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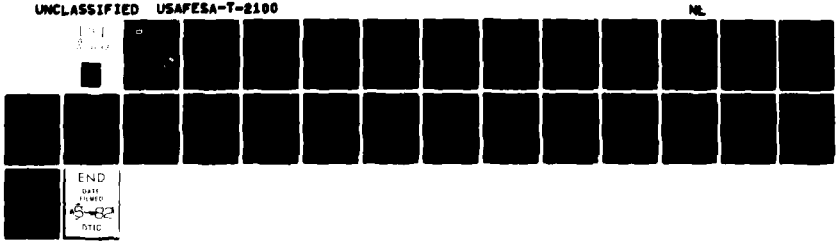

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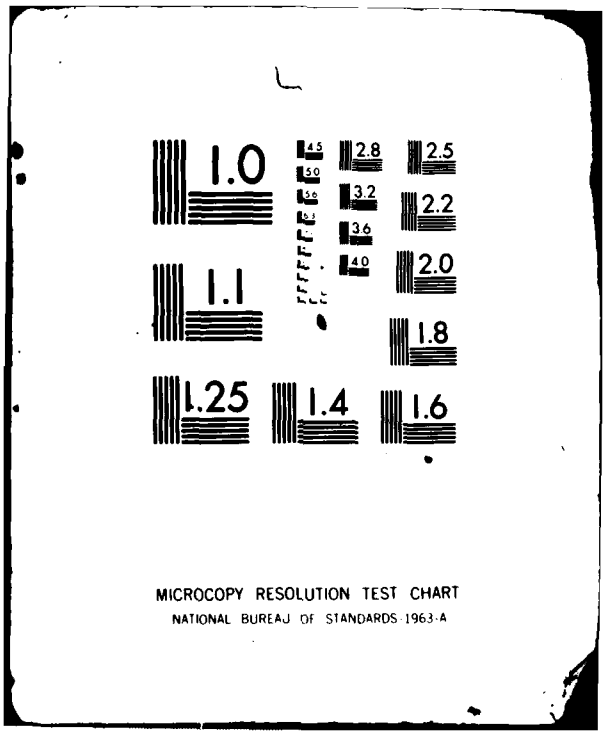
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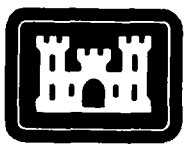

US Army Corps of Engineers
Facilities Engineering Support Agency

FESA-T-2100

COAL-OIL MIXTURES PROBLEMS AND OPPORTUNITIES

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15 January 1982

Prepared for:
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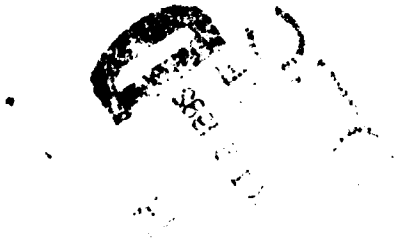

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report presents the problem areas and identifies solutions for implementing Coal-Oil Mixture Technology. The report also contains an overview of industrial and Government experiences in fuel production, stablization, and combustion. The report provides references and points of contact/addresses of those manufacturers currently involved in Coal-Oil Mixture Technology.

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ABSTRACT

This report presents the problem areas and identifies solutions for implementing Coal-Oil Mixture Technology. The report also contains an overview of industrial and Government experiences in fuel production, stablization, and combustion. The report provides references and points of contact/addresses of those manufacturers currently involved in Coal-Oil Mixture Technology.

TABLE OF CONTENTS

COAL OIL MIXTURES PROBLEMS AND OPPORTUNITIES

1. OBJECTIVE

1.1 The objective of this report is to delineate the advantages, disadvantages, technical problems, and solutions for implementing the use of coal-oil mixtures (C.O.M.) on Government and private installations.

2. BACKGROUND/INTRODUCTION

2.1 The use of C.O.M. for fuel is not a new idea. The first patents in the United States date back to 1879.[1] Most research which continued from 1879 through 1933 was devoted to C.O.M. preparation and suspension stabilization. Between 1917 and 1918, one group particularly interested in C.O.M., the Submarine Defense Association,[2] produced about 80 barrels of C.O.M. and tested it aboard the U.S.S. Gem. The fuel was made from Pocahontas Coal and a Texas oil. The fuel was stabilized by the addition of a lime-rosin mixture. On the first tests using this fuel the Gem experienced burner clogging, but this was later remedied by the installation of a steam purge system which kept the burner tips clean.

2.2 The next shipboard tests of C.O.M. were conducted by the Cunard Ship Lines of Great Britain. The tests were conducted aboard the SCYTHIA and the BERENGARIA. Very little documented results exist on these tests; however, it is known that the test aboard the SCYTHIA was fairly successful and the test aboard the BERENGARIA was plagued with coal-oil separation and heat exchanger plugging problems.[3]

2.3 Many small research, development, test, and evaluation (RDT&E) projects were conducted from 1933 through 1942. A very comprehensive history of this period was published by the Bureau of Mines and was presented at the 1942 meeting of the American Society of Mechanical Engineers by W. C. Schroeder.[3] From reading Schroeder's document and noting the lack of RDT&E projects between 1942 and 1974, it becomes quite evident that C.O.M. development and use did not progress to its full potential over this 95 year time period (1879-1974) due to the inexpensive price of oil. Renewed interest in C.O.M. came about during the 1973 Arab Oil Embargo and has continued up to now due to rapidly increasing oil prices and the unstable political situations in the Middle East.

2.4 These three motivators have initiated many C.O.M. demonstration projects and plants in the United States, Canada, England, Japan, and other industrialized countries. The country most advanced in C.O.M. development and use is Japan. Japan, having little of either resource, has developed an active, if not aggressive, role in the development of C.O.M. technology. They have completed research in the following areas:

a. Manufacture and storage of C.O.M.

b. Transportation (ocean transport and pipeline).

c. Combustion technology.

d. Piping and boiler controls.

As of 1979, the Japanese were planning to undertake the research effort to develop instrumentation for C.O.M. quality control.[4,5]

2.5 The most active interests shown here in the United States have been non-Government funded efforts by Florida Power and Light (FP&L) and Florida Power Corporation/DRAVO. FP&L in their search to lower fuel costs funded a $10 million C.O.M. demonstration project. This project was so successful that FP&L has built a $7 million C.O.M. fuel processing facility at their Sanford power station. This facility produces C.O.M. for use in the 400 MW, previously oil fired, power plant.[6]

2.6 Severely hurt by the 1974 Arab Oil Embargo, Florida Power Corporation was forced to examine alternate energy/fuel sources. After examining the economics of many alternate fuels they concluded that C.O.M. was the best alternate fuel for their facilities. Therefore, Florida Power Corporation formed a partnership with DRAVO Corporation to produce C.O.M. Their combined research effort culminated in a series of test burns at Florida Power's Crystal River Plant located outside of Petersburg, Florida. These tests were so successful that Florida Power/DRAVO are presently building a permanent C.O.M. manufacturing plant near St. Petersburg. This plant will not only produce C.O.M. for their power plants, but will also provide the fuel for any concern wanting to purchase it.[7]

3. TECHNICAL PROBLEM AREAS AND SOLUTIONS

3.1 Comparing the data presented in the references, the major problem areas which were identified in all the projects, domestic and foreign, were very much the same. This was due to the use of C.O.M. in plants/facilities which were primarily designed to be oil fired.

3.2 The following technical problems were identified in those efforts:

a. Pipe, flame retention head, and pump impeller erosion.

b. Slag accumulation on heat exchanger surfaces.

c. Coal/oil separation during long term storage.

d. Environmental considerations due to SO_x, NO_x, and coal ash.

e. Coal granulation process.

f. Coal ash removal from oil fired boilers.

g. Burner technology.

h. Furnace/boiler derating.

3.3 Solutions to these problems have either been identified or are under investigation. The identified solutions are as follows:

a. Florida Power Corporation/DRAVO has found that by using a coal granulation size of 44 microns (325 mesh), pipe, flame retension head, and pump impeller, erosion was reduced and plant modifications could be kept to a minimum. When using a coal granualation size of 74 microns (200 mesh), a combination of replaceable nozzle inserts, long radius elbow pipe, and tougher materials for pipe, pump impeller, and nozzles are needed. The use of ball and butterfly valves also reduces the risk of clogging and erosion.[8]

b. To reduce or eliminate slag accumulation on heat exchanger surfaces requires the installation of soot blowers in the boiler walls. If a coal granulation size of 44 microns (325 mesh) can be used, the slagging problem is even more reduced.

c. The use of heated and agitated tanks, and recirculation, are methods of controlling coal-oil separation. Two methods which reduce the need for periodic agitation or recirculation are the use of 44 micron coal and the ultrasonic mixing of coal and oil.[9,10]

d. In addressing the environmental questions, each states emission laws must be evaluated separately. Based upon the state emission laws, engineers will be able to determine the suitable coal sulpher ranges and size the pollution abatement equipment accordingly. It will be required that either bag houses or electrostatic precipitators be used to reduce the coal fly ash discharge.

e. There are three methods presently used to granulate coal for use in C.O.M. These are hammer mill/ball mill combination, Szego Grinding Mill, and fluid mill. The hammer mill/ball mill combinations, and the Szego Grinding Mill, are the least expensive types to use for 200 mesh size coal. To obtain ultrafine C.O.M., the more expensive fluid mills must be used. Florida Power Corporation/DRAVO has taken an active interest in fluid mill technology. Their engineers feel that ultrafine C.O.M. produces fewer retrofit and maintenance problems over long operating times. They also have been able to mill ultrafine C.O.M. at a competitive price (2% above 200 mesh C.O.M.) on an industrial scale.[8] The offset of lower maintenance costs will probably make ultrafine C.O.M. "the way to go."

f. Before C.O.M. can be used in boilers that were originally designed to be oil fired, an ash removal system must be incorporated into the system. Coal fired boilers that were converted to oil have either had their ash handling systems removed or they have fallen into disrepair. In either event, the expenditure for ash handling systems must be planned for.

g. Burner technology has been addressed in Government and private sector demonstration projects. It has been found that steam atomization of the fuel causes considerable burner tip and heat exchanger slagging. Test results have shown that air atomization produces less slagging, therefore, it is recommended that air atomization be used wherever possible.

h. Boiler derating due to C.O.M. use is a controversial subject. Pittsburgh Energy Technology Center (PETC) has burned C.O.M. in a 3.34 MBtuh [100 horsepower (hp)] firetube boiler and in a 23.4 MBtuh (700 hp) water tube boiler. PETC found that when using C.O.M. manufactured from a 50%-50% mixture of Pittsburgh seam coal (90% minus 200 mesh) and No. 6 fuel oil, no boiler derating was required in either boiler.[12, 13] However, in presentations given at the Energy Technology Conference on 11 March 1981 in Washington, DC, representatives from Florida Power Corporation and New England Power Service Corporation stated that their boilers had to be derated. In further conversations with the representatives, it was determined that boiler derating must be done on a case-by-case basis. This is due to the differences in boiler physical parameters.

4. DISCUSSION

4.1 All of the above major problem areas and solutions have been identified through foreign and domestic research projects. Because this much data has been gathered on C.O.M. manufacture and combustion, the Department of Energy (DOE) considers C.O.M. a proven technology no longer requiring further research and development. Therefore, DOE is in the process of phasing out the remaining demonstration projects and has cut the funding on all new C.O.M. projects.[14]

4.2 Despite the impressive data base that exists on C.O.M., four questions still remain concerning whether or not Army installations should use C.O.M. These are:

a. Why should the Army use it,

b. Is further testing under Army operation conditions warranted,

c. How much will it cost, and

d. Who will modify the plant to burn C.O.M.?

4.3 First of all, the Army should no longer continue to use oil in large boilers. In the national interest the Army should rely on alternate fuels, such as coal, wood, and refuse derived fuel. Recognizing this fact, coal fired boilers would provide the necessary independence. However, where direct coal conversion is economically prohibitive due to plant age, size, reduced coal capability, or lack of storage and handling facilities, C.O.M. is a viable alternative to reduce oil dependence.

4.4 Second, to date C.O.M. has not been tested in boilers of the size typically used on Army installations, nor has C.O.M. been evaluated under operating conditions at an Army installation. Therefore, the Army should conduct a test program to evaluate C.O.M. in these two areas prior to making any decision on whether or not to use C.O.M. as a fuel.

4.5 Third, no published C.O.M. conversion costs are presently available. The major C.O.M. conversions have been done by private industry and the cost data is proprietary information. It is known that the cost of C.O.M. conversion is so variable by geographic location that a case-by-case analysis of each Army facility would have to be conducted to reflect a realistic cost. This cost analysis should include:

a. C.O.M. commercial availability by location,

b. Cost of boiler modifications and environmental protection equipment,

c. Manpower impact between coal fired plant versus C.O.M. fired plant, and

d. Savings due to extended life of oil fired plants through use of C.O.M. versus cost of a new coal fired plant.

In other words, a total system analysis must be conducted.

4.6 Fourth, converting oil fired boilers to C.O.M. has been done successfully by PETC, Florida Power Corporation, and Florida Power and Light. Florida Power Corporation/DRAVO will not only sell fuel but will also place the customer in contact with the corporation that converted their plant. It should be stressed that if the Army intends to make C.O.M. conversion a successful venture it is important to contract conversion projects only to those corporations who are qualified in the state-of-the-art.

5. SUMMATION

5.1 Even though C.O.M. has been extensively tested, the only major data base for C.O.M. conversion exists in the private sector on plants ranging from 680 to 1360 MBtuh (200 to 400 M watts). Because the Army does not own plants of this size, the existing data base, although useful, does not provide all

the information needed for the Army to make a decision concerning C.O.M. conversion of its boiler plants.

5.2 Areas in need of Army investigation are:

a. Method to decide which plants should be converted,

b. Method/cookbook for systems analysis on selected plants to determine conversion costs,

c. Fuel (C.O.M.) specification based upon Btu output,

d. Cost of fuel made to the specification,

e. Mixability and combustion characteristics of the combination of different manufacturers fuels made to the Government specification, and

f. Impact on management and labor force due to C.O.M. conversion.

5.3 One area the Army will not investigate is the area of C.O.M. production. Data presented in references 4 and 5 show that C.O.M. can only be economically produced on an industrial scale in order to offset the capital equipment expenditure. In other words, there must be more than one fuel user in the transportable area (50 mile radius) of the fuel plant before the fuel becomes competitive with oil or coal. Therefore, the Army/DOD will purchase C.O.M. from a fuel specification based upon Btu output and leave the manufacturing problems to private industry.

6. CONCLUSIONS

6.1 It is recognized that C.O.M. technology is an interim method/approach which would allow the Army to reduce its oil consumption over a relatively short time period. Army installations should evaluate and use C.O.M. in this light; however, special emphasis will be placed on coal water mixture (C.W.M.) technology which could allow the use of coal as a primary fuel in oil fired boilers. C.W.M. is in the research and development stage at this time. If C.W.M. proves to be technologically/economically feasible, its use would reduce the need for major capital expenditures for new coal fired plants plants and would decrease the time to complete the Army coal conversion program.

6.2 Appendix A contains a listing of those persons and corporations involved in C.O.M. technology and industrial use. This listing was obtained from the US Department of Energy.

6.3 Any questions concerning this report should be directed to James F. Thompson, Jr., of FESA-T (664-5732/5864).

7. REFERENCES

(1) U. S. 219,181 (1879), H. R. Smith and H. M. Munsell.

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(14) D. Bienstock, Pittsburgh Energy Technology Center, U. S. Department of Energy, Coal Oil Mixture Panel at Energy Technology Showcase, 11 March 1981, Washington, DC.

APPENDIX A
COAL-OIL MIXTURE SUPPLIERS AND USERS

Adelphi Center for Energy Studies
Adelphi Research Center, Inc.
Adelphi University
Garden City, L.I., New York
John P. Dooer
phone (516) 248-1636

Allied Oil Company
Ashland Oil, Inc.
Cleveland, Ohio

American Refining Co., Inc.
Villanova, Pennsylvania

Atlantic Richfield Company
(ARCO Petroleum Products Co.)
Harvey, Illinois

Carbonyl Company
San Andreas, California

Cepheus Industries, Inc.
Albany, New York

Cibro Petroleum Products
Albany, New York

CoaLiquid, Inc.
Louisville, Kentucky
Dave Fuller, phone (502) 893-0106

Coaltech-Farrier, Inc.
Houston, Texas

Columbia Chase Corporation
Braintree, Massachusetts

Columbia/Surftex Fuel Inc.
McKeesport, Pennsylvania

Combustion Engineering, Inc.
R&D Sales
Windsor, Connecticut

Combustion Processes, Inc.
New York, New York

COMCO (Dravo Corporation)
Pittsburgh, Pennsylvania

Conoco Coal Development Co.
(CONOCO)
Library, Pennsylvania

Ergon, Inc.
Jackson, Mississippi

Ernest C. Friedrich
New Richmond, Ohio

Florida Power Corporation
3201 34th St. South
St. Petersburg, FL 33733
Larry A. Rodriquez
phone (813) 866-4230

Florida Power and Light
Miami, FL 33152
Alan S. Mendelssohn
phone (305) 552-3923

GATX Corporation
Chicago, Illinois

Hydro-Coal, Inc.
New York, New York

Indian River Industrial
Contractors, Inc.
Jacksonville, Florida

Inter-Mountain Coals, Inc.
Charlottesville, Virginia

Island Creek Coal Company
Lexington, Kentucky

Liquid Carbon, Inc.
Hackensack, New Jersey

Methacoal Corporation
Dallas, Texas

J. W. Miller & Associates, Inc.
Charleston, West Virginia

Nalco Chemical Company
Naperville, Illinois

APPENDIX A (CONTINUED)
COAL-OIL MIXTURE SUPPLIERS AND USERS

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Pittsburgh, PA
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C. H. Sprague & Son Company
Portsmouth, New Hampshire

Systems Technology Corporation
Xenia, Ohio

The Standard Oil Company (Ohio)
Cleveland, Ohio

Wyatt, Incorporated
New Haven, Connecticut

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ATTN: Dept of Mechanics
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HQDA (DAEN-MPO-B)
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HQDA (DAEN-MPR-A)
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HQDA (DAEN-MPO-U)
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HQDA (DAEN-MPZ-A)
WASH DC 20314

HQDA (DAEN-MPZ-E)
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HQDA (DAEN-MPZ-G)
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Facilities Engineer
Carlisle Barracks
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Facilities Engineer
Fort Chaffee
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Fort Dix
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Facilities Engineer
Fort Eustis
Fort Eustis, VA 23604

Facilities Engineer
Fort Gordon
Fort Gordon, GA 30905

Facilities Engineer
Fort Hamilton
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Facilities Engineer
Fort A P Hill
Bowling Green, VA 22427

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Fort Jackson
Fort Jackson, SC 29207

Facilities Engineer
Fort Knox
Fort Knox, KY 40121

Facilities Engineer
Fort Lee
Fort Lee, VA 23801

Facilities Engineer
Fort McClellan
Fort McClellan, AL 36201

Facilities Engineer
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Presidio of Monterey
Presidio of Monterey, CA 93940

Facilities Engineer
Fort Pickett
Blackstone, VA 23824

Facilities Engineer
Fort Rucker
Fort Rucker, AL 36362

Facilities Engineer
Fort Sill
Fort Sill, OK 73503

Facilities Engineer
Fort Story
Fort Story, VA 23459

Facilities Engineer
Kansas Army Ammunition Plant
Parsons, KS 67357

Facilities Engineer
Lone Star Army Ammunition Plant
Texarkana, TX 75501

Facilities Engineer
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Shreveport, LA 71130

Facilities Engineer
Milan Army Ammunition Plant
Milan, TN 38358

Facilities Engineer
Pine Bluff Arsenal
Pine Bluff, AR 71601

Facilities Engineer
Radford Army Ammunition Plant
Radford, VA 24141

Facilities Engineer
Rock Island Arsenal
Rock Island, IL 61201

Facilities Engineer
Rocky Mountain Arsenal
Denver, CO 80340

Facilities Engineer
Scranton Army Ammunition Plant
156 Cedar Avenue
Scranton, PA 18503

Facilities Engineer
Tobyhanna Army Depot
Tobyhanna, PA 18466

Facilities Engineer
Tooele Army Depot
Tooele, UT 84074

Facilities Engineer
Arlington Hall Station
400 Arlington Blvd
Arlington, VA 22212

Facilities Engineer
Cameron Station, Bldg 17
5010 Duke Street
Alexandria, VA 22314

Facilities Engineer
Sunny Point Military Ocean Terminal
Southport, NC 28461

Facilities Engineer
US Military Academy
West Point Reservation
West Point, NY 10996

Facilities Engineer
Fort Ritchie
Fort Ritchie, MD 21719

Facilities Engineer
Army Materials & Mechanics
Research Center
Watertown, MA 02172

Facilities Engineer
Ballistics Missile Advanced
Technology Center
P.O. Box 1500
Huntsville, AL 35807

Facilities Engineer
Fort Wainwright
172d Infantry Brigade
Fort Wainwright, AK 99703

Facilities Engineer
Fort Greely
Fort Greely, AK 98733

Facilities Engineer
Fort Richardson
Fort Richardson, AK 99505

Facilities Engineer
Harry Diamond Laboratories
2800 Powder Mill Rd
Adelphi, MD 20783

Facilities Engineer
Fort Missoula
Missoula, MT 59801

Facilities Engineer
New Cumberland Army Depot
New Cumberland, PA 17070

Facilities Engineer
Oakland Army Base
Oakland, CA 94626

Facilities Engineer
Vint Hill Farms Station
Warrentown, VA 22186

Facilities Engineer
Twin Cities Army Ammunition Plant
New Brighton, MN 55112

Facilities Engineer
Volunteer Army Ammunition Plant
Chattanooga, TN 37401

Facilities Engineer
Watervliet Arsenal
Watervliet, NY 12189

Facilities Engineer
St Louis Area Support Center
Granite City, IL 62040

Facilities Engineer
Fort Monmouth
Fort Monmouth, NJ 07703

Facilities Engineer
Redstone Arsenal
Redstone Arsenal, AL 35809

Facilities Engineer
Detroit Arsenal
Warren, MI 48039

Facilities Engineer
Aberdeen Proving Ground
Aberdeen Proving Ground, MD 21005

Facilities Engineer
Jefferson Proving Ground
Madison, IN 47250

Facilities Engineer
Dugway Proving Ground
Dugway, UT 84022

Facilities Engineer
Fort McCoy
Sparta, WI 54656

Facilities Engineer
White Sands Missile Range
White Sands Missile Range, NM 88002

Facilities Engineer
Yuma Proving Ground
Yuma, AZ 85364

Facilities Engineer
Natick Research & Dev Ctr
Kansas St.
Natick, MA 01760

Facilities Engineer
Fort Bragg
Fort Bragg, NC 28307

Facilities Engineer
Fort Campbell
Fort Campbell, KY 42223

Facilities Engineer
Fort Carson
Fort Carson, CO 80913

Facilities Engineer
Fort Drum
Watertown, NY 13601

Facilities Engineer
Fort Hood
Fort Hood, TX 76544

Facilities Engineer
Fort Indiantown Gap
Annville, PA 17003

Facilities Engineer
Fort Lewis
Fort Lewis, WA 98433

Facilities Engineer
Fort MacArthur
Fort MacArthur, CA 90731

Facilities Engineer
Fort McPherson
Fort McPherson, GA 30330

Facilities Engineer
Fort George G. Meade
Fort George G. Meade, MD 20755

Facilities Engineer
Fort Polk
Fort Polk, LA 71459

Facilities Engineer
Fort Riley
Fort Riley, KS 66442

Facilities Engineer
Fort Stewart
Fort Stewart, GA 31312

Facilities Engineer
Indiana Army Ammunition Plant
Charlestown, IN 47111

Facilities Engineer
Joliet Army Ammunition Plant
Joliet, IL 60436

Facilities Engineer
Anniston Army Depot
Anniston, AL 36201

Facilities Engineer
Corpus Christi Army Depot
Corpus Christi, TX 78419

Facilities Engineer
Red River Army Depot
Texarkana, TX 75501

Facilities Engineer
Sacramento Army Depot
Sacramento, CA 95813

Facilities Engineer
Sharpe Army Depot
Lathrop, CA 95330

Facilities Engineer
Seneca Army Depot
Romulus, NY 14541

Facilities Engineer
Fort Ord
Fort Ord, CA 93941

Facilities Engineer
Presidio of San Francisco
Presidio of San Francisco, CA 94129

Facilities Engineer
Fort Sheridan
Fort Sheridan, IL 60037

Facilities Engineer
Holston Army Ammunition Plant
Kingsport, TN 37662

Facilities Engineer
Baltimore Output
Baltimore, MD 21222

Facilities Engineer
Bayonne Military Ocean Terminal
Bayonne, NJ 07002

Facilities Engineer
Bay Area Military Ocean Terminal
Oakland, CA 94626

Facilities Engineer
Gulf Output
New Orleans, LA 70146

Facilities Engineer
Fort Huachuca
Fort Huachuca, AZ 86513

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Letterkenny Army Depot
Chambersburg, PA 17201

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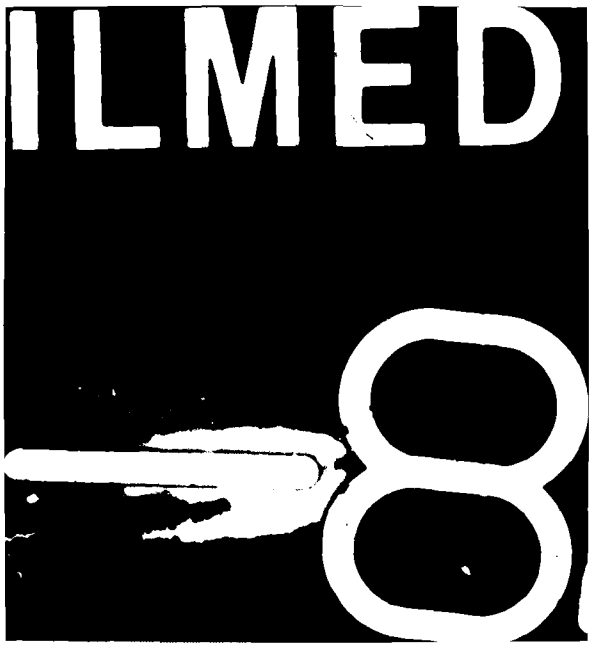
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