Public Health Service Engineering Capabilities During Disaster Responses:

Handbook for Deploying the Appropriate Public Health Service Engineer

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U.S. Public Health Service
Engineer Professional Advisory Committee
Emergency Preparedness Subcommittee

Disclaimer

This document provides guidance on the Engineering Professional Advisory Committee's (EPAC) current thoughts on the subject. An alternative approach may be used if such approach satisfies the situation. Periodically, EPAC will review this handbook and modify it according to comments submitted by people using the handbook.

Contributors

This document was produced by members of the EPAC, Emergency Preparedness Subcommittee. It is based, in part, on previous informational documents developed by the Subcommittee. The Emergency Preparedness Subcommittee members that provided significant input to this document were:

Lieutenant Chris Bradley
Captain Jose Cuzme
Lieutenant Commander David Elder
Captain Scott Hamilton
Commander Kathy Poneleit
Commander John Riegel
Captain Sven Rodenbeck, Chairperson
Commander Jim Simpson
Commander Andy Smith
Lieutenant Commander Mary Weber

Any comments or questions concerning this document should be sent to Captain Sven Rodenbeck, Chairperson, Emergency Preparedness Subcommittee, EPAC at Srodenbeck@cdc.gov.

Introduction

Most U.S. Public Health Service (PHS) deployments have been typically clinically oriented regardless of the disaster. Engineers, however, are a critical component of a comprehensive public health response team. This report is intended to familiarize the reader, primarily managers charged with organizing the PHS response to disasters and emergencies, with the capabilities of the engineering disciplines and to facilitate selection of the most appropriate engineer for the emergency at hand. A cadre of PHS engineers, formed from a variety of disciplines, is committed to responding to disasters and emergencies on short notice and making a positive contribution.

Overview of Capabilities

Engineers apply the theories and principles of science and mathematics to research. They develop economical solutions to technical problems. Their work is the link between scientific discoveries and commercial applications. They possess strong problem-solving and organizational skills. They have the analytical and technical skills to evaluate problems, develop solutions, and bring those solutions to reality. Engineers design, construct, operate, and repair all of the systems and equipment that the general public has come to rely upon in their every day activities.

While engineers specialize, their capabilities tend to transcend their specialization. For example, a civil engineer and an environmental engineer both typically possess expertise in water resources. While all engineers tend to possess many common characteristics that are desirable in most deployment scenarios:

Engineers are problem solvers --	they can contribute to pre-deployment planning.
Engineers are detail oriented --	they can contribute to logistics, including shelter, food & water, and transportation.
Engineers have computer skills --	they can offer hardware support, database management, and electronic record keeping.
Engineers have technical skills --	they can operate, maintain, and repair equipment (e.g., radios, computers, biomedical devices, pumps).

More than 25 major specialties are recognized by professional societies. The major branches have numerous subdivisions. In this report, the engineering specialties within the PHS are described and the contribution an engineer can make during emergency/disaster deployments are discussed. The two tables provided in this document identify (1) the different types of engineering duties/tasks/problems that may need to be addressed during natural or man-made disasters and (2) the particular engineering specialities that

could be utilized to perform those duties/tasks/problems. More detailed descriptions of the different types of engineers are included in the enclosed glossary.

Using the description and information provided by personnel at the disaster area and the two enclosed tables, the appropriate authorities can determine which type of engineer(s) will meet the needs of the mission. The glossary can also be used to comparing the mission requirements with the capabilities of the various engineering specialties. If the mission requires that the engineers will provide detailed engineering evaluations (e.g., development of construction plans or detailed evaluation of a system [e.g., water supply distribution system]), the engineer or the lead engineer for the mission should be professionally licensed (i.e., Professional Engineer [P.E.]) or have a similar credential (e.g., Certified Industrial Hygienist).

In addition to solving the problems identified in the two tables. PHS engineers can also provide general team (medical or otherwise) support such as:

Pre-deployment planning,
Logistics (including shelter, hygiene, food, water, and transportation management),
Communications,
Computer support,
Hazards evaluation,
Management, and
Security.

The engineers in the PHS are committed to making a valuable contribution to the nations emergency/disaster relief efforts. We believe this report will serve as a useful tool when forming an emergency/disaster response team.

Plans for the Future

PHS engineers believe strongly in the contributions we can make in emergency/disaster response. We have general skills that are desirable and specialized skills that are critical. We strive to seek continuous improvement and believe we can further develop our general skills to augment our contribution. Our hope is that every engineer of every discipline in our cadre will become familiar with, if not certified through training and evaluation, in each of the following areas:

Administrative Services

Administrative officer responsibilities, information officer responsibilities, command structure, staff organization, information management, and patient records management.

Communications

Communications officer responsibilities, Office of Emergency Preparedness operations, basic radio operation, hardware components, telecommunications systems, Federal Emergency Management Agency (FEMA), National Disaster Management System (NDMS) and Department of Defense frequencies, police, fire & public safety frequencies, preplanning, deployment, and departure issues.

Medical Product Logistics

Capital equipment, consumables, procurement, maintenance, and modernization issues.

Hazardous Materials Management (HazMat)

Physical and chemical science safety, health hazards of chemical, biological, radiological material, HazMat command and communications, preplanning for incidents, incident tactics, clean-up and restoration.

Water, Waste Water, Solid Waste Management

Treatment systems and testing methods.

Facility Management

Structural integrity; electric power supply systems; heating ventilation and air conditioning (HVAC) systems; and solid and biological waste management.

Health Care Provider (desirable skills)

CPR certification (required), First Aid (required), first responder certification, EMT certification, field management of mass casualties.

Table 1 - Different Types of Engineering Duties/Tasks/Problems That May Need to be Addressed During Natural or Man-Made Disasters

Problems With	Natural Disasters						Man-Made Disasters						
	Hurricane	Tornado	Flood	Earthquake	Heat Wave	Blizzard	Terrorism	Famine	Refuge Crisis	Air Pollution	Industrial Disaster	Nuclear Incidents	Fires
Drinking Water	✍	✍	✍	✍	✍	✍	✍	✍	✍				✍
Waste Water	✍	✍	✍	✍		✍		✍	✍				
Solid Waste	✍	✍	✍	✍				✍	✍				
Hazardous Waste	✍	✍	✍	✍			✍				✍	✍	
Radiologic Waste	✍	✍	✍	✍			✍				✍	✍	
Medical Waste	✍	✍	✍	✍			✍	✍	✍				
Power	✍	✍	✍	✍	✍	✍	✍	✍	✍				✍
Shelter	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍
Medical Facilities	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍	✍
Medical Equipment	✍	✍	✍	✍	✍	✍		✍	✍	✍	✍	✍	
Communication Systems	✍	✍	✍	✍	✍	✍	✍	✍	✍		✍	✍	✍
Computer Systems	✍	✍	✍	✍	✍	✍	✍	✍	✍				
Environmental Monitoring	✍		✍	✍			✍			✍	✍	✍	✍

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Air Quality	✍	✍	✍	✍	✍		✍			✍	✍	✍	✍
Industrial Facilities	✍	✍	✍	✍			✍			✍	✍		
Medical Records	✍	✍	✍	✍	✍	✍		✍	✍	✍	✍	✍	✍
Roads & Transportation	✍	✍	✍	✍			✍		✍				

Note: This matrix is not comprehensive. It is intended to provide guidance to officials responsible for identifying assignments that Public Health Service engineers could perform during natural or man-made disasters.

Table 2 - What Particular U.S. Public Health Service Engineering Speciality Could be Assigned to a Solve a Particular Problem

Problems With	Engineer Specialities Available from the U.S. Public Health Service																	
	Architecture	Biomedical	Chemical	Civil	Computer	Electronics	Electrical	Environmental	Environmental Health	Fire Prevention Protection	Health Facilities	Industrial	Materials	Mechanical	Mining	Nuclear	Occupational Safety and Health	Petroleum
Drinking Water				✍				✍	✍									
Waste Water			✍	✍				✍	✍									✍
Solid Waste				✍				✍	✍									
Hazardous Waste			✍	✍				✍	✍							✍	✍	✍
Radiological Waste			✍					✍	✍							✍	✍	
Medical Waste		✍		✍				✍	✍								✍	
Power							✍											
Shelter	✍			✍			✍			✍	✍			✍				
Medical Facilities	✍	✍					✍			✍	✍			✍		✍	✍	
Medical Equipment		✍			✍	✍												
Communication Systems					✍	✍												
Computer Systems					✍	✍												
Environmental Monitoring			✍	✍				✍	✍			✍			✍	✍	✍	

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Air Quality								✍	✍					✍		✍	✍	✍
Industrial Facilities			✍				✍			✍		✍		✍	✍	✍	✍	✍
Medical Records					✍													
Roads & Transportation				✍														

Note: This matrix is not comprehensive. It is intended to provide guidance to officials responsible for identifying assignments that Public Health Service engineers could perform during natural or man-made disasters. Some engineers may have experience beyond their speciality.

GLOSSARY OF ENGINEER SPECIALITIES AND SUB-SPECIALTIES

Engineering Explained in "Plain English"

The information below is taken from the US Department of Labor, Bureau of Labor Statistics, Occupational Outlook Handbook, 2000-01 Edition. Please see http://stats.bls.gov/ocohome.htm for additional information on the discipline of engineering.

Engineers apply the theories and principles of science and mathematics to research and develop economical solutions to technical problems. Their work is the link between scientific discoveries and commercial applications. Engineers design products, machinery to build those products, factories in which those products are made, and the systems that ensure the quality of the product and efficiency of the workforce and manufacturing process. Engineers design, plan, and supervise the construction of buildings, highways, and transit systems. They develop and implement improved ways to extract, process, and use raw materials, such as petroleum and natural gas. They develop new materials that both improve the performance of products and help implement advances in technology. They harness the power of the sun, the Earth, atoms, and electricity for use in supplying the Nation's power needs, and create millions of products using power. Engineering knowledge is applied to improving many things, including the quality of health care, the safety of food products, and the efficient operation of financial systems.

Engineers consider many factors when developing a new product. For example, in developing an industrial robot, engineers determine precisely what function the robot needs to perform; design and test the robot's components; fit the components together in an integrated plan; and evaluate the design's overall effectiveness, cost, reliability, and safety. This process applies to many different products, such as chemicals, computers, gas turbines, helicopters, and toys.

In addition to design and development, many engineers work in testing, production, or maintenance. These engineers supervise production in factories, determine the causes of breakdowns, and test manufactured products to maintain quality. They also estimate the time and cost to complete projects. Some work in engineering management or in sales, where an engineering background enables them to discuss technical aspects and assist in product planning, installation, and use.

Most engineers specialize. More than 25 major specialties are recognized by professional societies, and the major branches have numerous subdivisions. Some examples include structural, environmental, and transportation engineering, which are subdivisions of civil engineering; and ceramic, metallurgical, and polymer engineering, which are subdivisions of materials engineering. Engineers may also specialize in one industry such as motor vehicles or in one field of technology, such as jet engines or semiconductor materials.

Architecture - Understands the general principles of building design that are responsive to human needs and are structurally sound.

Design/Construction: Possesses a comprehensive understanding and skill to use pertinent aspects of the construction industry, engineering, and physical sciences to design and construct a new building or improve an existing building.

Structural: Possesses a comprehensive understanding and skill to design and construct new structures that are sound in routine and non-routine (e.g. earthquake or flood zones) situations. Also possesses an ability to evaluate existing structures for structural integrity and, if found deficient, to determine the needed improvements.

Biomedical Engineering - Understands the basic principles of many engineering disciplines along with the sciences of anatomy and physiology. Uses these skills and understanding to develop devices to monitor human biological activities and to correct human health problems.

Clinical Applications: Possesses special skill to design, maintain, test, and repair medical devices. Understands the operation of the medical device, the interface to the human body, and the human body's response.

Research and Development: Possesses special skill in designing medical devices to meet clinical needs, understands human factors design issues, understands environmental conditions in which the device is used (e.g. temperature extremes, interference, and physical abuse), and understands the human body interface and response to the device.

Chemical Engineering - Understands the principles of chemistry, particularly as it relates to the kinetics of reacting systems, transport of mass and energy, and balance of material and energy. Possesses knowledge and skill in control of pollutants and hazardous materials in chemical and related industries. Understands laboratory design, operations, instrumentation and analyses as it relates to chemical engineering.

Civil Engineering – Understands the principles of material strengths, structures, fluid mechanics, geology, and surveying. Understands aspects of planning, designing, construction and/or maintenance of structures and facilities that provide shelter, support transportation systems, or control natural resources.

Construction: Possesses an understanding of the construction industry. Understands material selection, availability, and conditions of use.

Geotechnical: Possesses special skill in understanding the fundamental physical properties of soil and rocks.

Highway/Transportation: Possesses special skill in roadway planning, air quality, surface treatments, pavement structures and roadway drainage systems.

Structural: Possesses special skill in design and analysis of structures taking into account location, materials, loads, and supports.

Water Resources: Possesses special skill in design of water supply and wastewater treatment facilities.

Computer Engineering - Understands the principles of research, design, development and maintenance of computer equipment and interfaces (hardware) and applications and support (software).

Data Base Manager: Possesses special skill to develop and deploy database programs.

Hardware Developer: Possesses special skill to design, production and implementation of computer hardware.

Hardware Administrator: Possesses a special understanding of computer hardware and would be responsible for its oversight and maintenance.

Network Administrator: Possesses special skill to maintain a network, including upgrades, backups, and maintenance of the "Back Office" equipment.

Network Designer: Possesses special skill to design, implement, and maintain a network; including the wiring, LAN, WAN, routers, and communication equipment.

Software Developer: Possesses special skill to conduct the needs analysis, design, production and implementation of computer application programs.

System Architect: Possesses special skill to design the overall computer system, such as LAN, WAN, Network Architecture, Network operating system, and workstations and the interaction of all theses components.

Electronics Engineering - Provides guidance and designs for electronic circuits, circuit elements, equipment, and systems for purposes of communication, computation, sensing, control, measurement, and navigation.

Communications: Possesses special skill to supervise communications systems, i.e., the planning, development, integration, utilization, or modification of communications facilities, procedures, and networks.

Facilities: Possesses special skill to design, review designs, and supervise construction of electric power distribution and utilization systems or electrical generating equipment of limited scope and complexity such as that used for small ordinary office buildings.

Instrumentation and Measurements: Possesses special skill to design and supervise the manufacture and operation of electrical and electronic systems, including semiconductor, magnetic, radio-frequency, microwave, optical, and superconducting equipment; flat-panel displays; electronic instrumentation; and electrical power apparatus and systems.

Electrical Engineering: Designs, troubleshoots designs, and supervises construction of electric power distribution or electrical generating equipment of large scope and complexity for projects such as high and low voltage electric power distribution systems for large installations or buildings, e.g., dam complexes, hydroelectric power plants, hospitals, industrial shops, airfields, or technical laboratories.

Environmental Engineering - Understands the principles of how chemicals and biological organisms move in the environment and to design and construct facilities to improve the quality of the environment and to protect human health.

Air Quality: Employs knowledge of the following in air quality management and emission standards development: air pollution control and prevention approaches; monitoring/measurement

of ambient air pollution and emissions; health effects of air pollution; and methods of estimating emissions. Develops policy and guidance for States, Tribes, and industry in addressing Clean Air Act requirements and Federal air pollution regulations.

Hazardous Waste: Conducts site evaluations to determine the health and environmental consequences of hazardous waste spills, illegal dumping, incineration, and transport. Advises communities on mitigation options and oversees cleanup efforts to determine compliance. Plans, designs and monitors facilities built for the legal disposal of hazardous wastes.

Solid Waste: Involved in the planning, design and construction of facilities for the transfer and disposal of municipal solid wastes. Serves as a consultant to communities on health and environmental issues relates to the generation, transport and disposal of solid wastes.

Water/Waste Water: Plans, designs, and manages the construction of drinking water and wastewater treatment facilities to serve both individuals and communities. Investigates, evaluates, advises on, and regulates existing water and wastewater systems to maintain the public's health.

Environmental Health - Understands the principles of health intervention and how to develop engineering solutions to the problems.

Community Injury Prevention: Assesses, designs and implements intervention programs for the protection of the public from unintentional injury such as automobile crashes or drowning. This work involves data gathering and interpretation, program design, prioritization and development of prevention strategies.

Hazardous Waste: Evaluates work sites and conditions that may affect worker health due to hazardous conditions or materials. Provides guidance and oversees safety programs on personal protective equipment, respirators, hazardous atmosphere testing, confined space entry and material safety data sheets.

Industrial Hygiene: Identifies conditions at work sites that affect the health and efficiency of employees, eliminates occupational disease hazards, and promotes industrial health programs. Advises on hazards identification, ergonomics, chemical handling, engineering controls, and plant design as related to worker health and safety.

Radiological Health: Performs work that deals with the protection of public from the hazards of ionizing radiation. This work includes knowledge of the regulation and standards governing ionizing radiation, inspection of radiological equipment, detection and measurement of radiation exposure and the implementation of protection techniques.

Vector Control: Involved in the study, control and eradication of insect and rodent vectors and pests that act as agents in the spread of disease to man. This work involves the use of appropriate surveillance methods, the formulation and application of insecticides for control, public education and risk assessment.

Water Resources: Provides guidance to communities and individuals on drinking water protection and regulatory compliance. Assesses systems in terms of well head and water shed protection, water quality standards, monitoring requirements, public notification, chlorination and records keeping.

Fire Prevention/Protection Engineering - Description covers positions that supervise or perform work to control and extinguish fires, rescue persons endangered by fire, and reduce or eliminate potential fire hazards. It also covers fire service positions that control hazardous materials incidents; trains personnel in fire protection and prevention; develop and implement fire protection and prevention plans, procedures, and standards.

Materials Engineering - Understands the properties (strength, machine ability, failure modes, etc.) and uses of various types of materials such as protective coatings (paints, plastics, enamels, metals), lubricants (greases, powders, liquids), and construction materials (metals, plastics, composites, wood, concrete and ceramics).

Health Facilities Engineering - Understands the special requirements of health care facilities. Knows how to design, construct, and maintain the equipment and structures associated with providing medical care.

Biomedical: Experience with the design, construction, operation, and maintenance of devices and equipment specifically developed for medical care, including defibrillators, fetal heart monitors, cardiac and respiratory monitoring devices, oral suction units, ventilators, x-ray and ultrasound imaging devices, and oxygen delivery devices or systems.

Construction: Experience with building construction principals and component installation technique specifically for health care facilities. Is familiar with construction and component installation standards as they relate to health care facilities construction. Is familiar with pertinent aspects of the construction industry, engineering and standard ICBO construction certifications to manage the construction or renovation of a new or renovated health care facility for minimum safe health care, particularly under post disaster situations.

Electrical: Experience with designs, design reviews, and installations of electric power distribution and generating equipment and alarm and signal systems for hospitals and health care projects. Must be familiar with minimum safe installation of components and equipment as defined by: NFPA 101 Life Safety Code, NFPA 72 Fire Alarm Code, NFPA 99 Health Care Facilities, NFPA 110 Generator Code, and NFPA 70 (National Electric Code), IEEE National Electrical Safety Code (NESC), and power reliability standards of ANSI 493. Must also be familiar with proper and safe operation of electrical equipment, smoke/fire detection and alarm systems, signal systems, electrical distribution systems, essential electrical systems and IES minimum lighting standards for safe operation of medical facilities.

Mechanical/HVAC: Experience with designs, design reviews, and design and construction of mechanical systems for hospitals and health care projects. Should be familiar with codes and standards including the following: NFPA 101Life Safety Code, NFPA 99 Health Care Facilities, Uniform Plumbing Code, Uniform Mechanical Code, and American Society of Heating, Ventilation, and Air Conditioning (ASHRAE) standards. Typical design related skills include heating, ventilation and air conditioning (HVAC); water distribution and drain & waste systems; elevator equipment, fire sprinkler systems, and medical gas systems.

Operation: Experience with the principals and practice of plant engineering for medical facilities. Is familiar with health care space functional requirements, such as AIA Guidelines for Health Care

Facilities. Has experience with managing maintenance and repair crews for operating and maintaining health care facilities. Has experience with mandatory facility equipment testing and records. Is familiar with OSHA standards for safe plant operation. Is familiar with Health Care Emergency Preparedness (NPFA 99, Chapter 11).

Structural: Experience with the designs, design reviews, and construction of structural systems for hospitals and health care projects. Should be familiar with codes and standards including the Uniform Building Code, the American Concrete Institute, the American Institute of Steel Construction, the Masonry Institute of America, the American Institute of Timber Construction, FEMA 178 and 273, along with other standard national structural codes. Typical design related skills include analysis and understanding of soils, foundations, structural materials, internal structural loading, external wind and seismic loading, and related supports for structural lifelines within the envelope of the health care facilities.

Industrial Engineering - Understands the general principles of designing, constructing, and supervising the operational processes that manufacture products (e.g., assembly lines).

Mechanical Engineering – Understands the general principles of designing, constructing, and operating machines.

Equipment Design: Making equipment do its required functions within the bounds of various safety and performance standards. Understands the environmental conditions under which equipment must function. Also familiar with the need for proper ergonomics, which studies the interaction between humans and machines.

HVAC: Heating, ventilation and air conditioning (HVAC) design and control. Understands the heating and cooling load conditions necessary to maintain climate control within a building. This is usually for human comfort, but it is occasionally for special purposes such as specific manufacturing processes or material storage conditions.

Industrial Ventilation: Ventilation necessary in an industrial setting to meet worker air quality standards and manufacturing process needs. This usually involves filtration and movement (via fans or other means) of large volumes of air. Applications include structures such as factories and warehouses, transportation tunnels, and special purpose facilities such as clean rooms.

Plumbing Systems/Pumps & Controls: Design and control of water distribution and waste removal systems. The requirements of such a system include the following: water storage, pumps and piping capacity, fluid pressures, and valving. The system can be relatively small, such one that would service a single building. The system can be larger, such as one that would service a small site with several buildings, or possible service a much larger area such as a town or small city.

Mining Engineering: The field of mining engineering is broad in scope. It includes metal ores of all kinds, nonmetallic minerals, and solid fuels and energy sources such as coal and nuclear materials. It encompasses the various kinds of mining systems such as underground mining, strip mining, and placer mining. In addition to traditional mining activities, there is much mining engineering work being done in the heavy construction industry, involving rock excavation, and support for highways, tunnels, and underground chambers. Mining

engineering efforts also involve exploration and development of mineral deposits located under large bodies of water.

Health and Safety: Concerned with the health and safety of mine workers and the public through mine waste disposal and related activities. Also includes environmental control, which involves water control and drainage, and control of mine atmosphere (including methane gas), temperature, and humidity.

Rock Mechanics: Understands the various aspects of excavation such as – Rock disintegration: drilling, blasting, mechanical mining, leaching, and solution; Materials handling: loading and mine transportation of broken material; Ground control: controlling or stabilizing the voids created through removal of the mineral.

Nuclear Engineering: Concerned with various aspects of nuclear power generation and handling of radioactive materials. Understands health implications of handling radioactive materials. Concerned with the protection of the public from potential hazards of radiation and radioactive materials. Research, development, design, construction, testing, installation, monitoring, operation and maintenance of nuclear reactors (fission or fusion) and other nuclear systems and immediate auxiliary or ancillary systems and equipment. Activities include all aspects of the manufacture, transportation, and use of radioactive materials.

Occupational Safety and Health Engineering - Understands the general principles of how workers preform tasks and designs, constructs and supervises the operation of equipment that protects the health of workers.

Petroleum Engineering - Understands the general principles locating petroleum, extracting petroleum from underground, transporting petroleum, and processing petroleum into useful products (e.g., gasoline). Is capable of designing, constructing, and supervising the operational processes used to extract, transport and refine petroleum.