TECHNICAL

TN NO: N-1661

TITLE: TEST AND EVALUATION OF THE MT 75 ROPE TESTER - A HAND-HELD NDT WIRE-ROPE INSPECTION DEVICE

AUTHOR: L. D. Underbakke

DATE: March 1983

SPONSOR: Naval Facilities Engineering Command

PROGRAM NO: YO995-01-004-620

NOTE

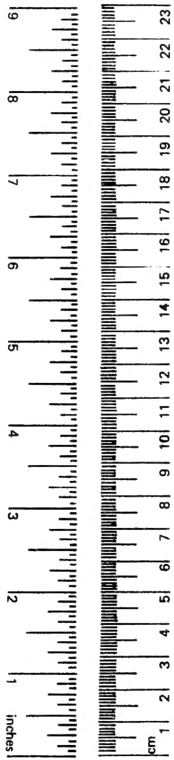
NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

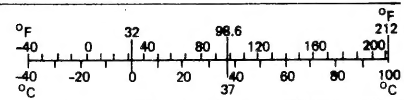
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: TN-1661
2. GOVT ACCESSION NO.: DN987077
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): TEST AND EVALUATION OF THE MT 75 ROPE TESTER – A HAND-HELD NDT WIRE-ROPE INSPECTION DEVICE
5. TYPE OF REPORT & PERIOD COVERED: Not final; Sep 81 – Sep 82
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): L. D. Underbakke
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: NAVAL CIVIL ENGINEERING LABORATORY, Port Hueneme, California 93043
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 63725N; Y0995-01-004-620
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Facilities Engineering Command, Alexandria, Virginia 22332
12. REPORT DATE: March 1983
13. NUMBER OF PAGES: 35
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):
18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number): Wire rope, steel cable, inspection, nondestructive test, nondestructive inspection, DC wire rope test, rope tester
20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

The nondestructive wire rope tester, MT 75, was investigated, tested, and evaluated in order to fill the gap between the hand-held rag inspection and the large unitized AC/DC wire rope inspection device. The MT 75 can provide better information on the condition of the wire rope than can be obtained by using the "rag and visual" inspection method.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(*When Data Entered*)

Library Card

Naval Civil Engineering Laboratory
TEST AND EVALUATION OF THE MT 75 ROPE TESTER – HAND-HELD NDT WIRE-ROPE INSPECTION DEVICE, by L. D. Underbakke

TN-1661 35 pp illus March 1983 Unclassified

1. Wire rope 2. Nondestructive testing I. Y0995-01-004-620

The nondestructive wire rope tester, MT 75, was investigated, tested, and evaluated in order to fill the gap between the hand-held rag inspection and the large unitized AC/DC wire rope inspection device. The MT 75 can provide better information on the condition of the wire rope than can be obtained by using the "rag and visual" inspection method.

CONTENTS

INTRODUCTION

The Naval Civil Engineering Laboratory (NCEL) under Naval Facilities Engineering Command (NAVFAC) and Bureau of Mines joint sponsorship has investigated nondestructive test (NDT) equipment for the inspection of wire rope. Conventional NDT equipment utilizes separate AC and DC units to detect loss of metallic area (LMA) and local faults (LF), respectively. A representative device was tested and compared to a newly developed type of NDT equipment that is a unitized AC/DC device. The two devices were compared considering operational capabilities and ease of use. The Magnograph™ equipment, the unitized AC/DC device, was recommended for use by the Navy. It is more versatile than the separate AC and DC units, as both LF and LMA data are recorded simultaneously on a 2-channel, brush-chart recorder and on a cassette tape. The Magnograph™ uses Hall effect sensors, which permit the wire rope speeds to vary from 0 fpm to over 800 fpm without any change in the reliability of the recorded LF and LMA data*. Figure 1 shows the Magnograph™ in operation.

As a result of extensive field testing of these NDT devices, inspectors stated that a need existed for a small, lightweight, and inexpensive NDT wire rope inspection device. This inspection device would be used to replace the "rag and visual" method for interim or preliminary inspections when there is a question of broken wires.

NCEL, under NAVFAC sponsorship, conducted a survey to find a NDT wire rope inspection device that met these criteria. As a result of this survey, the MT 75 Rope Tester was selected for test and evaluation (Figure 2). This report presents the results of the test and the evaluation program conducted on the MT 75 to determine its characteristics before Navy field activities acquire the units and start NDT wire rope inspection programs.

MT 75 ROPE TESTER

The MT 75 is a hand-held NDT wire rope inspection device that uses the DC method of detection. The MT 75 is 6 inches long, 8-1/2 inches wide, 1-1/2 inches deep, and weighs about 5 pounds.

The DC method of detection is a well-established method for detecting local faults such as broken wires. The DC NDT wire rope inspection equipment uses strong permanent magnets to magnetically saturate the wire rope to be inspected; this causes a magnetic flux field to radiate from the wire rope into the surrounding air. Search coils are positioned close to the wire rope inside this flux field. As the wire rope is

*Naval Civil Engineering Laboratory. Technical Note N-1639: Test and evaluation of the Magnograph™ unit - a nondestructive wire rope tester, by L. D. Underbakke. Port Hueneme, Calif., July 1982.

moved, the flux leakage intersects the search coils and if there is an anomality in the wire rope, such as a broken wire, corrosion, pitting, etc., the flux field is distorted. This induces a signal in the search coils which is then conditioned and displayed. In the case of the MT 75 the data are transmitted to headphones as "clicks" and "crackles". The data can also be recorded on a 1-channel, brush-type recorder for a permanent record. The recorder, however, does not come with the MT 75 and must be obtained elsewhere.

LABORATORY TESTING

Test Procedures

New wire ropes, of 6x25 right-regular-lay-fiber-core construction, with diameters of 1/2 and 3/4 inch were used for the laboratory testing. They were modified with simulated broken wires. The gaps in the crown wires were made with a special chisel that produced clean square breaks. Gap spacings were initally less than 1/128th of an inch and were increased, by filing, in 1/16-inch increments to a maximum of 3/8 inch.

NCEL's wire rope test track was used to move the test wire rope through the MT 75. The test track was designed to accommodate 100-foot loops of wire rope from 1/8 to 2-1/2 inches in diameter. The speed of the wire rope was changed by a variable speed transmission powered by a 1-3/4 horsepower electric motor. The wire rope speeds were varied from 0 to over 800 fpm. Each end support consisted of three 1-foot diameter sheaves that simulated a 4-foot diameter sheave. The larger sheave diameters were needed for wire rope with larger diameters to provide adequate bend radius.

Gap Configuration

A broken wire can, depending on the cause, have various end configurations. For example, a fatigue break produces square ends, a tensile break produces necked down ends, and a shear break produces angular ends. The various types of gap configurations are shown in Figure 3. A series of tests were conducted to determine the effective gap size for all four types of configurations. The results indicate that the signal loudness depended on the clear gap space size in the longitudinal direction.

Gap Orientation

Gap orientation is the location of a broken wire or any other abnormality in relation to the two halves of the search coils located 180 degrees apart in the MT 75. In these tests a wire break could be directly under a search coil or up to 90 degrees from the coil. To determine the effect of gap orientation on signal size, a 1/2-inch wire rope, with two simulated wire breaks about 3 yards apart, was run on the wire rope test track. The broken wires maintained the same orientation after each completed loop. Break A was a broken crown wire and break B was a broken filler wire. The MT 75 was then rotated from 0 to 90 degrees in 22.5-degree increments. The signals were compared to observe any changes in the signal size. Figure 4 shows that the signal size changed from a strong signal to a weak signal. The signal size for breaks A and B differ because of their orientation. The amplitude of the spike in the signal trace is related to the loudness of the click. The higher the amplitude of the spike the louder the click.

Gap Space

A series of tests were conducted on new wire rope in order to determine broken wire signal size, as a function of longitudinal air-gap space.

These tests were conducted on 1/2- and 3/4-inch diameter wire ropes. A rope speed of about 200 fpm was maintained for all the tests. Results showed that gaps of 1/128th inch or less do not always produce clicks. Gap spaces of greater than 1/128 have a detection rate that is much higher. Test data are shown in Figure 5.

Results for gap spaces greater than 1/4 inch are not given because the signal size did not increase after the 1/4-inch gap space was reached. It must be realized that the only signal output from the MT 75 Rope Tester, as provided by the manufacturer, is clicks and crackles in the headphones. The signal size in Figure 6 represents the loudness of the click, although some clicks in the headphones did not produce a signal on the brush-chart recorder.

New wire rope is usually clear of background noise. However, it tends to increase when surface corrosion, internal and external wear, peening, etc. begin to develop. As wire ropes approach the end of their useful life this background noise tends to mask the broken wire signals, making detection much harder. If the background noise becomes great it can completely mask the broken wire signal. However, based on field test results using several NDT devices and data supplied by the manufacturers, background noise is a good indication of the overall condition of the wire rope. When it becomes loud (continuous "thundering") enough to mask the broken wire signals, the wire rope has degraded to a point where it should be considered for replacement.

Rope Speed

The signal generated by the search coils, when the broken wires create a magnetic flux leakage field, is normally proportional to rope speed in DC devices. However, the MT 75 rope tester has a preamplifier and speed compensation circuit, which amplifies the search coil signal and equalizes its strength allowing the wire rope to move as slow as 5 fpm or as fast as 500 fpm with no significant change in signal strength (Figure 7).

Wire rope speeds greater than 200 fpm, while allowing good quality signal pickup, are hazardous because the hand-held unit can be pulled from the inspector's hands, or the inspector could be pulled with the rope if it snags the MT 75. The MT 75 can be removed from the moving wire rope by pulling perpendicular to the axis of the wire rope. If the MT 75 is moved to an angle which is not perpendicular from the wire rope, it is difficult to pull free. A lanyard attachment from the equipment to the MT 75 is recommended for the inspector's safety if rope speeds exceed 200 fpm.

Rope Guides

The MT 75 is designed for use on wire ropes from 3/8- to 3/4-inch in diameter by using different size rope guides. The rope guides perform a two-fold function: (1) they concentrate, in the wire rope, the magnetic field generated by the strong permanent magnets, and (2) they guide the rope through the search coils. A test was conducted on 1/2-inch wire rope to observe the effects of tight and loose fit on each of the search coil sizes. The search coil is available in four sizes: 3/8, 1/2, 5/8, and 3/4 inch. The test results showed that the best signals occurred when the search coil's fit was as snug as possible without it touching the wire rope. Figure 8 shows that the closer fitting coil (1/2-inch diam) produces the best signal-to-background noise ratio.

FIELD TESTING

Tests were performed to evaluate the MT 75's field inspection capabilities. The first test was on a load line of a 35-ton truck crane which was recently inspected by the visual-rag technique shown in Figure 9. The MT 75 shown in (Figure 10) detected broken wires and an area of corrosion which were missed on the earlier inspection. Several other small capacity cranes were also inspected with similar findings. Inspection time was on the order of one sixth that required using the "visual and rag" method. Some of this time was used for a close inspection of those areas which were in the worst condition. Wire ropes on overhead cranes, lift slings, winch wires and elevators were also tested.

The MT 75 was loaned to a Public Works inspection division for two months. The inspectors were given several hours of training on its use and signal interpretation. After the two months, the inspectors provided a brief evaluation of the device. The concensus was that the device was much faster than the standard method. About 8 hours were required for a "visual and rag" inspection of truck crane and only 1.5 hours for the MT 75. Because of the MT 75's light weight, it is easy to handle and the inspectors were inclined to carry it with them and use it in their daily inspections.

CONCLUSIONS

1. The MT 75 provides useful information than cannot be obtained from rag and visual inspection methods, e.g., internal broken wires, corrosion pitting, peening, and nicking.

2. Field tests have shown that the time required for wire rope inspections may be reduced by as much as 80% over that required by the visual and rag method

3. The wire rope can be inspected at higher rope speeds and only those areas that "sound" bad need to be inspected closely.

4. The MT 75 is an effective "electronic rag" which complements the larger, more sophisticated NDT wire rope inspection devices on the market.

RECOMMENDATIONS

1. The MT 75 is recommended for use with the Magnograph™. Its value lies in its ability to inspect small diameter short length wire ropes rapidly, while providing informaton not acquired by the visual and rag method.

2. The MT 75 should be modified to have an easily detachable sensor head. It then could be used either (a) as a hand-held unit or (b) as a unit attached to the equipment on which the wire rope is being inspected.

3. The electronic section (connected to the sensor head by an instrument wire) could be carried by a strap over the inspector's shoulder. This would reduce the danger of the inspector being in close proximity with the moving wire rope and reduce the strain on the inspector during a long inspection.

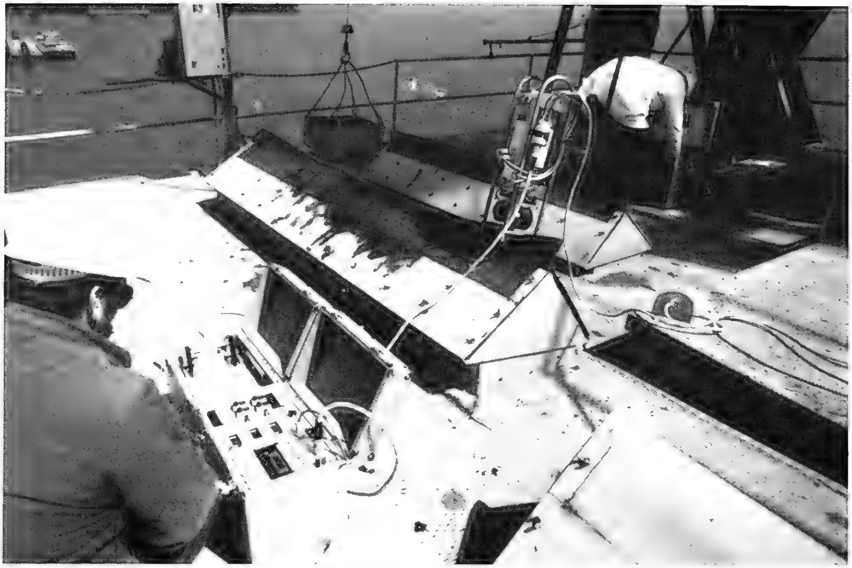


Figure 1. Wire rope being inspected using the Magnograph^{TM}.

Figure 2. MT 75 wire rope inspection device.

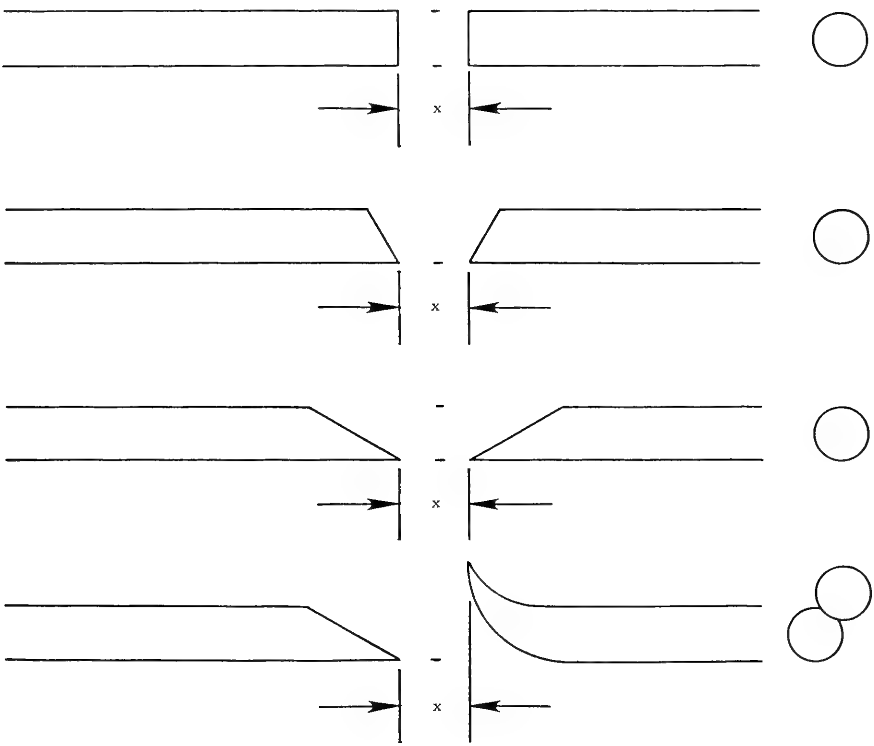


Figure 3. Gap configuration for wire rope.

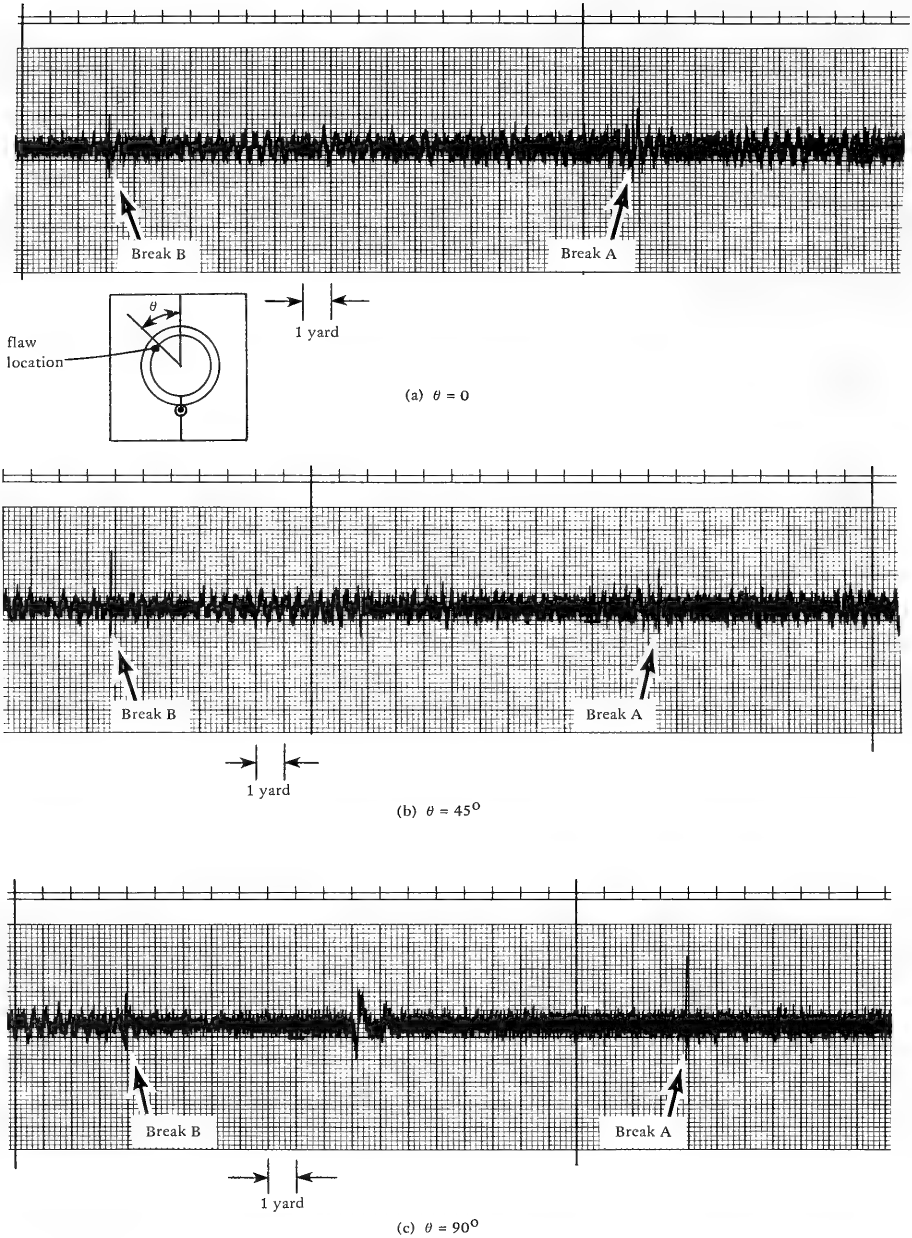
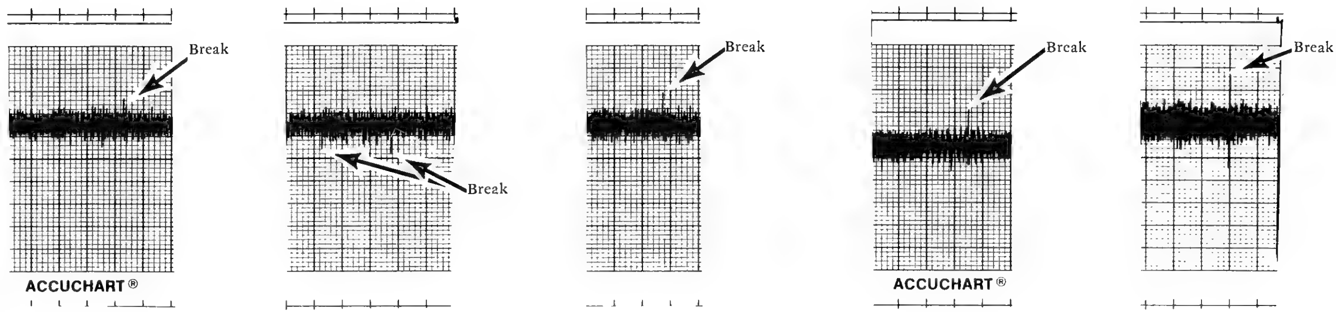
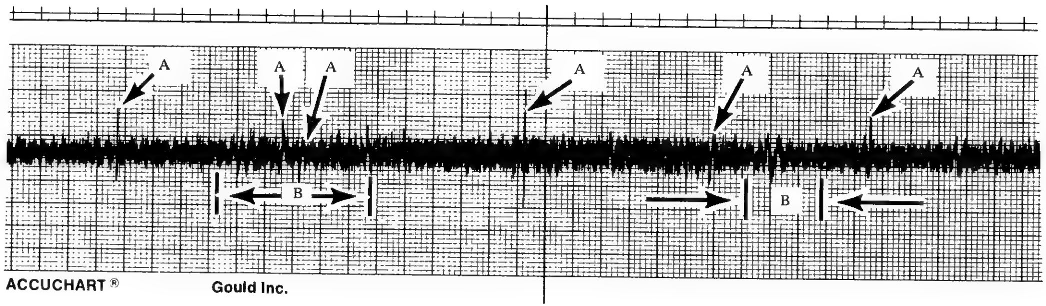


Figure 4. The effect of sensor head rotated on signal strength using a 1/2-inch diameter wire rope.



1/128 in. | 1/16 in. | 1/8 in. | 3/16 in. | 1/4 in.

Figure 5. Broken wire signal size as a function of gap size for 1/2-inch diameter wire rope. Tests at equal rope speeds.



A = Broken wires

B = Areas of corrosion pitting

Figure 6. Data from a field inspection of a 1/2-inch diameter wire rope.

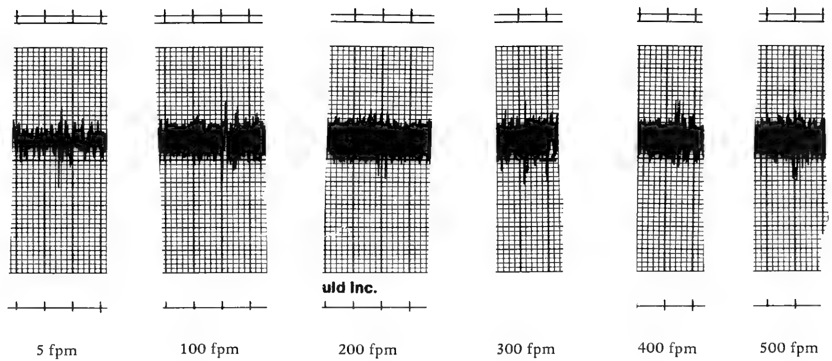
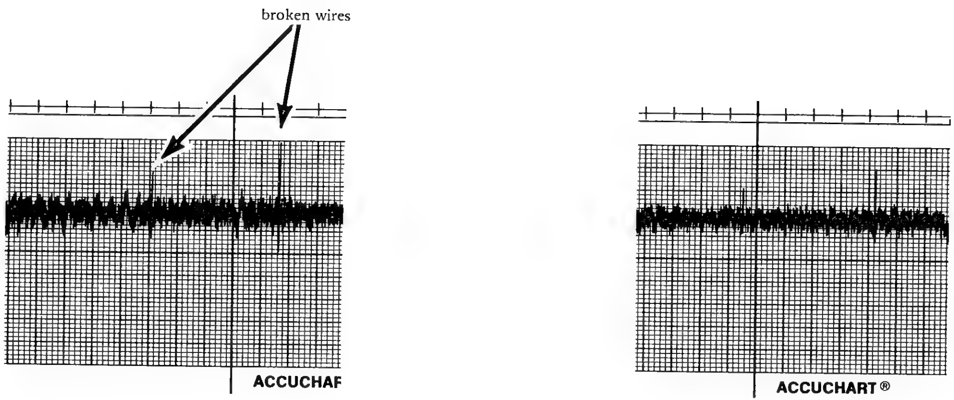


Figure 7. Signal amplitude remains constant as line speed increases. (Recorded at a constant chart speed.)



signal amplitude with 1/2 inch
diameter search coil

signal amplitude with 3/4 inch
diameter search coil

Figure 8. An oversized search coil reduces the signal amplitude (1/2-inch diameter wire rope).

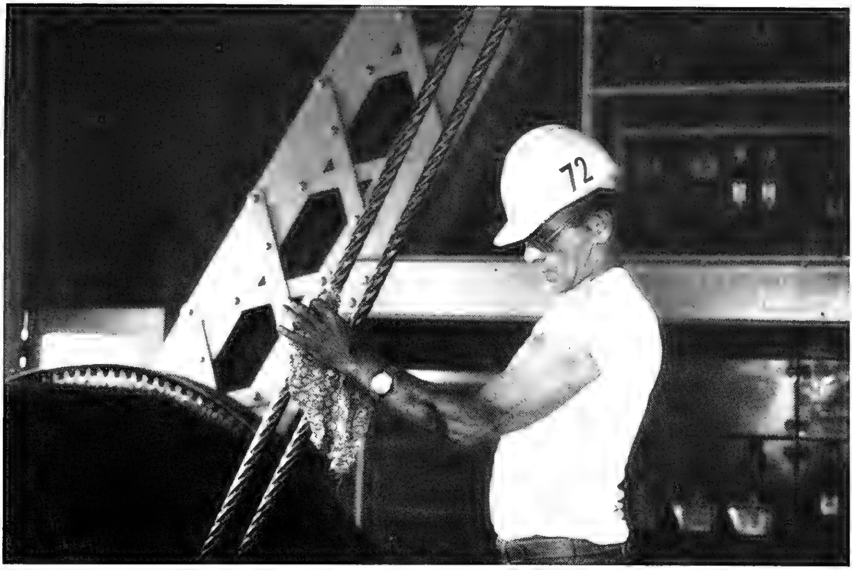


Figure 9. Inspector using the "rag and visual" inspection method.

Figure 10. Inspector using the MT 75 rope tester.

NDT technologies, inc.
125 mohegan trail
south windsor, ct. 06074
(203) 644-8507

Appendix

MT 75

ROPE TESTER

Operation and Maintenance Manual

D E S C R I P T I O N

APPLICATION

The DC Rope Tester MT-75 is used in the field to test for and detect external and internal broken wires, broken cores, deformations, abrasion and corrosion in steel wire ropes. It was developed particularly for routine testing of wire ropes in mining, industrial and military applications where safety and hence the detection of anomalies is of paramount importance.

OPERATION

A section of the steel rope is magnetically saturated in the longitudinal direction by a strong permanent magnet. Where there is an inhomogeneity in the rope such as a broken wire, a broken core, corrosion or abrasion, the magnetic flux is distorted and leakage flux radiates from the rope into the surrounding air space. Test coils are positioned close to the rope to sense the leakage flux. The rope is moved which causes the leakage flux to intersect the coils. The changing intersecting flux induces signals in the coils. The signals are conditioned by electronic circuitry and aurally and/or visually displayed by headphones or a recorder.

The Rope Tester MT-75 consists of the following items:

- 1 ea. Tester Assembly comprising
  - 1 ea. Magnet Assembly
  - 1 ea. Signal Conditioning Circuitry
  - 1 ea. Instrument Case

- 2 ea. Hinged Sensors
- 8 ea. Rope Guides
- 1 ea. Headphone Set
- 1 ea. Carrying Case
- 1 ea. Operation and Maintenance Manual

D E S C R I P T I O N

Fig.1 shows the MT-75 DC Rope Tester with Headphones attached. The tester assembly including headphones is stored in a compact Carrying Case (not shown).

In operation, the Tester Assembly attaches to the rope by means of guide shoes to detect flaws as the rope moves at rates from 5 fpm to high speeds of 500 fpm. Rope flaws are indicated by clicking sounds in the Headphones. The fault signal can also be recorded by a strip chart recorder or a cassette recorder. Different rope flaws can then be identified from their characteristic chart patterns.

The Rope Tester operates from replaceable or rechargeable 9 V batteries.

FUNCTION OF SIGNAL CONDITIONING CIRCUITS

Fig.2 shows a Functional Block Diagram of the instrument. The signal conditioning circuitry comprises the following components:

1. PREAMPLIFIER AND SPEED COMPENSATION CIRCUIT - This circuit amplifies the sense coil signal. At the same time, it equalizes the signal to make its amplitude independent of rope test speed (at speeds greater than 5 fpm).

2. DETECTION LEVEL CIRCUIT - This circuit controls the threshold level at which fault signals are detected.

3. SIGNAL ENHANCER CIRCUIT - This circuit controls the extent to which that part of the test signal above the detection level is enhanced and that part below the detection level is suppressed.

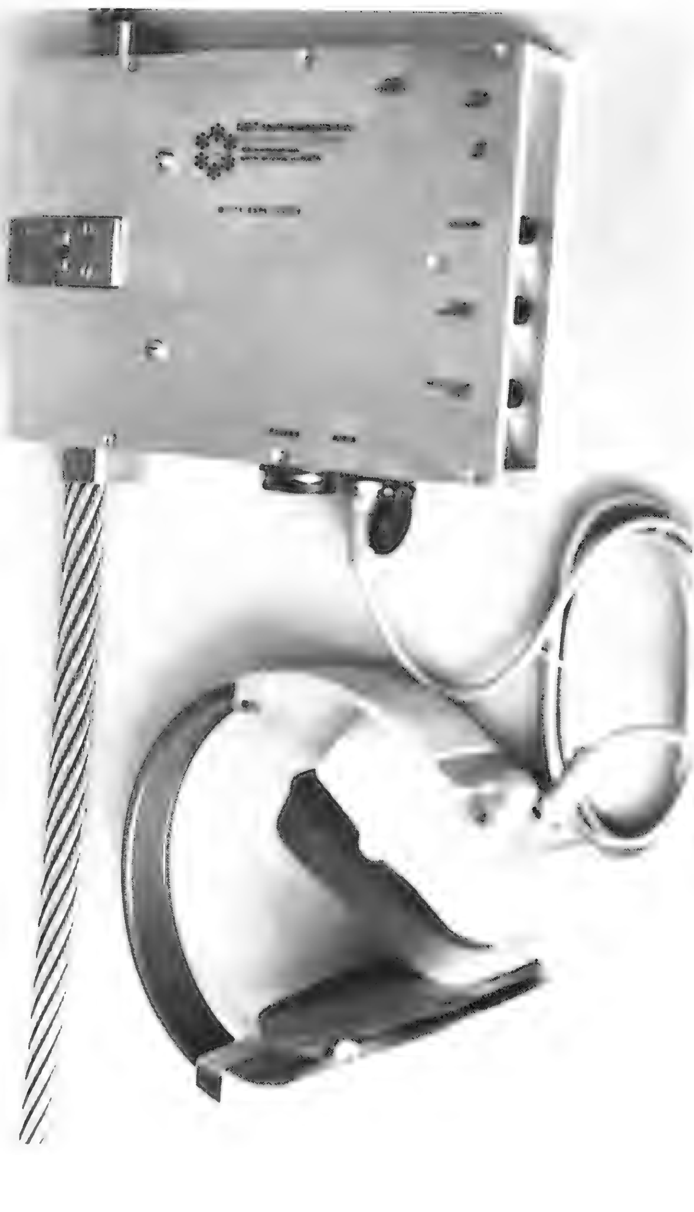


Figure 1. MT-75 rope tester.

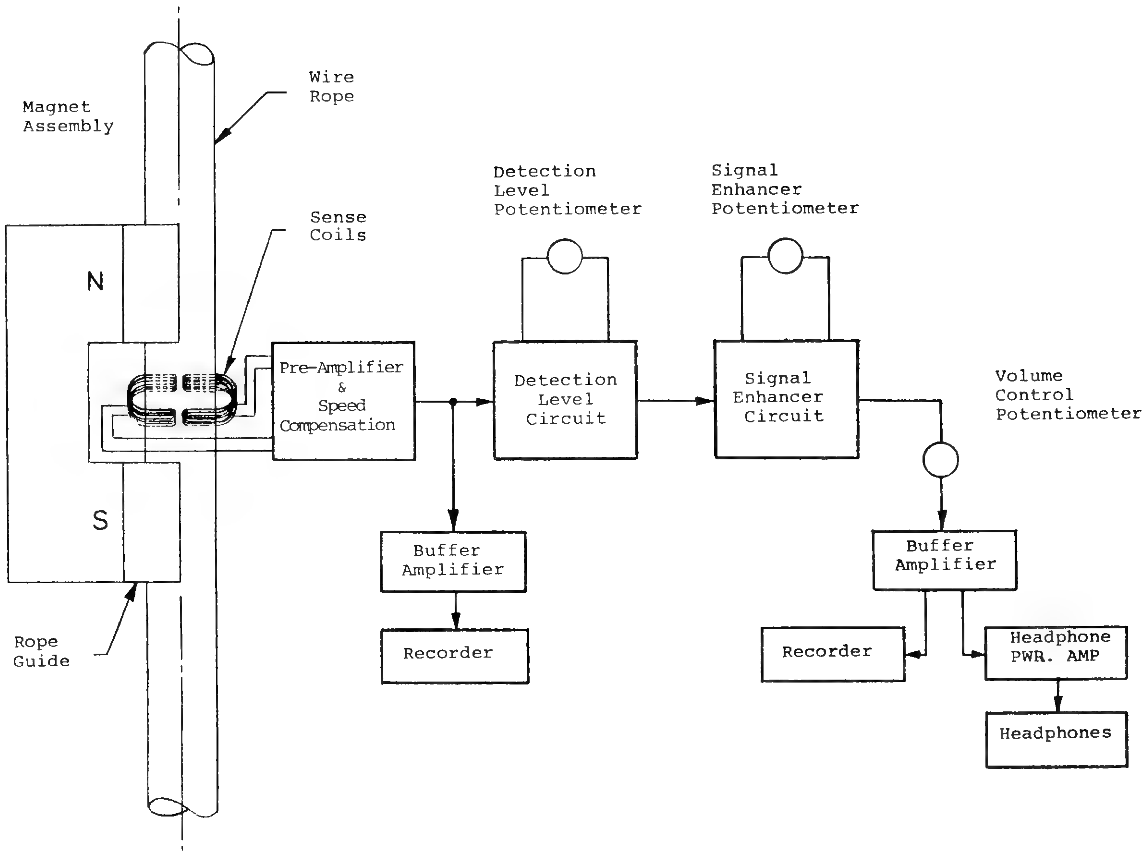


Figure 2. Functional block diagram.

4. <u>BUFFER AMPLIFIERS</u> - The buffer amplifiers amplify the test signals to a level necessary for driving headphones or a recorder.

5. <u>HEADPHONE POWER AMPLIFIER</u> - This amplifier, built into the headphones, amplifies the test signal to a power level necessary for driving the headphone speakers.

S P E C I F I C A T I O N S

Input Limits

Rope Speed:	5 to 500 fpm
Faults Sensed:	External and internal broken wires. Broken core. Corrosion. Abrasion. Various changes in rope structure.
Wire Ropes:	Up to 0.75 inch diameter

Power

Batteries:	9 V Rectangular Batteries (replaceable or rechargeable) Eveready CH22 or equivalent.
Low Voltage Indicator:	LED indicator turns on at end of battery life.
Battery Life:	4-5 hours of continuous operation.

Readout and Recording

Headphones:	Built-in power amplifier including battery. Broken wires indicated by clicking sounds. Other rope deteriorations indicated by "thundering" or "crackling" sounds. Indication independent of speed.

SPECIFICATIONS

Strip Chart Recorder: One or two channel recorder. Rope flaws indicated by characteristic chart patterns. Signal amplitudes independent of rope speed.

Dimensions

Length:	6 inches
Width:	1.5 inches
Depth:	8.5 inches
Weight:	5 lb. (Test instrument including electronic and battery)

Environmental Conditions

Dust proof, splash proof (oil and water)
Humidity to 95%

Operating temperature: 0° to 55° C
Storage temperature: -40° to 55° C

O P E R A T I O N

FUNCTION OF CONTROLS AND CONNECTORS

1. ON-Off Switch - The ON-OFF Switch turns on battery power.

2. BATTERY INDICATOR - Turn-on of the red LED indicator light indicates the end of useful battery life. No light indicates adequate battery voltage for operation of the instrument.

3. BATTERY CHARGE CONNECTOR - This connector allows charging of the rechargeable batteries from the battery charger.

4. AUDIO PLUG - A modified test signal is available at this jack intended for audio detection by headphones. The modified signal can also be recorded by a strip chart recorder or a cassette recorder.

5. RECORD PLUG - The unmodified test signal is available at this jack. It can be recorded by a strip chart recorder or a cassette recorder. The unmodified signal can also be monitored by earphones.

6. VOLUME POTENTIOMETER - This potentiometer controls the volume at the Audio Plug.

7. Detection Level Potentiometer - This potentiometer controls the signal level at the Audio Plug at which fault signals are detected.

8. SIGNAL ENHANCE POTENTIOMETER - This potentiometer controls the degree to which that part of the signal at the Audio Plug above the detection level is enhanced, and that part of the signal below the detection level is suppressed.

O P E R A T I O N

CALIBRATION

1. Mount proper size Guide Shoes and Pick-up Head on the instrument (see page 11 of this manual).

2. Plug Headphones into Audio Plug.

3. Turn Detection Level Potentiometer to the "0" setting (Extreme counterclockwise position).

4. Turn the Signal Enhance Potentiometer to the "10.0" setting (Extreme clockwise position).

5. Turn the Volume Potentiometer to the "10.0" setting (Extreme clockwise position).

6. Turn on Power Switch.

7. LED indicator above power switch should not turn on. (A turned on LED indicates weak batteries. Charge or replace batteries. See page 11 of this manual.)

8. Find a rope section without flaws to be tested.

9. Open Sense Head. Attach instrument to the rope. The instrument is held against the rope by magnetic attraction. Close Sense Head.

10. Put on Headphones. Turn on Headphones.

11. Move instrument by hand up and down along the flawless part of the rope. Crackling or clicking sounds are usually audible.

12. Keep moving the instrument. Increase the detection level by turning the Detection Level Potentiometer in the clockwise direction until crackling or clicking sounds disappear.

13. Make a note of all potentiometer settings for later reference. Lock potentiometers. The instrument is now ready for testing.

14. Note: If during testing, clicking or crackling sounds are audible for rope sections which have definitely no flaws that warrent attention, the detection level can be raised even further. Ideally, the detection level should be set such that for marginally acceptable ropes no sounds are audible.

TESTING INSTALLED ROPES

Audio Inspection

1. Mount proper size Guide shoes (3/8", 1/2", 5/8" or 3/4") on instrument. (Refer to page 11)

2. Mount proper sized Pick-Up Head on instrument. (Refer to page 11)

3. Set all potentiometers to calibrated setting. (Refer to page 7 for calibration procedure.) Lock potentiometers.

4. Plug Headphones into Audio Plug.

5. Open Sense Head. Attach instrument to the rope. The instrument is held against the rope by magnetic attraction. Close Sense Head.

6. Turn on Power Switch.

7. A turned on LED indicates weak batteries. In that case, charge or replace batteries. (Refer to page 11)

8. Put on Headphones. Turn on Headphones.

9. Holding instrument so that it cannot move, run rope at inspection speed.

10. If crackling or clicking sounds are audible, stop rope and visually search for flaws. Flaws can be located by moving instrument manually up and down along the rope and listening to sounds in the headphones.

11. Mark position of flaw for later reference.

Permanent Record:

If a permanent record of the rope condition is desired, a two channel strip chart recorder can be used as follows:

1. Connect first channel of Strip Chart Recorder to Audio Jack.

2. Connect second channel of Strip Chart Recorder to Record Jack.

3. Turn Detection Level Potentiometer to calibrated setting.

4. Turn Volume Potentiometer to 10.0 setting.

5. Turn Signal Enhance Potentiometer to 10.0 setting.

6. Lock Potentiometers.

7. Turn on Instrument Power Switch.

8. Open Sense Head. Attach instrument to rope. Close Sense Head.

9. Signals will be in the 0.1 to 5V range. Adjust Strip Chart Recorder sensitivity accordingly.

10. Start Strip Chart Recorder.

11. Holding instrument so that it cannot move, run rope at inspection speed and record signals.

12. The amplitude and shape of the "Audio" signal can be adjusted by the Volume and Enhancement controls.

13. Inspect strip chart recording. In general, flaws will be indicated by pronounced pulses in the "Audio" recording. The nature of the flaw can usually be better identified from the "Record" recording.

13. Reinspect rope visually making use of the headphones to precisely locate the flaw and compare results with strip chart recording.

SERVICE

BATTERY CHARGING

1. Plug Battery Charger into wall outlet. Turn off instrument Power Switch.
2. Plug Charger Cord into "Battery Charge" connector of instrument.
3. Charge for approximately 14 hours.

CAUTION: Charge Nickel-Cadmium batteries only! Other types of batteries may rupture causing severe damage to instrument.

BATTERY REPLACEMENT

If battery recharging is not feasible, used batteries can be replaced by charged Nickel-Cadmium batteries or by replaceable batteries.

1. Remove 9 screws from instrument lid.
2. Lift off instrument lid.
3. Remove old batteries from battery holders.
4. Install new batteries (9V Rectangular replaceable or rechargeable batteries).
5. Replace instrument lid.

EXCHANGE OF GUIDE SHOES AND SENSE HEAD

1. Loosen two brass srews on bottom of instrument.
2. Remove sense head by <u>gently</u> pulling it in a foreward direction

3. Lift guide shoes and slide them out of the instrument in opposite longitudinal directions. The guide shoes are magnetically retained and moderate force is required.
   Note: Guide Shoes cannot be removed with sense head in place.

4. Insert new guide shoes by reversing the above procedure.

5. Insert sense head by <u>gently</u> pushing it into the magnet assembly.

6. Secure sense head by tightening two brass srews on bottom of instrument.

CAUTION: Keep connectors absolutely clean!
Sense head, guide shoes and magnet assembly can be cleaned with most cleaning compounds. Iron filings can be removed from magnet assembly by using self-adhesive tape.

DISTRIBUTION LIST

AF HQ LEEH (J Stanton) Washington, DC
AFB AF Tech Office (Mgt & Ops), Tyndall, FL; CESCH, Wright-Patterson; HQ MAC/DEEE, Scott, Il; SAMSO/MNND, Norton AFB CA; Stinfo Library, Offutt NE
NATL ACADEMY OF ENG. Alexandria, VA
ARCTICSUBLAB Code 54, San Diego, CA
ARMY ARRADCOM, Dover, NJ; BMDSC-RE (H. McClellan) Huntsville AL; DAEN-MPE-D Washington DC; ERADCOM Tech Supp Dir. (DELSD-L) Ft. Monmouth, NJ; Tech. Ref. Div., Fort Huachuca, AZ
ARMY COASTAL ENGR RSCH CEN Fort Belvoir VA; R. Jachowski, Fort Belvoir VA
ARMY COE Philadelphia Dist. (LIBRARY) Philadelphia, PA
ARMY CORPS OF ENGINEERS Fac Engr Supp Agency, Ft. Belvoir, VA; MRD-Eng. Div., Omaha NE; Seattle Dist. Library, Seattle WA
ARMY CRREL A. Kovacs, Hanover NH; Library, Hanover NH
ARMY DARCOM Code DRCMM-CS Alexandria VA
ARMY ENG DIV HNDED-CS, Huntsville AL; HNDED-FD, Huntsville, AL
ARMY ENG WATERWAYS EXP STA Library, Vicksburg MS
ARMY ENGR DIST. Library, Portland OR
ARMY ENVIRON. HYGIENE AGCY HSE-EW Water Qual Eng Div Aberdeen Prov Grnd MD
ARMY MATERIALS & MECHANICS RESEARCH CENTER Dr. Lenoe, Watertown MA
ARMY MOBIL EQUIP R&D COM DRDME-GS Fuel Tech Br, Ft Belvoir, VA
ARMY MTMC Trans Engr Agency MTT-CE, Newport News, VA
ARMY TRANSPORTATION SCHOOL Code ATSPO CD-TE Fort Eustis, VA
ASST SECRETARY OF THE NAVY Spec. Assist Submarines, Washington DC
BUREAU OF RECLAMATION Code 1512 (C. Selander) Denver CO
CINCPAC Fac Engrng Div (J44) Makalapa, HI
CNM MAT-0718, Washington, DC; NMAT - 044, Washington DC
CNO Code NOP-964, Washington DC; Code OP 323, Washington DC; Code OPNAV 09B24 (H); Code OPNAV 22, Wash DC; Code OPNAV 23, Wash DC; OP-098, Washington, DC; OP-23 (Capt J.H. Howland) Washinton, DC; OP987J, Washington, DC
COMCBPAC Operations Off, Makalapa HI
COMDEVGRUONE CMDR San Diego, CA
COMFLEACT, OKINAWA PWD - Engr Div, Sasebo, Japan; PWO, Kadena, Okinawa; PWO, Sasebo, Japan
COMNAVBEACHPHIBREFTRAGRU ONE San Diego CA
COMNAVSURFLANT Norfolk, VA
COMOCEANSYSLANT PW-FAC MGMNT Off Norfolk, VA
COMRNCF Nicholson, Tampa, FL; Nicholson, Tampa, FL
COMSUBDEVGRUONE Operations Offr, San Diego, CA
NAVSURFPAC Code N-4, Coronado
DEFENSE INTELLIGENCE AGENCY DB-4C1 Washington DC
DEFFUELSUPPCEN DFSC-OWE (Term Engrng) Alexandria, VA; DFSC-OWE, Alexandria VA
DOE Div Ocean Energy Sys Cons/Solar Energy Wash DC
DTIC Defense Technical Info Ctr/Alexandria, VA
DTNSRDC Anna Lab, Code 2724 (D Bloomquist) Annapolis, MD; Anna Lab, Code 4121 (R A Rivers) Annapolis, MD
FLTCOMBATTRACENLANT PWO, Virginia Bch VA
GIDEP OIC, Corona, CA
GSA Assist Comm Des & Cnst (FAIA) D R Dibner Washington, DC
HCU ONE CO, Bishops Point, HI
KWAJALEIN MISRAN BMDSC-RKL-C
LIBRARY OF CONGRESS Washington, DC (Sciences & Tech Div)
MARINE CORPS BASE M & R Division, Camp Lejeune NC; Maint Off Camp Pendleton, CA; PWD - Maint. Control Div. Camp Butler, Kawasaki, Japan; PWO Camp Lejeune NC; PWO, Camp Pendleton CA; PWO, Camp S. D. Butler, Kawasaki Japan
MARINE CORPS HQS Code LFF-2, Washington DC
MCAS Facil. Engr. Div. Cherry Point NC; CO, Kaneohe Bay HI; Code S4, Quantico VA; Facs Maint Dept - Operations Div, Cherry Point; PWD - Utilities Div, Iwakuni, Japan; PWD, Dir. Maint. Control Div., Iwakuni Japan; PWO, Iwakuni, Japan; PWO, Yuma AZ
MCRD SCE, San Diego CA
MILITARY SEALIFT COMMAND Washington DC
NAF PWO, Atsugi Japan
NALF OINC, San Diego, CA
NARF Code 100, Cherry Point, NC; Code 640, Pensacola FL; Equipment Engineering Division (Code 61000), Pensacola, FL

NAS AUW Officers, Brunswick, ME; CO, Guantanamo Bay Cuba; Code 114, Alameda CA; Code 183 (Fac. Plan BR MGR); Code 18700, Brunswick ME; Code 18U (ENS P.J. Hickey), Corpus Christi TX; Code 8E, Patuxent Riv., MD; Dir of Engrng, PWD, Corpus Christi, TX; Dir. Maint. Control Div., Key West FL; Dir. Util. Div., Bermuda; PW (J. Maguire), Corpus Christi TX; PWD - Engr Div, Gtmo, Cuba; PWD - Engr Div, Oak Harbor, WA; PWD Maint. Div., New Orleans, Belle Chasse LA; PWD, Code 1821H (Pfankuch) Miramar, SD CA; PWD, Maintenance Control Dir., Bermuda; PWO Belle Chasse, LA; PWO Chase Field Beeville, TX; PWO Key West FL; PWO Lakehurst, NJ; PWO Sigonella Sicily; PWO, Dallas TX; PWO, Glenview IL; PWO,, Moffett Field CA; SCE Norfolk, VA; SCE, Cubi Point, R.P; Security Offr, Alameda CA

NASDC-WDC T. Fry, Manassas VA

NATL BUREAU OF STANDARDS Kovacs, Washington, D.C.; R Chung Washington, DC

NATL RESEARCH COUNCIL Naval Studies Board, Washington DC

NAVACT PWO, London UK

NAVACTDET PWO, Holy Lock UK

NAVAEROSPREGMEDCEN SCE, Pensacola FL

NAVAIRDEVCEN Code 813, Warminster PA

NAVAIRTESTCEN PATUXENT RIVER PWD (F. McGrath), Patuxent Riv.,MD

NAVAVIONICFAC PW Div Indianapolis, IN

NAVCHAPGRU Engineering Officer, Code 60 Williamsburg, VA

NAVCOASTSYSCEN CO, Panama City FL; Code 423 Panama City, FL; Code 715 (J Quirk) Panama City, FL; Code 715 (J. Mittleman) Panama City, FL; Code 719, Panama City, FL; Library Panama City, FL; PWO Panama City, FL

NAVCOMMAREAMSTRSTA Maint Control Div., Wahiawa, HI; PWO, Norfolk VA; SCE Unit 1 Naples Italy; SCE, Wahiawa HI

NAVCOMMSTA CO, San Miguel, R.P.; Code 401 Nea Makri, Greece; PWD - Maint Control Div, Diego Garcia Is.; PWO, Exmouth, Australia; SCE, Balboa, CZ

NAVCONSTRACEN Curriculum/Instr. Stds Offr, Gulfport MS

NAVEDTRAPRODEVCEN Technical Library, Pensacola, FL

NAVEDUTRACEN Engr Dept (Code 42) Newport, RI

NAVELEXSYSCOM Code PME 124-61, Washington, DC; PME 124-612, Wash DC

NAVEODTECHCEN Code 605, Indian Head MD

NAVFAC PWO, Centerville Bch, Ferndale CA

NAVFACENGCOM Alexandria, VA; Code 03 Alexandria, VA; Code 03T (Essoglou) Alexandria, VA; Code 043 Alexandria, VA; Code 044 Alexandria, VA; Code 0453 (D. Potter) Alexandria, VA; Code 0453C, Alexandria, VA; Code 0454B Alexandria, Va; Code 04A1 Alexandria, VA; Code 09M54, Tech Lib, Alexandria, VA; Code 100 Alexandria, VA; Code 1002B (J. Leimanis) Alexandria, VA; Code 1113, Alexandria, VA

NAVFACENGCOM - CHES DIV. Code 101 Wash, DC; Code 405 Wash, DC; Code 407 (D Scheesele) Washington, DC; Code FPO-1C Washington DC; Code FPO-1E, Wash. DC; Contracts, ROICC, Annapolis MD; FPO-1 Washington, DC; FPO-1EA5 Washington DC; FPO-1P/1P3 Washington, DC; Library, Washington, D.C.

NAVFACENGCOM - LANT DIV. Eur. BR Deputy Dir, Naples Italy; Library, Norfolk, VA; RDT&ELO 102A, Norfolk, VA

NAVFACENGCOM - NORTH DIV. (Boretsky) Philadelphia, PA; CO; Code 04 Philadelphia, PA; Code 09P Philadelphia PA; Code 1028, RDT&ELO, Philadelphia PA; Code 111 Philadelphia, PA; Code 405 Philadelphia, PA; Library, Philadelphia, PA; ROICC, Contracts, Crane IN

NAVFACENGCOM - PAC DIV. (Kyi) Code 101, Pearl Harbor, HI; CODE 09P PEARL HARBOR HI; Code 2011 Pearl Harbor, HI; Code 402, RDT&E, Pearl Harbor HI; Commander, Pearl Harbor, HI; Library, Pearl Harbor, HI

NAVFACENGCOM - SOUTH DIV. Code 90, RDT&ELO, Charleston SC; Library, Charleston, SC

NAVFACENGCOM - WEST DIV. 102; Code 04B San Bruno, CA; Library, San Bruno, CA; O9P/20 San Bruno, CA; RDT&ELO Code 2011 San Bruno, CA

NAVFACENGCOM CONTRACTS AROICC, NAVSTA Brooklyn, NY; Colts Neck, NJ; Dir, Eng. Div., Exmouth, Australia; Eng Div dir, Southwest Pac, Manila, PI; OICC, Southwest Pac, Manila, PI; OICC-ROICC, NAS Oceana, Virginia Beach, VA; OICC/ROICC, Balboa Panama Canal; ROICC AF Guam; ROICC Code 495 Portsmouth VA; ROICC Key West FL; ROICC, Diego Garcia Island; ROICC, Keflavik, Iceland; ROICC, NAS, Corpus Christi, TX; ROICC, Pacific, San Bruno CA; ROICC, Point Mugu, CA; ROICC, Yap; ROICC-OICC-SPA, Norfolk, VA

NAVMAG PWD - Engr Div, Guam; SCE, Subic Bay, R.P.

NAVOCEANO Code 3432 (J. DePalma), Bay St. Louis MS; Library Bay St. Louis, MS

NAVOCEANSYSCEN Code 09 (Talkington), San Diego, CA; Code 4473 Bayside Library, San Diego, CA; Code 4473B (Tech Lib) San Diego, CA; Code 5204 (J. Stachiw), San Diego, CA; Code 5214 (H. Wheeler), San Diego CA; Code 5221 (R.Jones) San Diego Ca; Code 5322 (Bachman) San Diego, CA; Code 6700, San Diego, CA; Hawaii Lab (R Yumori) Kailua, HI; Hi Lab Tech Lib Kailua HI

NAVPETOFF Code 30, Alexandria VA

NAVPGSCOL C. Morers Monterey CA; E. Thornton, Monterey CA

NAVPHIBASE CO, ACB 2 Norfolk, VA; COMNAVBEACHGRU TWO Norfolk VA; Code S3T, Norfolk VA; Harbor Clearance Unit Two, Little Creek, VA; SCE Coronado, SD,CA

NAVRADRECFAC PWO, Kami Seya Japan

NAVREGMEDCEN PWD - Engr Div, Camp Lejeune, NC; PWO, Camp Lejeune, NC; SCE; SCE, Camp Pendleton CA; SCE, Guam; SCE, Newport, RI

NAVSCOLCECOFF C35 Port Hueneme, CA; CO, Code C44A Port Hueneme, CA

NAVSCSOL PWO, Athens GA

NAVSEASYSCOM Code OOC-D, Washington, DC; Code PMS 395 A 3, Washington, DC; Code PMS 395 A2, Washington, DC; Code SEA OOC Washington, DC; PMS-395 A1, Washington, DC; PMS395-A3, Washington, DC; SEA05E1, Washington, D.C.

NAVSECGRUACT Facil. Off., Galeta Is. Panama Canal; PWO, Adak AK; PWO, Edzell Scotland; PWO, Puerto Rico; PWO, Torri Sta, Okinawa; Security Offr, Winter Harbor ME

NAVSHIPREPFAC Library, Guam; SCE Subic Bay

NAVSHIPYD Bremerton, WA (Carr Inlet Acoustic Range); Code 134, Pearl Harbor, HI; Code 202.4, Long Beach CA; Code 202.5 (Library) Puget Sound, Bremerton WA; Code 380, Portsmouth, VA; Code 400, Puget Sound; Code 410, Mare Is., Vallejo CA; Code 440 Portsmouth NH; Code 440, Norfolk; Code 440, Puget Sound, Bremerton WA; L.D. Vivian; Library, Portsmouth NH; PWD (Code 420) Dir Portsmouth, VA; PWD (Code 450-HD) Portsmouth, VA; PWD (Code 457-HD) Shop 07, Portsmouth, VA; PWD (Code 460) Portsmouth, VA; PWO, Bremerton, WA; PWO, Mare Is.; PWO, Puget Sound; SCE, Pearl Harbor HI; Tech Library, Vallejo, CA

NAVSTA CO Roosevelt Roads P.R. Puerto Rico; Dir Engr Div, PWD, Mayport FL; Dir Mech Engr 37WC93 Norfolk, VA; Engr. Dir., Rota Spain; Long Beach, CA; Maint. Cont. Div., Guantanamo Bay Cuba; Maint. Div. Dir/Code 531, Rodman Panama Canal; PWD (LTJG.P.M. Motolenich), Puerto Rico; PWD - Engr Dept, Adak, AK; PWD - Engr Div, Midway Is.; PWO, Guantanamo Bay Cuba; PWO, Keflavik Iceland; PWO, Mayport FL; SCE, Guam; SCE, Pearl Harbor HI; SCE, San Diego CA; SCE, Subic Bay, R.P.; Security Offr, San Francisco, CA

NAVSUBASE SCE, Pearl Harbor HI

NAVSURFWPNCEN PWO, White Oak, Silver Spring, MD

NAVTECHTRACEN SCE, Pensacola FL

NAVWPNCEN Code 2636 China Lake; Code 3803 China Lake, CA; ROICC (Code 702), China Lake CA

NAVWPNEVALFAC Sec Offr, Kirtland AFB, NM

NAVWPNSTA (Clebak) Colts Neck, NJ; Code 092, Colts Neck NJ; Code 092, Concord CA; Maint. Control Dir., Yorktown VA

NAVWPNSTA PW Office Yorktown, VA

NAVWPNSTA PWD - Maint. Control Div., Concord, CA; PWD - Supr Gen Engr, Seal Beach, CA; PWO, Charleston, SC; PWO, Seal Beach CA

NAVWPNSUPPCEN Code 09 Crane IN

NCBC Code 10 Davisville, RI; Code 15, Port Hueneme CA; Code 155, Port Hueneme CA; Code 156, Port Hueneme, CA; PWO (Code 80) Port Hueneme, CA; PWO, Davisville RI

NCR 20, Commander

NMCB FIVE, Operations Dept; Forty, CO; THREE, Operations Off.

NOAA (Dr. T. Mc Guinness) Rockville, MD; Library Rockville, MD

NORDA Code 410 Bay St. Louis, MS; Code 440 (Ocean Rsch Off) Bay St. Louis MS; Code 500, (Ocean Prog Off-Ferer) Bay St. Louis, MS

NRL Code 5800 Washington, DC; Code 5843 (F. Rosenthal) Washington, DC; Code 8441 (R.A. Skop), Washington DC

NROTC J.W. Stephenson, UC, Berkeley, CA

NSC Code 54.1 Norfolk, VA

NSD SCE, Subic Bay, R.P.

NUCLEAR REGULATORY COMMISSION T.C. Johnson, Washington, DC

NUSC Code 131 New London, CT; Code 332, B-80 (J. Wilcox) New London, CT; Code EA123 (R.S. Munn), New London CT; Code TA131 (G. De la Cruz), New London CT

ONR Central Regional Office, Boston, MA; Code 481, Bay St. Louis, MS; Code 485 (Silva) Arlington, VA; Code 700F Arlington VA

PACMISRANFAC HI Area Bkg Sands, PWO Kekaha, Kauai, HI

PERRY OCEAN ENG R. Pellen, Riviera Beach, FL

PHIBCB 1 P&E, San Diego, CA; 1, CO San Diego, CA

PMTC Code 3144, (E. Good) Point Mugu, CA; Code 3331 (S. Opatowsky) Point Mugu, CA; Code 4253-3, Point Mugu, CA; EOD Mobile Unit, Point Mugu, CA

PWC CO Norfolk, VA; CO, (Code 10), Oakland, CA; CO, Great Lakes IL; CO, Pearl Harbor HI; Code 10, Great Lakes, IL; Code 105 Oakland, CA; Code 110, Oakland, CA; Code 120, Oakland CA; Code 128, Guam; Code 154 (Library), Great Lakes, IL; Code 200, Great Lakes IL; Code 200, Guam; Code 400, Great Lakes, IL; Code 400, Oakland, CA; Code 400, Pearl Harbor, HI; Code 400, San Diego, CA; Code 420, Great Lakes, IL; Code 420, Oakland, CA; Code 424, Norfolk, VA; Code 500 Norfolk, VA; Code 505A Oakland, CA; Code 600, Great Lakes, IL; Code 700, San Diego, CA; Library, Code 120C, San Diego, CA; Library, Pensacola, FL; Code 700, Norfolk, VA; Library, Guam; Library, Norfolk, VA; Library, Oakland,

CA; Library, Pearl Harbor, HI; Library, Subic Bay, R.P.; Library, Yokosuka JA; Utilities Officer, Guam
SUPANX PWO, Williamsburg VA
TVA Smelser, Knoxville, Tenn.; Solar Group, Arnold, Knoxville, TN
UCT ONE OIC, Norfolk, VA
UCT TWO OIC, Port Hueneme CA
U.S. MERCHANT MARINE ACADEMY Kings Point, NY (Reprint Custodian)
US DEPT OF INTERIOR Bur of Land Mgmnt Code 583, Washington DC
US GEOLOGICAL SURVEY Off. Marine Geology, Piteleki, Reston VA
US NATIONAL MARINE FISHERIES SERVICE Highlands NY (Sandy Hook Lab-Library)
US NAVAL FORCES Korea (ENJ-P&O)
USCG (G-MP-3/USP/82) Washington Dc; (Smith), Washington, DC; G-EOE-4 (T Dowd), Washington, DC
USCG R&D CENTER CO Groton, CT; D. Motherway, Groton CT
USDA Forest Products Lab. (R. DeGroot), Madison WI; Forest Service Reg 3 (R. Brown) Albuquerque, NM; Forest Service, San Dimas, CA
USNA ENGRNG Div, PWD, Annapolis MD; PWO Annapolis MD; USNA/Sys Eng Dept, Annapolis, MD
USS FULTON WPNS Rep. Offr (W-3) New York, NY
WATER & POWER RESOURCES SERVICE (Smoak) Denver, CO
BERKELEY PW Engr Div, Harrison, Berkeley, CA
CALIF. DEPT OF NAVIGATION & OCEAN DEV. Sacramento, CA (G. Armstrong)
CALIF. MARITIME ACADEMY Vallejo, CA (Library)
CALIFORNIA INSTITUTE OF TECHNOLOGY Pasadena CA (Keck Ref. Rm)
CALIFORNIA STATE UNIVERSITY (Yen) Long Beach, CA; LONG BEACH, CA (CHELAPATI)
CATHOLIC UNIV. Mech Engr Dept, Prof. Niedzwecki, Wash., DC
COLORADO STATE UNIV., FOOTHILL CAMPUS Fort Collins (Nelson)
CORNELL UNIVERSITY Ithaca, NY (Civil & Environ. Engr)
DAMES & MOORE LIBRARY LOS ANGELES, CA
DUKE UNIV MEDICAL CENTER B. Muga, Durham NC; DURHAM, NC (VESIC)
FLORIDA ATLANTIC UNIVERSITY Boca Raton, FL (McAllister)
GEORGIA INSTITUTE OF TECHNOLOGY (LT R. Johnson) Atlanta, GA
HARVARD UNIV. Dept. of Architecture, Dr. Kim, Cambridge, MA
INSTITUTE OF MARINE SCIENCES Morehead City NC (Director)
IOWA STATE UNIVERSITY Ames IA (CE Dept, Handy)
WOODS HOLE OCEANOGRAPHIC INST. Woods Hole MA (Winget)
LEHIGH UNIVERSITY BETHLEHEM, PA (MARINE GEOTECHNICAL LAB., RICHARDS); Bethlehem PA (Linderman Lib. No.30, Flecksteiner)
MAINE MARITIME ACADEMY CASTINE, ME (LIBRARY)
MICHIGAN TECHNOLOGICAL UNIVERSITY Houghton, MI (Haas)
MIT Cambridge MA; Cambridge MA (Rm 10-500, Tech. Reports, Engr. Lib.)
NATL ACADEMY OF ENG. ALEXANDRIA, VA (SEARLE, JR.)
NATURAL ENERGY LAB Library, Honolulu, HI
NEW MEXICO SOLAR ENERGY INST. Dr. Zwibel Las Cruces NM
NY CITY COMMUNITY COLLEGE BROOKLYN, NY (LIBRARY)
OREGON STATE UNIVERSITY (CE Dept Grace) Corvallis, OR; CORVALLIS, OR (CE DEPT, BELL); Corvalis OR (School of Oceanography)
PENNSYLVANIA STATE UNIVERSITY STATE COLLEGE, PA (SNYDER)
PORTLAND STATE UNIVERSITY H. Migliore Portland, OR
PURDUE UNIVERSITY Lafayette IN (Leonards); Lafayette, IN (Altschaeffl); Lafayette, IN (CE Engr. Lib)
SAN DIEGO STATE UNIV. 1. Noorany San Diego, CA
SCRIPPS INSTITUTE OF OCEANOGRAPHY LA JOLLA, CA (ADAMS)
SEATTLE U Prof Schwaegler Seattle WA
SOUTHWEST RSCH INST King, San Antonio, TX; R. DeHart, San Antonio TX
STATE UNIV. OF NEW YORK Buffalo, NY
TEXAS A&M UNIVERSITY College Station TX (CE Dept. Herbich); W.B. Ledbetter College Station, TX
UNIVERSITY OF ALASKA Doc Collections Fairbanks, AK; Marine Science Inst. College, AK
UNIVERSITY OF CALIFORNIA A-031 (Storms) La Jolla, CA; BERKELEY, CA (CE DEPT, GERWICK); BERKELEY, CA (CE DEPT, MITCHELL); Berkeley CA (Dept of Naval Arch.); Berkeley CA (E. Pearson); DAVIS, CA (CE DEPT, TAYLOR); La Jolla CA (Acq. Dept, Lib. C-075A)
UNIVERSITY OF DELAWARE Newark, DE (Dept of Civil Engineering, Chesson)
UNIVERSITY OF HAWAII HONOLULU, HI (SCIENCE AND TECH. DIV.); Ocean Engrng Dept
UNIVERSITY OF ILLINOIS (Hall) Urbana, IL; Metz Ref Rm, Urbana IL; URBANA, IL (DAVISSON); URBANA, IL (LIBRARY)
UNIVERSITY OF MASSACHUSETTS (Heronemus), ME Dept, Amherst, MA
UNIVERSITY OF MICHIGAN Ann Arbor MI (Richart)
UNIVERSITY OF NEBRASKA-LINCOLN Lincoln, NE (Ross Ice Shelf Proj.)
UNIVERSITY OF NEW HAMPSHIRE DURHAM, NH (LAVOIE)

UNIVERSITY OF NOTRE DAME Katona, Notre Dame, IN
UNIVERSITY OF PENNSYLVANIA P. McCleary Dept of Architecture Philadelphia, PA; PHILADELPHIA, PA (SCHOOL OF ENGR & APPLIED SCIENCE, ROLL)
UNIVERSITY OF RHODE ISLAND Narragansett RI (Pell Marine Sci. Lib.)
UNIVERSITY OF SO. CALIFORNIA Univ So. Calif
UNIVERSITY OF TEXAS Inst. Marine Sci (Library), Port Arkansas TX
UNIVERSITY OF TEXAS AT AUSTIN AUSTIN, TX (THOMPSON); Austin, TX (Breen)
UNIVERSITY OF WASHINGTON Seattle WA (M. Sherif); SEATTLE, WA (APPLIED PHYSICS LAB); SEATTLE, WA (MERCHANT); SEATTLE, WA (OCEAN ENG RSCH LAB, GRAY); SEATTLE, WA (PACIFIC MARINE ENVIRON. LAB., HALPERN); Seattle WA (E. Linger)
UNIVERSITY OF WISCONSIN Milwaukee WI (Ctr of Great Lakes Studies)
VENTURA COUNTY PWA (Brownie) Ventura, CA
WOODS HOLE OCEANOGRAPHIC INST. Doc Lib LO-206, Woods Hole MA
ALFRED A. YEE & ASSOC. Librarian, Honolulu, HI
AMETEK Offshore Res. & Engr Div
ANALYTICAL TECH Lawrence, Port Hueneme, CA
ARCAIR CO. D. Young, Lancaster OH
ARVID GRANT OLYMPIA, WA
ATLANTIC RICHFIELD CO. DALLAS, TX (SMITH)
BATTELLE-COLUMBUS LABS (D. Hackman) Columbus, OH
BECHTEL CORP. SAN FRANCISCO, CA (PHELPS)
BETHLEHEM STEEL CO. Dismuke, Bethelehem, PA
BRAND INDUS SERV INC. J. Buehler, Hacienda Heights CA
BRITISH EMBASSY M A Wilkins (Sci & Tech Dept) Washington, DC
BROWN & ROOT Houston TX (D. Ward)
COLUMBIA GULF TRANSMISSION CO. HOUSTON, TX (ENG. LIB.)
CONCRETE TECHNOLOGY CORP. TACOMA, WA (ANDERSON)
CONTINENTAL OIL CO O. Maxson, Ponca City, OK
DESIGN SERVICES Beck, Ventura, CA
DILLINGHAM PRECAST F. McHale, Honolulu HI
DRAVO CORP Pittsburgh PA (Wright)
EVALUATION ASSOC. INC KING OF PRUSSIA, PA (FEDELE)
EXXON PRODUCTION RESEARCH CO Houston, TX (Chao)
FURGO INC. Library, Houston, TX
GEOTECHNICAL ENGINEERS INC. Winchester, MA (Paulding)
GLIDDEN CO. STRONGSVILLE, OH (RSCH LIB)
GOULD INC. Tech Lib, Ches Instru Div Glen Burnie MD
GRUMMAN AEROSPACE CORP. Bethpage NY (Tech. Info. Ctr)
HALEY & ALDRICH, INC. Cambridge MA (Aldrich, Jr.)
HUGHES AIRCRAFT Culver City CA (Tech. Doc. Ctr)
NUSC Library, Newport, RI
LAMONT-DOHERTY GEOLOGICAL OBSERVATORY (Selwyn) Palisades, NY
LIN OFFSHORE ENGRG P. Chow, San Francisco CA
LOCKHEED MISSILES & SPACE CO. INC. Dept 57-22 (Rynewicz) Sunnyvale, CA; L. Trimble, Sunnyvale CA
MARATHON OIL CO Houston TX
MC CLELLAND ENGINEERS INC Corp Library Houston, TX
MEDERMOTT & CO. Diving Division, Harvey, LA
MOBIL PIPE LINE CO. DALLAS, TX MGR OF ENGR (NOACK)
MOFFATT & NICHOL ENGINEERS (R. Palmer) Long Beach, CA
MUESER, RUTLEDGE, WENTWORTH AND JOHNSTON New York (Richards)
NEWPORT NEWS SHIPBLDG & DRYDOCK CO. Newport News VA (Tech. Lib.)
OPPENHEIM Los Angeles, CA
PACIFIC MARINE TECHNOLOGY (M. Wagner) Duvall, WA
PORTLAND CEMENT ASSOC. SKOKIE, IL (CORLEY; SKOKIE, IL (KLIEGER); Skokie IL (Rsch & Dev Lab, Lib.)
R J BROWN ASSOC (McKeehan), Houston, TX
RAYMOND INTERNATIONAL INC. E Colle Soil Tech Dept, Pennsauken, NJ; J. Welsh Soiltech Dept, Pennsauken, NJ
SANDIA LABORATORIES Library Div., Livermore CA; Seabed Progress Div 4536 (D. Talbert) Albuquerque NM
SCHUPACK ASSOC SO. NORWALK, CT (SCHUPACK)
SEAFOOD LABORATORY MOREHEAD CITY, NC (LIBRARY)
SEATECH CORP. MIAMI, FL (PERONI)
SHANNON & WILLSON INC. Librarian Seattle, WA
SHELL DEVELOPMENT CO. Houston TX (C. Sellars Jr.); Houston TX (E. Doyle)

SHELL OIL CO. HOUSTON, TX (MARSHALL); Houston TX (R. de Castongrene)
TIDEWATER CONSTR. CO Norfolk VA (Fowler)
TILGHMAN STREET GAS PLANT (Sreas), Chester, PA
TRW SYSTEMS REDONDO BEACH, CA (DAI)
WESTINGHOUSE ELECTRIC CORP. Annapolis MD (Oceanic Div Lib, Bryan)
WESTINTRUCORP Egerton, Oxnard, CA
WEYERHAEUSER CO. (Fortman) Tacoma, WA
WISS, JANNEY, ELSTNER, & ASSOC Northbrook, IL (D.W. Pfeifer)
WM CLAPP LABS - BATTELLE DUXBURY, MA (LIBRARY)
WOODWARD-CLYDE CONSULTANTS (Dr. M. Akky), San Francisco, CA; (Dr. R. Dominguez), Houston, TX; Library, West. Reg., Walnut Creek, CA; PLYMOUTH MEETING PA (CROSS, III)
AL SMOOTS Los Angeles, CA
ANTON TEDESKO Bronxville NY
BRAHTZ La Jolla, CA
BULLOCK La Canada
DOBROWOLSKI, J.A. Altadena, CA
ERVIN, DOUG Belmont, CA
GERWICK, BEN C. JR San Francisco, CA
LAYTON Redmond, WA
PAULI Silver Spring, MD
R.F. BESIER Old Saybrook CT
BROWN & CALDWELL Saunders, E.M./Oakland, CA
SMITH Gulfport, MS
T.W. MERMEL Washington DC
WM TALBOT Orange CA

DEPARTMENT OF THE NAVY

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DoD 316

U.S.MAIL

85 - 823.001 - 81

1

Document Library LO-206
Woods Hole Oceanographic Institution
Woods Hole, MA 02543