accordance with SSPC SP 5 using the same abrasive that will be used on the tank. Record the blast nozzle type and size, air pressure, distance of nozzle from plate, and angle of blast to establish procedures for blasting to develop a 0.075 to 0.10 mm 3 to 4 mil anchor pattern. Use a Keane-Tator surface profile comparator, appropriate to the abrasive being used, to determine the profile of the test panels before and after the white blast test. Keep the test panels wrapped and sealed in vapor tight material for use as a standard of comparison for the steel surfaces throughout the course of the work.

### 3.6 INITIAL ABRASIVE BLAST

Perform brush-off blast cleaning in accordance with SSPC SP 7 of the steel surfaces to be lined including 600 mm 2 feet up on the tank wall and columns. Use conventional air, force-feed, or pressure type blasting equipment. Water or vapor blast is not permitted. Provide filtered air supply, free of oil and moisture. After abrasive blasting, remove loose sand and dust from the surfaces by brushing, blowing with dry compressed air, or vacuuming, and then remove loose material from the tank interior.

### 3.7 SURFACE REPAIR

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**NOTE: Estimate areas to be repaired. These areas may be difficult to define prior to thorough cleaning and sandblasting.**  
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Following cleaning and initial abrasive blasting, inspect the surfaces to be lined for defects requiring repair. Total area of repairs is estimated to be [\_\_\_\_] square meters square feet. Repair perforations, cracks, or splits by welding. Plate edges or welds shall be ground smooth with a minimum radius of 3 mm 1/8 inch. Remove weld spatter. Fill voids, pits, or other surface imperfections with epoxy resin mortar or polyester putty conforming to the paragraphs entitled "Epoxy Resin Mortar" or "Polyester Putty." Make the repair even with the adjacent steel surface and carefully remove excess material so that none remains spread on the adjacent surface.

### 3.8 COVES

Clean out the existing ring joint where the tank wall meets the tank floor and repack with either epoxy resin mortar or polyester putty conforming to the paragraphs entitled "Epoxy Resin Mortar" or "Polyester Putty." Form new coves, using the same material, around the ring joint and around the base of columns and other 1.57 rad 90 degree corners. Form the coves so that the exterior surface slopes at a 0.785 rad 45 degree angle and the sides of the cove are a minimum of 75 mm 3 inches long.

### 3.9 SECOND ABRASIVE BLAST

Following completion of the surface repair and hardening of the resin

surface fillers, give a white metal blast in accordance with [SSPC SP 5](#) to the surfaces to be lined. The abrasive blast shall provide a "tooth" or anchor pattern of [0.075 to 0.10 mm](#) [3 to 4 mils](#) on the surfaces for proper adhesion of the lining system. Abrasive blasting and cleanup shall be as conducted for the initial abrasive blast.

### 3.10 DISPOSAL OF USED ABRASIVE

Determine if the used blast cleaning abrasive is a hazardous waste in accordance with [40 CFR 261](#). Handle and dispose of abrasive determined to be hazardous waste in accordance with [40 CFR 260](#), [40 CFR 261](#), [40 CFR 262](#), [40 CFR 263](#), [40 CFR 264](#), and [40 CFR 265](#). Dispose of abrasive which is not hazardous waste at a landfill off Government property in accordance with applicable regulations. The contract price will be adjusted for disposal of the used abrasive determined to be hazardous waste. However, payment for disposal of hazardous waste will not be made until a completed manifest from the treatment or disposal facility is returned, and a copy is furnished to the Government. If a laboratory sample is required to be analyzed, provide the results to the Government along with the [manifest](#).

### 3.11 TANK LINING

Line the entire tank bottom and up [600 mm](#) [2 feet](#) on the tank wall and columns including abrasive blasted surfaces with a fiberglass reinforced plastic laminate system. The complete lining system shall consist of an epoxy primer, a coat of polyester resin, layers of polyester-impregnated fiberglass mat and fiberglass cloth, and a top coat of paraffinated polyester resin. Use sufficient alternating layers of fiberglass mat and cloth to provide a cured-laminate minimum thickness of [3 mm](#) [1/8 inch](#) and a fiberglass mat bottom and top layer.

#### 3.11.1 Primer

Allow no more than 8 hours to elapse between the second abrasive blasting of the steel surfaces and application of the epoxy primer. Apply the primer by spray or brush to give a dry film thickness of not less than [0.05 mm](#) [2 mils](#). Provide a cure time of at least 4 but not more than 24 hours before application of the first coat of polyester. If 24 hours are exceeded before application of the polyester, lightly abrasive blast the surface again, clean up, and apply another coat of primer.

#### 3.11.2 Polyester Resin

Determine that the primer is dry to the touch before applying the first coat of polyester. Insure that surfaces are dry and free from condensate or moisture before applying the polyester resin. Where natural or forced air circulation does not achieve dry conditions, circulate heated air through the tank to dry the surfaces. Mix the polyester resin with the catalyst, promoter, and additives in conformance with the proportions provided in the resin manufacturer's written instructions. Mixes may vary when necessary to suit ambient temperatures and surface conditions in the tank. Do not mix the materials until the coating is ready to be used and mix only the quantity that can be properly applied during the pot life of the resin system. Mix the promoter and catalyst separately into the resin in accordance with the resin manufacturer's instructions; never mix the promoter and catalyst together or add both to the resin without mixing one completely into the resin before adding the other, as an explosion or fire could result.

#### 3.11.2.1 First Coat

Spray, roll, or brush the first coat of the resin system onto the primed surface until the surface is thoroughly wet but the resin is not running. Place a layer of fiberglass mat over the wetted surface and roll or knead the mat in both directions to remove wrinkles and air bubbles and to wet the mat with the resin. Brush and roll additional resin onto the mat where areas appear dry or not thoroughly wet. Carefully mold the resin-wetted mat around the columns and extend up the columns and tank wall a distance of 600 mm 2 feet. Each new area covered shall overlap the preceding area with a 50 to 75 mm 2 to 3 inch seam. Lapped edges of adjacent layers shall be staggered.

#### 3.11.2.2 Second Coat

Spray, roll, or brush the second coat of the resin system onto the mat. Place a layer of fiberglass cloth on the wetted mat and roll or knead the cloth to remove wrinkles and air bubbles and to impregnate the cloth with the resin. Apply additional resin as required to insure that all areas of the cloth are wet. Overlap the cloth and mold-up the columns and walls as was done with the mat.

#### 3.11.2.3 Additional Coats

Apply additional coats of the resin system with alternating layers of mat and cloth in the same manner indicated for the first and second coats as needed to provide the required laminate thickness. Use a layer of mat as the top layer of the laminate.

#### 3.11.2.4 Top Coat

Add paraffin wax to the resin system to be used for the top coat to prevent air inhibition. The amount of paraffin and its manner of addition to the resin shall be in accordance with the resin manufacturer's recommendations. Apply the paraffinated resin system over the entire laminate surface by spray, brush, or roller to a thickness of not less than 0.25 mm 10 mils. Care shall be taken not to use the paraffinated resin system in the lamination work.

#### 3.11.2.5 Cure

Allow the lining system to cure until it is no longer sticky or soft to the touch. If the ambient temperature is below 15.6 degrees C 60 degrees F, circulate warm air in the range of 15.6 to 27 degrees C 60 to 80 degrees F over the coated areas during the curing period. In no case shall the tank be put back into service until a minimum of 10 full days have elapsed from the time of completion of the lining work.

### 3.12 FINAL INSPECTION AND TESTS

Following completion and cure of the lining system, arrange with the Contracting Officer for an inspection of the lining visually and by holiday detector test and for air inhibition testing. Repair pinholes, cracks, voids, bubbles, delaminations, inadequate lining thickness, poor adhesion, or other imperfections so designated by the Contracting Officer.

#### 3.12.1 Air Inhibition Test

Perform the air inhibition test on areas of the lining system selected by

the Contracting Officer. Apply several drops of acetone to the laminate surface and rub the acetone with the fingers until it evaporates. If the surface becomes softened or tacky, it is evidence of undercure. When undercure is found, circulate warm air again over the coated areas until retest indicates no softening or tackiness.

### 3.12.2 Holiday Detector Test

While visually inspecting the lining, conduct holiday testing on the lined steel surfaces using a high frequency spark type holiday detector. Set the voltage output at 10,000 volts. Use a detector equipped with an audible signal device to indicate imperfections in the lining, and conduct the test in accordance with the printed instructions of the detector manufacturer. Repair holidays or imperfections by lightly sanding and applying an additional top coat.

### 3.12.3 Fill Test

After the work has been completed, inspected, and approved, the tank shall be fill tested. Remove the blind flanges and reconnect tank piping ready for service. The Government will fill the tank with fuel, providing the necessary fuel and labor. Advise the Contracting Officer in writing at least 10 days in advance of the need for this service. Fill tank half full with fuel, check that drain valves are closed, and check tank for leaks. Keep tank half full the first 12 hours of test, then fill to full capacity. Check again that drain valves are closed and tank does not leak. Monitor the fuel level hourly during the first 24 hours of the fill test and then daily for the next 9 days with measurements taken at the same time each day. Use a measuring rule with at least 3 mm 1/8 inch calibrations. Padlock drain valves closed for the duration of the test and provide one set of keys to the Contracting Officer. Notify the Contracting Officer immediately of any leaks detected. If there is no measurable drop in the fuel level during the test period, the tank will be accepted. If leakage is detected, Government personnel will then pump the fuel from the tank. When empty, clean the tank, make it vapor free, and obtain written certification from the NFPA certified "Marine Chemist" or "Gas Free Engineer" that the tank is "safe for entry" and "safe for hot work" in accordance with Section 33 65 00 CLEANING PETROLEUM STORAGE TANKS. Carefully inspect the lining for evidence of failures or other possible sources of leakage. Repair defects found in the lining and repeat tests.

### 3.13 CLEANUP

After the work and testing have been completed, remove debris, equipment, and materials from the site. Remove temporary connections to Government water and electrical services. Restore existing facilities in and around the work area to their original condition.

-- End of Section --