AD NUMBER

AD479246

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

**Distribution authorized to U.S. Gov't. agencies and their contractors;
Administrative/Operational Use; 07 MAR 1966.
Other requests shall be referred to Bureau of Naval Weapons, Washington, DC 20360.**

AUTHORITY

NATC ltr 15 May 1974

U. S. NAVAL AIR TEST FACILITY (SI)

LAKEHURST, NEW JERSEY

Report NATF-E-1081

USE OF EPOXY IN WIRE-ROPE TERMINALS

Interim Report
7 March 1966

by

C. Ward Wallace
Recovery Division

Prepared under Bureau of Naval Weapons
Problem Assignment Number RSSH-03-201/204/1,
Task Number 201-10

DISTRIBUTION LIST
CNO (Op03EG) - 2 copies
BUWEPS (DLI-3) - 4 copies (2 copies for DLI-3, 2 copies for RSSH-3)
DDC - 20 copies
NAEC, Phila., Pa. (Attn: Dir., NAEL(SI)) - 2 Copies

NOTICE

The following Espionage notice can be disregarded unless this document is plainly marked CONFIDENTIAL or SECRET.

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

The discussions or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

U. S. NAVAL AIR TEST FACILITY
(SHIP INSTALLATIONS)
U. S. NAVAL AIR STATION
LAKEHURST, NEW JERSEY 08733

Report NATF-E-1081

USE OF EPOXY IN WIRE-ROPE TERMINALS

Interim Report
7 March 1966

Prepared under Bureau of Naval Weapons
Problem Assignment Number RSSH-03-201/204/1,
Task Number 201-10

Prepared by C. Ward Wallace
C. Ward Wallace
Recovery Division

Reviewed by C. T. Abrahamsen
C. T. Abrahamsen
Head, Recovery Division

Approved by B. F. Kolaez
B. F. Kolaez
Superintendent of Engineering

ABSTRACT

The use of zinc in pouring arresting-gear-cable terminals is time-consuming, complex, and hazardous, requires many tools and appliances, and may reduce the strength of the wire rope as a result of the high temperatures inherent in the process. Because of these problems, it is very desirable that zinc be replaced with another medium. This report presents the problem areas which have been present, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin.

Dynamic tests (utilizing 46,000- to 50,000-pound A-3 type aircraft at engaging speeds ranging from 105 to 115 knots) and pull tests were conducted using single wires in special 5-inch-high and 2-1/2-inch-high terminals. A variety of commercially-available epoxies were tested and various wire-cleaning processes were used.

In the testing of all of the single-wire terminals prepared (using both epoxy and zinc), the wire did not fail, but it did pull out of the terminal; the bond strength of the epoxy resins to single wires varied over a wide range; the various methods of wire preparation (cleaning) did not appear to affect the bond strength of the epoxy to the wires; the tests conducted to determine the effect of post-cure on the bond strength were inconclusive and revealed no significant increase in bond strength; and the loads at failure of the epoxy-poured single-wire terminals were within the same approximate range as those of zinc-poured terminals.

Based on these tests using epoxy, which have been conducted since January of 1963, a saving of five hours in the total time required to prepare a terminal for use has been achieved; many less materials are required; additional safety has resulted in that epoxy resins do not require the handling of molten metal, high-terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated.

Future plans include the use of an electric heater to obtain more uniform heat application and better temperature control which should insure properly-controlled epoxy-curing cycles, and the discussion of our epoxy usage with various manufacturers to obtain their recommendations. Any epoxies purchased will be tested in conjunction with the single-wire-terminal program. Upon completion of these tests, those epoxies which warrant further testing will be tested first in the full-size-terminal static-loading phase of the program and finally in the dynamic-loading phase.

APPENDIX A
TERMINAL-POURING PROCEDURE USING DEVCON B EPOXY RESIN

I INTRODUCTION

A. The use of zinc in arresting-gear-cable terminals is time consuming, complex, and hazardous, requires many tools and appliances, and may reduce the strength of the wire rope as a result of the high temperatures inherent in the process. Because of these problems, it is very desirable that zinc be replaced with another medium.

B. The feasibility of using epoxy in arresting-gear cable terminals is being investigated at this Facility. Testing of epoxy-poured terminals has been conducted at the Naval Air Test Facility (Ship Installations) (NATF(SI)), U. S. Naval Air Station, Lakehurst, New Jersey, on the Runway Arrested Landing Site (RALS) concurrently with Mark 5, Mark 7 Mod 1, and Mark 7 Mod 2 arresting-gear tests with aircraft since November 1962, and at the Recovery Systems Track Site (RSTS) with deadloads since March 1962.

C. This report presents:

1. The problem areas present when utilizing zinc as a terminal-pouring medium,

2. Information on the progress of the epoxy-poured-terminal investigation, supplementary to the information presented in references (a) and (b), and

3. A complete terminal-pouring procedure for using DEVCON B epoxy resin, which is presented in Appendix A.

II PROBLEM AREAS PRESENT WHEN UTILIZING ZINC TERMINALS

A. Materials: The following materials are necessary for the pouring of zinc terminals:

Asbestos gloves
Goggles
Chalk
Wire: braided steel
copper
Asbestos cloth
Steel grit
Adhesive cloth tape
Ladle
Split wafer
Cable clamp
Melting furnace
Grit blast cabinet
Acetylene torch
Pyrometer
Zinc
Balance scale
Thermometer
Electric hot plate
Fluxing chemicals
Cable terminal driver
Cable twisting wrench
Die and tap set
Copper mallet
End nippers
Side cutting pliers
Gas pliers
File
Hacksaw

B. Time: The total time to prepare zinc-poured terminals is nine hours; five hours more than required for epoxy-poured terminals, as shown in the following table:

	Time (Hours)	
	Zinc	Epoxy Resin
Pre-pour*	5	2
Post-pour†	4	2
TOTAL	9	4

* Preparation of cable wires and terminal, and related operations.
† Time required for cooling and further work to prepare terminal for use.

C. Safety: The use of zinc in the preparation of terminals requires handling of molten metal, high-terminal temperatures, and hot fuming hydrochloric acid.

D. Pouring Instructions: The pouring procedure for zinc is complex, lengthy, and meticulous. Some of the operations involved in pouring zinc are: (a) grit blasting the cable wires and terminal, (b) procedures necessary for preparing the fluxing chemicals, and (c) fluxing the cable wires.

III TEST PROGRAMS AND RESULTS OF INVESTIGATION

A. General: Tests of epoxy-poured terminals were very successful and clearly demonstrated that an epoxy resin is better than zinc in cable terminals. Since January 1963, all terminals utilized at NATF(SI) for both deadload and aircraft programs have been prepared with an epoxy resin; almost all terminals were prepared with DEVCON B, a commercially-available epoxy resin.

B. Dynamic Tests

1. Epoxy-poured terminals have been used for 8,776 and 682 aircraft arrestments into the cables of the RALS Mark 7 Mod 1 and Mark 7 Mod 2 arresting gears respectively. Approximately 90 percent of the arrestments made into the Mark 7 Mod 1 arresting gear were conducted with 46,000- to 50,000-pound A-3 type aircraft at engaging speeds ranging from 105 to 115 knots.

2. Because purchase-cable wear, cable elongation, and program requirements necessitate frequent removal of terminals, the maximum number of aircraft arrestments conducted has been 796 using an epoxy-poured deck terminal and ,002 using an epoxy-poured anchor terminal. It should be noted that this deck terminal was modified as referred to in Section IV, paragraph D, on page 4.

C. Single-Wire-Terminal Pull Tests

1. To save time and material, and in an effort to simplify testing, special 5-inch-high and 2-1/2-inch-high terminals and single wires were used instead of standard terminals and 1-3/8-inch wire rope in order to obtain the following information which would be pertinent to the epoxy program:

a. The bond strength of various epoxies to single wires,

b. The bond strength of zinc to single wires for comparison purposes, and

c. The effect of terminal height, accelerators, wire preparation, and post-cure on the bond strength of epoxy to single wires.

2. The following epoxies were tested:

a. Devcon Corporation DEVCON B with and without the addition of an accelerator,

b. Minnesota Mining and Manufacturing Company formulas 2158 and 2216, and

c. Hysol Corporation epoxy base TC9-4351 and hardener TH8-3521.

3. Various wire-cleaning processes were used in order to determine their affect on the bond strength of epoxy to the wires. The wires were cleaned as follows:

a. With trichloroethylene only,

b. With trichloroethylene followed by grit blasting,

c. With trichloroethylene followed by toluene, and

d. With trichloroethylene followed by ALCONOX detergent.

4. Single-Wire-Terminal-Tests Results

a. In the testing of all of the single-wire terminals prepared (using both epoxy and zinc), the wire did not fail, but it did pull out of the terminal.

b. The bond strength of the epoxy resins to single wires varied over a wide range:

(1) The average failure load of the 5-inch terminals was 30% greater than that of the 2-1/2-inch terminals; therefore, a 100% increase in terminal height resulted in only a 30% increase in terminal strength.

(2) The addition of accelerator to the DEVCON B epoxy did not appreciably affect the bond strength of epoxy to the single wire, but it did accelerate the cure cycle and is therefore normally added to this epoxy when full-size terminals are prepared.

c. The various methods of wire preparation (cleaning) did not appear to affect the bond strength of the epoxy to the wires.

d. The tests conducted to determine the effect of post-cure on the bond strength were inconclusive and revealed no significant increase in bond strength. Two of the many problems encountered in this phase of the program were maintaining the post-cure temperature, and not being able to test the samples within approximately one hour after preparation.

e. The loads at failure of the epoxy-poured single-wire terminals were within the same approximate range as those of zinc-poured terminals.

IV FUTURE PLANS

A. Plans for more uniform heat application and better temperature control for the post-cure phase of the program include curing by use of an electric heater. The use of the heater should result in complete epoxy cure. A terminal heater has been designed and constructed. Testing will be conducted utilizing this heater which should insure properly-controlled epoxy curing cycles.

B. Various manufacturers of epoxies will be contacted and our epoxy usage will be discussed with them. Based on their recommendations, epoxies will be purchased and tested in conjunction with the single-wire-terminal program.

C. Upon completion of the above tests, the epoxies which warrant further testing will be tested first in the full-size-terminal static-loading phase of the prc and finally in the dynamic-loading phase.

D. The terminals will be modified by machining smooth the internal striations for approximately the first inch from large I.D. end of the terminal.

V RECOMMENDATION

It is recommended that NATF(SI) demonstrate to COMNAVAIRLANT and COMNAVAIRPAC epoxy terminal-pouring procedures.

VI REFERENCES

(a) Report NATF(SI)-EI-69 of 25 June 1962, Preliminary Evaluation of Epoxy Poured Sockets on 1-3/8-inch-diameter Wire Rope

(b) Report NATF(SI)-EI-75 of 19 November 1962, Preliminary Evaluation of Epoxy Poured Terminals on 1-1/8-inch-diameter Wire Rope - Second Report

APPENDIX A - TERMINAL-POURING PROCEDURE USING DEVCON B EPOXY RESIN

1. Preparation

a. Prepare the wire rope for cutting by wrapping two seizings (15 or 20 turns per seizing) of 3/32-inch-diameter seizing wire approximately 1 inch apart. Cut the wire rope between the seizings.

b. Remove the seizing from the end of the wire rope to which the terminal is to be attached. Using a wire brush and trichloroethylene, clean the cable to approximately one foot from the end.

NOTE

Trichloroethylene is a volatile liquid, the fumes of which can cause headaches, nausea, and unconsciousness; therefore, this cleaning agent should be used only in a well-ventilated area.

c. Place the cable in the jaws of a vise in a vertical position so that approximately 10 inches of the cable protrudes. The vise jaws must be covered with wood or soft metal to protect the individual wires. Use a marlinspike to unlay three of the strands of cable and remove 5-1/2 to 5-3/4 inches of hemp core. Re-lay the strands. Six inches from the end, install a seizing of 15 to 20 turns.

d. Unlay and straighten the strands to the top of the seizing using a marlinspike and tubing. Working with one strand at a time, unlay and straighten the individual wires with the hand tool provided for this purpose. When all the wires of a strand have been straightened, tie their ends together with a few wraps of seizing wire. This will keep the wires out of the way while working on the other strands.

e. After all the wires have been straightened and the seizing installed on the end of each strand, use the tubing to pull the strands into the center. Remove the seizing from the ends of the strands and check the broomed cable for an even wire distribution.

f. Thoroughly and carefully wash the broomed-out wires in a bath of trichloroethylene with a wire brush until the wires appear clean. The wires must be cleaned to at least 7 inches from the end Repeat the cleaning operation by rinsing the broomed-out wires in a second bath of trichloroethylene. Inspect the wires to insure that all grease, preservative, dirt, etc., has been removed. Dry by shaking the broomed-out wires. (Do not use compressed air for this purpose because it may be contaminated with oil and/or grease.)

NOTE

Replace the cleaning solutions after processing six broomed-out cables. (When cleaning heavily-preserved cables, it may be necessary to change the solution more frequently.) Containers are to be thoroughly cleaned before adding fresh trichloroethylene.

g. After the broomed-out wires have been thoroughly cleaned and dried, clamp the wire rope vertically in the jaws of a vise approximately one inch below the seizing. Do not touch the broomed-out wires with hands or with any item that has not been thoroughly cleaned in trichloroethylene.

h. Attach handles to each end of a length of aluminum wire cleaned in trichloroethylene as in subparagraph f, loop this wire once around near the top of the broomed-out wires, and squeeze the broomed-out wires together by tightening the loop.

i. Install a terminal, which has been thoroughly cleaned in two rinses of trichloroethylene and dried, by sliding the terminal over the wires until it bottoms on the seizing. The wire used to squeeze the broomed wires together will fall away at this point.

j. Re-clamp the wire rope in the vise at a point 4 inches below the seizing, with the terminal in a vertical position above the vise. Carefully align the terminal with the cable.

k. Prepare a paste of powdered asbestos and water to the consistency of putty, and cover the base of the terminal and the adjoining wire rope with this preparation to prevent seepage of the epoxy resin from the terminal. Coat the inside of the "hot top" fitting with the epoxy release agent included with the DEVCON B epoxy kit and install the fitting on the terminal. Pack asbestos paste about the outside of the hot-top fitting to completely seal it for the pour.

l. Mix the DEVCON B epoxy resin in accordance with directions on the container.

NOTE

Two pounds of epoxy are required for one terminal. It is recommended that the epoxy be stored at a temperature of 65° F to 100° F prior to mixing so that the material can be readily mixed and poured. When the epoxy resin base and hardener are thoroughly mixed, add one tablespoon of DEVCON accelerator per pound of epoxy. Continue to blend until the mixture becomes homogeneous.

NOTE

Epoxy resins contain materials which may be irritating to the skin and to the nasal passages. Accordingly, prolonged contact with the skin should be avoided and adequate ventilation should be provided during mixing, pouring, and curing operations. If skin contact occurs, immediately use waterless cleaner followed by washing the skin area with soap and water. Wear a mask during machining operations in confined areas to avoid breathing of dust. Wash hands thoroughly before eating or smoking when working with epoxy.

m. While the epoxy is being mixed, uniformly heat the terminal by means of a propane torch until a 113° F TEMPILSTIK leaves a wet mark on the terminal. Recheck the terminal just prior to pouring. Pour epoxy resin into the terminal until it is approximately 1/4 inch above the top of the terminal.

NOTE

Care must be taken that air does not become entrapped at the bottom of the terminal during the pouring of the epoxy. To avoid this, initially pour the epoxy resin slowly down the side of the terminal.

n. Maintain a terminal temperature of 113° F until the epoxy hardens (approximately 20 minutes). Approximately 15 minutes and 30 minutes after the epoxy hardens, check the terminal temperature by means of the 113° F TEMPILSTIK. If the TEMPILSTIK does not leave a wet mark at either time, reheat the terminal as above to 113° F. Care must be taken that the terminal is not overheated.

o. Approximately 15 minutes after the last terminal reheat, remove the asbestos packing and hot-top fitting. Allow the terminal to air cool until the terminal is no longer warm or for approximately 30 to 60 minutes. Cut off the hot top flush with the top of the terminal. Inspect the terminal for cracks and uneven distribution of wires (wires should not be grouped together) throughout the terminal cross section. If either cracks or uneven wire distribution exist, cut off the terminal and repeat the entire procedure of pouring a new epoxy terminal. If the terminal is satisfactory (no cracks are present), remove the seizing wire and attach the clevis socket.

2. Proofloading: Poured terminals must be proofloaded after each satisfactory poured fitting is obtained and prior to resumption of normal operations, as follows:

a. Place the assembly in the cable-terminal proofloading machine, NAEL PN 607843-1, and apply a load of 120,000 pounds for one minute. Remove the assembly from the proofloading machine and inspect the poured terminal. The terminal shall be rejected if either of the following conditions exist:

(1) Any wire slippage in excess of 1/32 inch, or

(2) Epoxy recession in excess of 3/32 inch.

b. The application of a proofloading and/or normal usage of a terminal may cause a circular crack to occur at the epoxy periphery. These cracks develop as a result of a major portion of the epoxy slightly recessing into the terminal. Small amounts of epoxy at the top of the terminal adhere to the walls of the terminal and consequently do not recess. A few wires will pull into the small amount of epoxy which has adhered to the terminal wall. Wire recession in this area (that is, wire recession which is not greater than the epoxy recession) shall be considered satisfactory and shall not be a cause for terminal rejection.

c. If the terminal attachment is satisfactory, immerse the terminal and at least 6 inches of the cable in 190° F to 210° F wire-rope lubricating oil Type II, Grade A, Federal Specification VV-L-751b. Make sure the lubricating oil runs into the base of the terminal and coats the wire rope wherever the lubricant has been removed in cleaning the wire. The poured terminal may now be utilized.

3. Inspection Criteria

a. The above-deck poured terminals should be inspected once a day. This inspection may be of a routine nature and should consist of a visual external inspection after each day's operation to determine the presence of any damage. It is unnecessary to disassemble the terminal except in doubtful cases.

b. All terminals should also be inspected immediately after any excessive loading such as that caused by an engagement exceeding 20 feet OFF-CENTER, an excessive runout which two-blocks the engine, and any short runout.

c. Further inspection shall be performed as follows: (a) at least once a month or after every 300 arrestments, whichever occurs first, for the above-deck poured terminals, and (b) at least once a month or every 400 arrestments, whichever occurs first, for the below-deck poured terminals.

d. Each inspection shall be accomplished in the following manner:

(1) Remove the clevis and clean the terminal thoroughly with a clean rag. Do not use solvent. Be sure to clean thoroughly around the base of the terminal, removing all grease and dirt accumulations. Examine the condition of the terminal and check the condition of threads.

(2) Inspect the top of the terminal for any evidence of individual wire slippage in the epoxy or a depression of the epoxy into the terminal. Insure that the lay of the wire rope is not disturbed below the base of the terminal, and that the terminal is properly aligned with the wire rope. The following shall be causes for terminal rejection, cropping and repouring:

(a) Broken threads,

(b) Wire slippage of more than 1/32 inch,

(c) Epoxy depression of more than 3/32 inch,

(d) Unlaying of the wire rope, and/or

(e) Misalignment of the terminal with respect to the cable.

e. Above-deck poured terminals, which have had approximately 18 months of service are to be cropped regardless of condition.

f. Below-deck poured terminals may be retained in service provided they satisfactorily pass each monthly inspection or 400-arrestment inspection.

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

Naval Air Test Facility (Ship Installations)
Naval Air Station
Lakehurst, New Jersey

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

3. REPORT TITLE

USE OF EPOXY IN WIRE-ROPE TERMINALS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Interim Report

5. AUTHOR(S) *(Last name, first name, initial)*

C. Ward Wallace

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
7 March 1966	5p, Appendix 5p.	2

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. P.A. 03-201/204/1	NATF-E-1081
c. Task Number 201-10	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. AVAILABILITY/LIMITATION NOTICES

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of Chief, Bureau of Naval Weapons, Washington, D. C. 20360

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Bureau of Naval Weapons, Department of the Navy

13. ABSTRACT

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin.

Epoxy resin has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

DD FORM 1 JAN 64 1473

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
EPOXY RESIN						
CABLE TERMINALS						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through

_____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through

_____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through

_____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/ 204/1
Task No. 201-10

UNCLASSIFIED

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(Over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/ 204/1
Task No. 201-10

UNCLASSIFIED

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/ 204/1
Task No. 201-10

UNCLASSIFIED

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/ 204/1
Task No. 201-10

UNCLASSIFIED

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal. high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/204/1
Task No. 201-10

UNCLASSIFIED

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(Over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/204/1
Task No. 201-10

UNCLASSIFIED

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/204/1
Task No. 201-10

UNCLASSIFIED

Naval Air Test Facility (SI) (Report No. NATF-E-1081)
USE OF EPOXY IN WIRE-ROPE TERMINALS, Interim Report, by C. Ward Wallace, 7 Mar 1966, 5p.
UNCLASSIFIED

Report presents previous problem areas when using zinc as a terminal-pouring medium, information on the progress of the feasibility of using epoxy in arresting-gear-cable terminals, and, as an Appendix, a complete terminal-pouring procedure for using DEVCON B epoxy resin. Epoxy resin

(over)

1. Epoxy Resins
2. Cable Terminals

P.A. RSSH-03-201/204/1
Task No. 201-10

UNCLASSIFIED

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

has resulted in saving five hours total time to prepare a terminal; requires many less materials; does not require handling molten metal, high terminal temperatures, and hot fuming hydrochloric acid; and necessary instructions to personnel for the pouring of epoxy are not as complicated. Future plans include the use of a heater to obtain more uniform heat application and better temperature control, obtain recommendations from various epoxy manufacturers, and conduct further tests in order to completely evaluate epoxy resins for use in arresting-gear-cable terminals.

SUPPLEMENTARY

INFORMATION

AD-479246

(70) 18

U. S. NAVAL AIR TEST FACILITY
(SHIP INSTALLATIONS)
U. S. NAVAL AIR STATION
LAKEHURST, NEW JERSEY 08733

Report NATF-E-1081

REVISION NOTICE

USE OF EPOXY IN WIRE-ROPE TERMINALS

Interim Report
7 March 1966

Prepared under Bureau of Naval Weapons
Problem Assignment Number RSSH-03-201/204/1,
Task Number 201-10

Prepared by C. Ward Wallace
C. Ward Wallace
Recovery Division

Reviewed by C. T. Abrahamsen
C. T. Abrahamsen
Head, Recovery Division

Approved by B. F. Kolacz
B. F. Kolacz
Superintendent of Engineering

REVISION 1 (12/66) - Appendix A revised.

APPENDIX A

TERMINAL-POURING PROCEDURE USING DEVCON B EPOXY RESIN

1. General

a. There are presently two methods of applying heat to the terminal to cure the epoxy. The use of the electric terminal heater is the recommended procedure; however, when the electric heater is not available, the epoxy may be heated with a propane torch.

b. Non-critical cracks which may develop in the epoxy, if any epoxy recession occurs during testing, have been eliminated through the use of a modified terminal; therefore, all terminals (PN 400791-1) to be used in conjunction with epoxy pouring, must be modified as follows: the internal surfaces of the terminal shall be machined smooth from the large-diameter end to the second 1/16-inch-deep circular slot (approximately one inch from the large-diameter end).

2. Preparation

a. Prepare the wire rope for cutting by wrapping two seizings (15 or 20 turns per seizing) of 3/32-inch-diameter seizing wire approximately one inch apart. Cut the wire rope between the seizings.

b. Remove the seizing from the end of the wire rope to which the terminal is to be attached. Using a wire brush and trichloroethylene, clean the cable to approximately one foot from the end.

CAUTION

Trichloroethylene is a volatile liquid, the fumes of which can cause nausea, headaches, and unconsciousness; therefore, this cleaning agent should be used only in a well-ventilated area.

(Issued 5/66)

c. Place the cable in the jaws of a vise in a vertical position so that approximately 10 inches of the cable protrudes. The vise jaws must be covered with wood or soft metal to protect the individual wires. Use a marlinspike to unlay three of the strands of cable and remove 5-1/2 inches of hemp core (Figure 1).

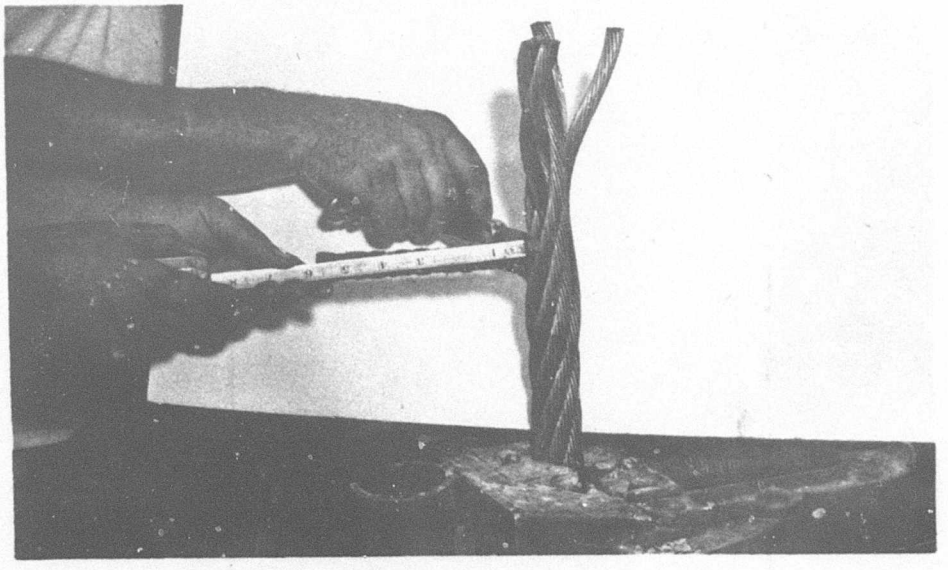

Figure 1

d. Wash the cable in a bath of trichloroethylene with a wire brush to a point approximately seven inches from the cut end. Re-lay the strands. Five and one-half inches from the cut end, install a seizing of 15 to 20 turns. Start the seizing at the 5-1/2-inch location, and install the seizing working away from the cut end.

e. Unlay and straighten the strands to the top of the seizing, using a marlinspike and tubing (Figure 2). Working with one strand

at a time, unlay and straighten the individual wires with the hand tool provided for this purpose. (It is important that the wire at the base of the terminal where it enters the seizing, is unlayed and straightened in order to obtain good epoxy penetration.) When all the wires of a strand have been straightened, tie their ends together with a few wraps of seizing wire. This will keep the wires out of the way while working on the other strands.

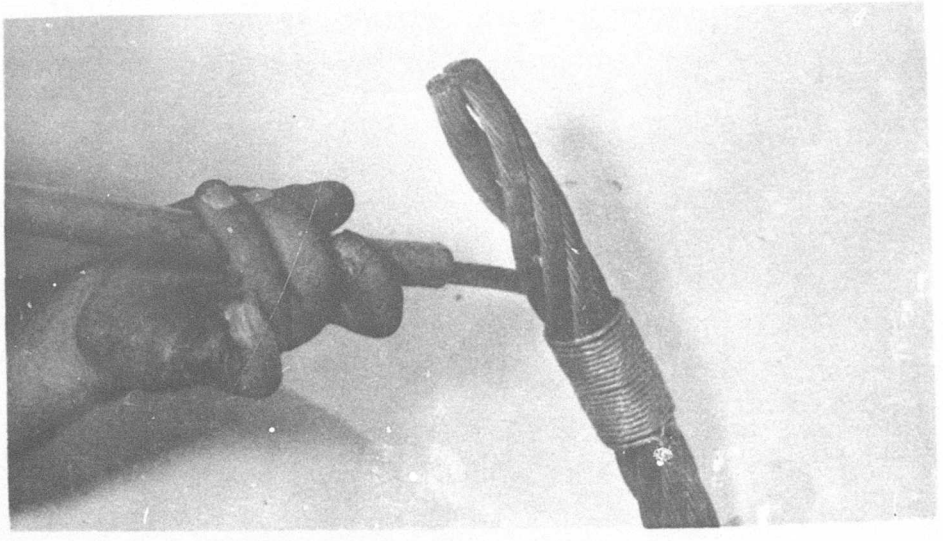

Figure 2

f. After all the wires have been straightened and the seizing installed on the end of each strand, use the tubing to pull the strands into the center (Figure 3). Remove the seizing from the ends of the strands and check for an even wire distribution. (It is important in the preparation of epoxy terminals, that the wires are evenly distributed through the terminal cross-section.) The cable end in this configuration is normally called "broomed".

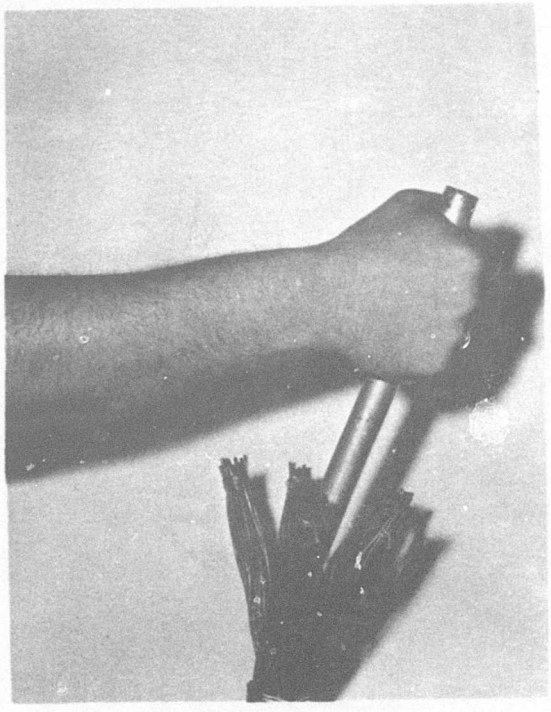

Figure 3

g. Thoroughly and carefully wash the broomed-out wires in a bath of trichloroethylene (Figure 4) with a wire brush until the wires appear clean. The wires must be cleaned to at least seven inches from the end. Repeat the cleaning operation by rinsing the broomed-out wires in a second bath of trichloroethylene. The trichloroethylene will evaporate rapidly; therefore, there is no need to dry the broomed wires. Do <u>not</u> try to dry the broomed section by shaking when it is removed from the trichloroethylene (shaking only tends to cause preservative to flow from the hemp core to the cleaned broomed wires). Do not use compressed air for drying the broomed cable because the air may be contaminated with

oil and/or grease. Inspect the wires to insure that all grease, preservative, dirt, etc., has been removed. If the cable is still dirty, rewash until it is clean.

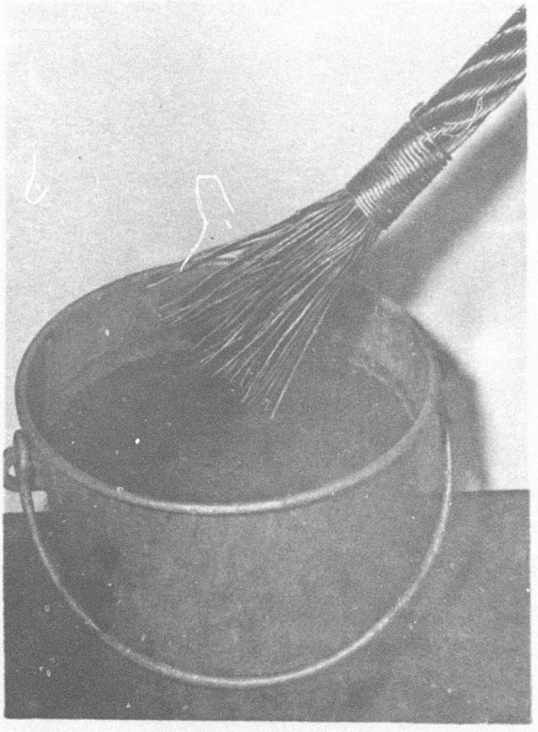

Figure 4

NOTE

Replace the cleaning solutions after processing six broomed-out cables. (When cleaning heavily-preserved cables, it may be necessary to change the solution more frequently.) Containers are to be thoroughly cleaned before adding fresh trichloroethylene.

h. After the broomed-out wires have been thoroughly cleaned and dried, clamp the wire rope vertically in the jaws of a vise approximately one inch below the seizing. Do not touch the broomed-out wires with hands or with any item that has not been thoroughly cleaned in trichloroethylene.

i. Attach handles to each end of a length of aluminum wire cleaned in trichloroethylene as in subparagraph g., loop this wire around once near the top of the broomed-out wires, and squeeze the broomed-out wires together by tightening the loop.

j. Install a terminal, which has been thoroughly cleaned in two rinses of trichloroethylene and dried, by sliding the terminal over the wires (Figure 5). The wire used to squeeze the broomed wires together will fall away at this point. If the electric terminal heater is to be used, do not bottom the terminal on the seizing until after the heater has been installed on the terminal; if the propane torch is to be used, the terminal should be bottomed on the seizing.

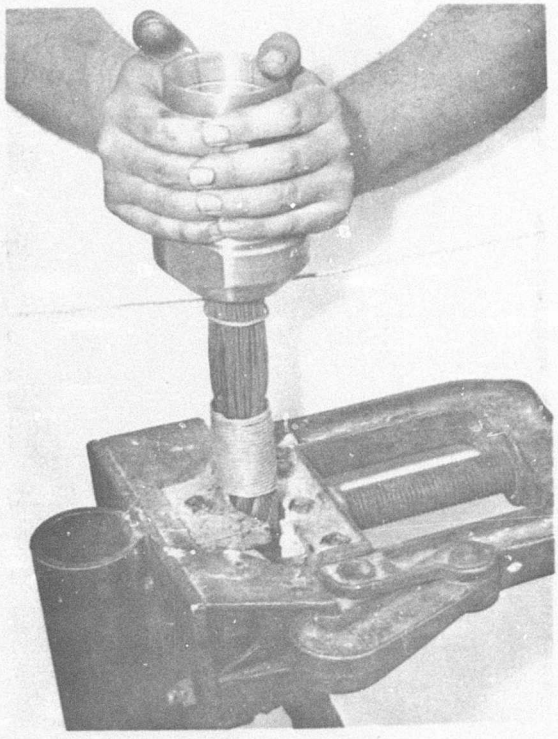

Figure 5

3. Terminal Heating. There are two methods of applying heat to the terminal to cure the epoxy. The first method is the use of the electric terminal heater and the second is the use of a propane torch.

a. Using the electric heater: The electric terminal heater (Figure 6) consists of two major components: the heating unit which is threaded and screws onto the terminal; and the control box which regulates the terminal temperature.

Figure 6

(1) Coat the outside top unthreaded section of the terminal and also the outside threaded section with a thin film of release agent included with the DEVCON B epoxy kit. Install the heater on the terminal until it bottoms on the terminal and the assembly bottoms on the seizing.

(2) Reclamp the wire rope in the vise at a point four inches below the seizing with the terminal in a vertical position above the vise.

(3) Coat the inside of the "hot top" fitting with a thin film of release agent and install the fitting on the terminal. Prepare a paste of powdered asbestos and water to the consistency of putty. Cover the base of the terminal and the adjoining wire rope with this preparation to prevent seepage of the epoxy resin from the terminal. (It is necessary to pack the asbestos firmly about the base of the terminal and between the strands of the wire at the start of the seizing.) Also, pack asbestos paste about the outside of the "hot top" fitting to completely seal it for the pour.

(4) Dry the asbestos with a propane torch until the asbestos becomes firm.

(5) Place both the power switch and the heating switch on the control box in the OFF position. Set the temperature indicator on 110° F. Connect the terminal heater and the heater control box. Plug the control box into 110-volt AC current. Place the power switch in the ON position. Place the heating switch in the ON position.

(6) Allow approximately five minutes for the terminal to get up to temperature. In the meantime, gather the ingredients for mixing the epoxy.

b. Using the propane torch: Curing the epoxy by heating the terminal with a propane torch is not the recommended procedure; however, it is an acceptable procedure. When heating with a propane torch, temperature control is very important.

(1) Coat the outside top unthreaded section of the terminal with a thin film of release agent included with the DEVCON B epoxy kit.

(2) Reclamp the wire rope in the vise at a point four inches below the seizing with the terminal in a vertical position above the vise.

(3) Coat the inside of the "hot top" fitting with a thin film of release agent and install the fitting on the terminal. Prepare a paste of powdered asbestos and water to the consistency of putty. Cover the base of the terminal and the adjoining wire rope with this preparation, to prevent seepage of the epoxy resin from the terminal. (It is necessary to pack the asbestos firmly about the base of the terminal and between the strands of the wire at the start of the seizing.) Also, pack asbestos paste about the outside of the "hot top" fitting to completely seal it for the pour.

(4) Dry the asbestos with the propane torch until the asbestos becomes firm.

(5) After the asbestos has been dried, uniformly heat the terminal with the propane torch until a 113° F TEMPILSTIK leaves wet marks on the terminal surface. (An individual can grasp and hold a terminal which is 113° F to 115° F without undue discomfort. Therefore, if the terminal is so hot that a person cannot hold his hand on it, the epoxy must not be poured.) While the terminal is being heated, the ingredients for mixing the epoxy should be gathered. The terminal is to be at approximately 113° F when the epoxy is poured.

4. Mixing the Epoxy

CAUTION

In some cases persons have applied the propane torch (in drying the asbestos) for too long a period of time which has resulted in the terminal becoming very warm. Under all conditions, the epoxy must not be poured when the terminal temperature is above 120° F. Excessive heat application to epoxy will cause too rapid a chemical reaction which will result in a porous cure with no strength.

NOTE

Two pounds of epoxy are required for one terminal. It is necessary that the epoxy be stored at a temperature of 65° F to 100° F for at least two hours prior to mixing so that the material can be readily mixed and poured.

CAUTION

Epoxy resins contain materials which may be irritating to the skin and to the nasal passages. Accordingly, prolonged contact with the skin should be avoided and adequate ventilation should be provided during mixing, pouring, and curing operations. If skin contact occurs, immediately use waterless cleaner followed by washing the skin area with soap and water. Wear a mask during machining operations in confined areas to avoid breathing dust. Wash hands thoroughly before eating or smoking when working with epoxy.

a. Use a large screwdriver (approximately 12 inches in length) which has been cleaned in trichloroethylene for the epoxy stirring operation.

b. Open the epoxy-resin-base container (which is similar to a standard paint container) and use the screwdriver to puncture at least four equally-spaced holes in the circular groove on the top of the can.

The purpose of these holes is that if any of the hardener spills into the groove during the mixing operation, it will drain back into the can.

c. The epoxy resin base is very thick and should be scraped from the side of the can and stirred for a few minutes before adding any other ingredients. (Do not stir by other than manual means.)

d. Open the can of hardener and add the entire contents to the epoxy resin base. Stir these ingredients until the mixture becomes smooth and homogeneous. (Do not add the accelerator until the base and hardener are thoroughly mixed.)

e. When the epoxy resin base and hardener are thoroughly mixed, add two teaspoons of DEVCON accelerator per pound of epoxy. Continue to blend these ingredients until the mixture becomes homogeneous.

f. Pour epoxy resin into the terminal until it is approximately 1/4 inch above the top of the terminal.

NOTE

Care must be taken that air does not become entrapped at the bottom of the terminal during the pouring of the epoxy. To avoid this, pour the epoxy resin slowly down the side of the terminal.

g. Under most conditions, the epoxy should harden in approximately 20 to 25 minutes after the epoxy is poured.

5. Post Cure Operations

a. Using the electric heater

(1) Leave the heater on for approximately 20 minutes after the epoxy solidifies, then turn the heating switch and the power switch to the OFF position. When the unit cools, disassemble the unit and remove the asbestos packing.

(2) Allow the terminal to air cool until the terminal is no longer warm or for approximately 30 to 60 minutes. Cut off the "hot top" flush with the top of the terminal. Inspect the terminal for cracks and uneven distribution of wires (wires should not be grouped together) throughout the terminal cross-section. If either cracks or uneven wire distribution exist, cut off the terminal and repeat the entire procedure of pouring a new epoxy terminal. If the terminal is satisfactory (no cracks are present), remove the seizing wire and attach the clevis socket.

b. Using the propane torch

(1) If the epoxy has not solidified in 30 minutes, reheat the terminal to 113° F, again making sure that the terminal is not overheated. Twenty minutes after the epoxy solidifies, reheat the terminal to 113° F. When the unit cools, disassemble the unit and remove the asbestos packing.

(2) Allow the terminal to air cool until the terminal is no longer warm or for approximately 30 to 60 minutes. Cut off the "hot top" flush with the top of the terminal. Inspect the terminal for cracks and uneven distribution of wires (wires should not be grouped together) throughout the terminal cross-section. If cracks or uneven wire distribution exist, cut off the terminal and repeat the entire procedure of pouring a new epoxy terminal. If the terminal is satisfactory (no cracks are present), remove the seizing wire and attach the clevis socket.

6. Proofloading: Poured terminals must be proofloaded after each satisfactory poured fitting is obtained and prior to resumption of normal operations, as follows:

a. Place the assembly in the cable-terminal proofloading machine, NAEL PN 607843-1, and apply a load of 120,000 pounds for one minute. Remove the assembly from the proofloading machine and inspect the poured terminal. The terminal shall be rejected if either of the following conditions exist:

(1) Slippage of ten wires in excess of 1/32 inch (filler wires are not counted), or

(2) Epoxy recession in excess of 3/32 inch.

b. If the terminal attachment is satisfactory, immerse the terminal and at least six inches of the cable in 190° F to 210° F wire-rope lubricating oil, Type II, Grade A, Federal Specification VV-L-751 revision b. Make sure the lubricating oil runs into the base of the terminal and coats the wire rope wherever the lubricant has been removed in cleaning the wire. The poured terminal may now be utilized.

7. Terminal-Inspection Criteria

a. The above-deck poured terminals should be inspected once a day. This inspection may be of a routine nature and should consist of a visual external inspection after each day's operations to determine the presence of any damage. It is unnecessary to disassemble the terminal except in doubtful cases.

b. All terminals should also be inspected immediately after any excessive loading such as that caused by an engagement exceeding 20 feet

OFF-CENTER, an excessive runout which two-blocks the engine, and any short runout.

c. Further inspection shall be performed as follows: at least once a month or after every 300 arrestments, whichever occurs first, for the above-deck poured terminals; and at least once a month or every 400 arrestments, whichever occurs first, for the below-deck poured terminals.

d. Each inspection shall be accomplished in the following manner:

(1) Remove the clevis and clean the terminal thoroughly with a clean rag. Do not use solvent. Be sure to clean thoroughly around the base of the terminal, removing all grease and dirt accumulations. Examine the condition of the terminal and check the condition of threads.

(2) Inspect the top of the terminal for any evidence of individual wire slippage in the epoxy or a depression of the epoxy into the terminal. Insure that the lay of the wire rope is not disturbed below the base of the terminal, and that the terminal is properly aligned with the wire rope. The following shall be causes for terminal rejection, cropping, and repouring:

(a) Broken threads,

(b) Slippage of ten wires in excess of 1/32 inch (filler wires are not counted),

(c) Epoxy depression of more than 3/32 inch,

(d) Unlaying of the wire rope, and/or

(e) Misalignment of the terminal with respect to the cable.

e. The manual for each shipboard arresting-gear system states that all purchase cables shall be replaced if installed for more than 12 months; accordingly, terminal life is not to exceed purchase-cable life.