Civil Preparedness Guide

Federal Emergency Management Agency

Washington, D.C. 20472

CPG **1-20 chg 1** May 16, 1989

Emergency Operating Centers Handbook

1. Purpose. This transmits appendix I, Emergency Operating Technical Design Guidance, for inclusion in CPG 1-20, Emergency Operating Centers Handbook, dated May 29, 1984.

2. **Action Required. Holders** of CPG 1-20, Emergency Operating Centers Handbook, shall make the following changes and file this transmittal sheet in front of CPG 1-20 for reference purposes.

Page Changes **:**

Remove	Insert
	Pages I-1 thru I-57 After Appendix **H.**

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Appendix I

Emergency Operating Centers Technical Design Guidance

A. General.

1. Focus. This appendix contains recommended design guidance for Emergency Operating Centers **(EOC's).** The focus of this appendix is on the planning and development of technical aspects of the EOC facility. Included are definitions, descriptions, standards, and procedures for meeting the requirements necessary for an EOC to become functional in the event a major catastrophe occurs.... This includes natural and man-caused catastrophes such as a nuclear attack.

a. A fixed EOC facility is considered essential to this functional capability, but consideration is also given, in this appendix, to the added value of a mobile command center. This additional capability permits on-the-scene direction and control where the emergency is site specific and provides the community with a capability to relocate its primary direction and control operation if the fixed EOC facility is threatened, damaged or otherwise made inoperable.

b. To develop the needed design parameters, the designer must be aware of what it would be like inside and outside of the EOC as emergency events unfold. It is therefore recommended that architects and engineers commissioned to design EOC's have staff capability and experience in multihazard designs, including such hazards as nuclear weapon's effects, floods, fires, tornadoes, extreme winds, and earthquakes.

2. **Purpose.** The purpose of this appendix is to provide information and guidance and make recommendations for the design, construction, or designation of a space in a building or other facility as an EOC.

3. **Applicability.** This appendix applies to all state and local officials considering the development of an EOC. The guidance is applicable whether or not Federal funding requests are anticipated.

4. EOC Defined. An EOC is generally defined as the protected site, from which civil government officials (municipal, county, State, and Federal) issue warnings and exercise direction, and control in an emergency. It is designed and equipped to provide staff support to officials in coordinating and guiding disaster relief activities. The EOC

normally provides the space, facilities, and protection necessary for the following broad functions of which the architect/engineer (A/E) should be concerned:

a. Collection, evaluation, display and dissemination of information:

b. Coordination and control of operations:

c. Issuance of emergency information, warnings and instructions to the general public: and

d. Direction and control of all emergency planning and operations, including locating and controlling the emergency use of all community resources not sheltered within the EOC.

5. Design Criteria. The design criteria for an EOC depend to a great extent on the types of disasters that could occur in any given community. Disasters are usually classified into two categories: natural and/or manmade. Natural disasters are usually more predictable and their probability of occurrence can be determined based on a hazard analysis of a specific area. Manmade disasters, however, are much less predictable and therefore pose an added burden on preparedness and emergency operations. In broad terms, possible disasters that should influence the design approach taken by the A/E, are as follows:

a. Natural Disasters.

(1) Earthquake;

(2) Flood and Tsunami:

(3) Fire: and

(4) Strong Winds, Tornadoes, Hurricanes.

b. Manmade Disasters.

(1) Nuclear War;

(2) Nuclear Accident;

(3) Hazardous Materials' Spills:

(4) Conventional War:

(5) Civil Disorder; and

(6) Other Major Accidents.

6. [Designing for Natural and Manmade Disasters. In designing an EOC to withstand the effects of natural disasters, it is recommended that the A/E follow standard building codes and regulations. Providing protection from certain manmade disasters, especially nuclear war, requires a building to meet unique design criteria. A building designed to resist all the effects of nuclear weapons should be able to withstand all the forces associated with natural disasters, with the exception perhaps of major floods, and certain volcanic eruptions. The guidelines presented here are intended to address the unique technical requirements which are necessary for the A/E to consider in designing an EOC. CPG l-3, CCA General Program Guidelines.

7. Initial A/E Contracts.

a. Predesian Conferences. Several conferences may be required to establish the basic requirements for the proposed EOC before and following the signing of a contract with an A/E. All interested parties should attend a preliminary conference to discuss such matters as a centralized point of contact for various elements of the project, reports and detailed requirements for the EOC. It is recommended that technical, operational, and administrative personnel from the A/E firm, and from the region, state, and local governmental offices attend the conference.

b. Data to be Furnished by the A/E. The A/E should be required to submit architectural working drawings at the 35, 75, and 100 percent completion stages. The review of the drawings should be performed by engineers or architects familiar with the EOC program. The review should include a check of the fallout radiation protection factor (PF) for the building.

(1) Upon completion of the EOC design, the A/E should provide a predetermined number of copies of the architectural working drawings and specifications to the contracting officer.

(2) The A/E should provide a breakdown of the estimated cost of the entire project. Separate cost estimates should be provided for the following items and for any other unique elements in the EOC in accordance with the A/E contract:

(a) Partitions:

(b) Floor, wall, and ceiling treatment or covering:

(c) All electric wiring, panels, batteries and required controls:

(d) All mechanical requirements such as generator(s), ancillary generator equipment, ventilation, heating and air conditioning:

(e) Communication and warning equipment;

(f) Emergency water equipment and storage:

(g) All plumbing and sewerage equipment, including an outside holding tank, if applicable:

(h) Kitchen equipment;

(i) Medical equipment, if applicable:

(j) Display equipment;

(k) Furnishings;

(1) The structural shell of the EOC;

(m) Electromagnetic pulse protection.

(3) Cost estimates should include spare parts if applicable.

c. <u>Operations Manual (OM)</u>. The A/E should be required to provide an emergency OM for the EOC. The manual should contain detailed instructions on all special features in the EOC's structural shell such as blast valves, security systems, and special filters if such items have been incorporated. Operational guidance should also be included for mechanical and electrical equipment, including periodic maintenance requirements and wiring diagrams. Appropriate as-built architectural drawings should also be provided with the OM. When the sanitation system or any major system in the EOC designed or selected by the A/E depends upon specific actions by the EOC occupants, the action to be taken must be explained.

d. Special Desian Assistance. FEMA provides, through its regional offices, design assistance for incorporating protection from the effects of nuclear weapons, i.e., initial nuclear radiation, fallout gamma radiation, electromagnetic pulse, and blast overpressure into EOC's. FEMA also provides an electronic computer analysis service to architects and engineers for the purpose of evaluating facilities to determine the protection afforded from initial nuclear radiation and fallout gamma radiation. This is called the SAND (Shelter Analysis for Nuclear Defense) system, TR-55 and TR-55A.

B. Technical Guidance.

1. General. The criteria recommended here generally represent minimum requirements for federally funded EOC's. Nothing contained herein shall be considered to preclude exceeding criteria for any EOC.

2. EOC Occuoancv. Provisions should be made for accommodating personnel assigned to an EOC who routinely occupy the EOC on a daily basis and during natural and manmade disasters. When the disaster involves the effects of nuclear weapons, the length of time the EOC might be occupied in an environmentally protected (button-up) mode might extend to several weeks. The warning time associated with nuclear disasters necessitating button-up mode operations can be as short as a few minutes, but most likely will be preceded by much longer periods of general alert. Since the warning time is not certain, everything required for the efficient operations of the EOC in a 14-day button-up mode should always be in place.

3. **Space Reguirements.** Space allocations should be based on requirements stipulated herein.

a. Area. There should be a minimum of 50 square feet per EOC staff member assigned to the EOC in an emergency on a sustained 24-hour basis. A range of 50 to 85 square feet per person is recommended, but should be determined based on the EOC concept of operation and extenuating variables agreed upon by the applicant, State, and FEMA Region.

b. Bead Room. A minimum head room of 8 feet should be provided in the EOC. Some sections of the EOC may require additional head room, e.g., operations area, mechanical equipment room, and perhaps the dormitory areas.

4. Site Recruirements.

a. Location. It is recommended that the EOC be entirely below the ground. This applies to EOC's being constructed as separate and distinct facilities as well as those being incorporated into existing structures. When the EOC is to be located above the ground, the facility should still meet the structural shell requirements specified in this appendix.

b. Built-UD Areas. The EOC should not be located too close to medium or high rise structures due to the potential collapse and subsequent debris and dust which could affect the EOC mission. In a nuclear attack environment, antennas not destroyed by over-pressure could be destroyed by the debris. Retractable antennas could also become inoperable. Dust from collapsed buildings could also clog filters and create problems for the mechanical equipment and the EOC staff.

c. Sub-Surface Water. The existing water table should also be considered when selecting a site. The water table can be handled with minimal difficulty for normal construction. EOC's could experience wall and floor fracturing and allow ground water to enter if subjected to overpressure and ground shock caused by nuclear weapons or extensive movement during an earthquake.

d. Site Testing. Soil borings should be made so that subsurface materials can be identified. Sufficient borings should be made to provide a clear profile of the subsurface conditions within the zone of interest. Geologic hazards that might affect the proposed site should be identified.

e. **Accessibility.** **The proposed EOC site should be readily accessible to vehicular traffic and should not be located near hazardous products or facilities which regularly deal with hazardous materials.**

5. Structural Shell Requirements.

a. Design Criteria for NonNuclear Hazards Protection. The forces associated with such hazards as tornadoes, hurricanes, and fires are familiar to the practicing A/E. EOC design should incorporate protection to resist these forces, in accordance with criteria established in existing local and national building codes. EOC's subject to seismic forces should be designed in accordance with provisions specified in the 1985 edition of the National Earthquake Hazards Reduction Program (NEHRP) Recommended Provisions for the Development of Seismic Regulations for New Buildings (FEMA publication Nos. 95, 96, and 97 with associated maps, February 1986). When seismic codes in local or national building codes are equal to or exceed the NEHRP provisions, those codes may be used in lieu of the NEHRP provisions provided the A/E certifies this in writing.

b. Design Criteria for Blast-Hardened EOC's. A blast-resistant EOC may be defined as one which has been designed to resist a specified blast overpressure, and other associated weapons' effects, so as to insure a very high probability of survival of the occupants and contents when it is subjected to that overpressure. It is recommended that an EOC be designed to withstand the blast overpressure likely to be experienced as suggested in the FEMA publication Nuclear Attack Planning Base - 1990. The design of a blast-hardened EOC should be accomplished by an A/E who has successfully completed the FEMA course on nuclear blast protection design or has acquired blast-hardening design expertise through another means. Specific instructions about blast-hardening design are contained in the FEMA publication TR-20, Vol. IV, Protective Construction, Nuclear Blast Resistant Design.

c. Minimum Protection Factor (PF) Requirements.

(1) A PF is a numerical value which expresses the relationship between the amount of fallout radiation that would be received by an individual in a protected location and the amount that would be received if unprotected in the same location. For example, if the radiation level on the outside

of a shelter is "100 Roentgens per hour" and the radiation at the detector inside the shelter is "1 Roentgen per hour," then the shelter has a PF of 100 or one-hundredth of the exposed reading. The minimum PF recommended for EOC's is 100. In an area designated as high risk due to a high level of fallout anticipated, a PF greater than 100 may be necessary. The protection factor is to be determined by the FEMA Standard Method for fallout gamma radiation shielding analysis, as explained in the FEMA publication entitled Shelter Desian and Analysis TR-20, Volume 1, or a FEMA approved computerized analysis method.

(2) The Standard Method is applicable to shielding analysis for fallout gamma radiation only. It does not apply to initial nuclear radiation since the energy spectrum for initial nuclear radiation is significantly greater than that for fallout gamma radiation. Fallout does not involve neutron radiation. PF's for EOC's should be determined by a Fallout Shelter Analyst certified by FEMA.

(3) Funding restrictions relative to the incorporating of protection from fallout gamma radiation are contained in CPG 1-3.

d. Protection from Initial Nuclear Radiation (INR) INR is that radiation emitted from the fireball and radioactive cloud within the first minute after the explosion. It consists of both neutrons and gamma rays given off almost instantaneously and emitted by fission products and other radioactive material from the weapon. An INR analysis of the EOC should be based on the procedures explained in TR-55A, Shelter Analysis for Nuclear Defense from Initial Nuclear Radiation and should be performed by a FEMA certified Fallout Shelter Analyst. INR should only be considered if the EOC is to be blast-hardened.

e. Opening in the Shell.

(1) The EOC should have'a minimum number of apertures in the structural shell, especially if protection from blast overpressure and fallout gamma radiation is being incorporated. When positioning openings in the structural shell, consideration should also be given to the anticipated debris loading. The air blast at 10 and 15 psi overpressure levels can destroy buildings and uproot trees, and create debris several hundred feet around the collapsed buildings.

EOC's in built-up areas would be subjected to this debris disposition. For example, a 1-story industrial building will produce an average debris depth of 0.3 ft., a 3-story duplex will produce 3 ft. of debris: a 5-story steel frame apartment house will produce 7 ft. of debris, and a 23-story high-rise building will produce 33 ft. of debris. Generally, the volume of debris is twice as much as the volume of the actual material involved.

(2) Several openings in the EOC may be essential for access and egress, EOC ventilation and utilities to provide intake air and exhaust for emergency generators.

f. Exterior Walls. If a structure is used where the basement is partially exposed, the exposed exterior walls would be subjected to reflected overpressures and dynamic pressures, as well as the overpressures behind the incident shock wave. Exposed basement walls may be protected from reflected pressure and dynamic pressure by earth berms with a gentle slope (not to exceed one vertical unit to two horizontal units).

6. EOC Comoonents and Special Considerations. The following paragraphs provide a limited description of the separate elements which should be considered in the design of the EOC.

a. Emerqencv Power. Fuel and Fuel Storaae. One of the minimum requirements for an EOC is an emergency power generator, sized to provide for the maximum demand loads of the EOC. There should be sufficient fuel capacity to furnish the necessary power to maintain the EOC fully operational 24 hours per day for a minimum of 14 days. Above or belowground emergency fuel tanks are acceptable, but water table considerations should be taken into account for belowground tanks due to buoyancy effects.

(1) Types of Generator Svstems. Various types of generator systems are available for use in EOC's. Possible systems which might be considered are:

(a) Internal combustion engines:

(b) Gas turbines: and

(c) Steam engines or turbines.

(2) Other Power-Producing Devices. There are many other power-producing devices available or in development such as fuel cells, storage batteries, thermoelectric devices, solar cells, magnetohydrodynamic (MHD) generators, thermionic generators, wind-driven generators, tidal power, and nuclear power. Many of these are not capable of meeting heavy current demands and are not appropriate for an EOC. The others have not been developed, at the present time, to a stage where they are competitive with more conventional power generators in terms of cost, efficiency or reliability. Of those mentioned, the fuel cell has probably been-developed to the greatest extent and is very close to being competitive with internal combustion engines in cost and exceeds them in efficiency.

(3) Auxiliary Power Considerations.

(a) When considering an auxiliary power system for EOC application, some of the factors which must be taken into account, not necessarily in order of importance are:

(i) Availability:

(ii) Initial cost:

(iii) Operating cost:

(iv) Reliability:

(v) Ease of starting and operating:

(vi) Maintenance requirements;

(vii) Fuel storage characteristics;

(viii) Safety;

(ix) Air and water requirements;

(x) Auxiliary equipment required;

(xi) Space requirements;

(xii) Resistance to weapons' effects: and

(xiii) Fuel supply connections.

(b) If practical, the generator and its fuel supply should be located near or inside the EOC facility. (Noise abatement procedures should be considered when placing the generator inside the EOC.) Both should be installed in accordance with the manufacturer's specifications with special emphasis on limiting damage to them when subjected to ground acceleration caused by a nuclear explosion or seismic activity.

(c) The generator exhaust outlet should extend to the roof of the host building if possible: otherwise, it should be exhausted a safe distance from any building inlet to ensure that the exhaust fumes are not brought back into the EOC facility.

(d) The size of the generator selected for an EOC will depend on the maximum electrical load created by the electrical and mechanical equipment. Some of the load will be relatively constant such as that for lights and stand-by power for communications equipment. Other loads will be intermittent such as electrical cooking equipment and transmitting power for communications. Electric motors, operating pumps, fans, blowers and those driving air-conditioning compressors may operate steadily or intermittently depending on the application. A line-load analysis by a certified electrical engineer will have to be performed to determine the minimum size of the generator required by the EOC. If more than one generator is used, one should be sized for the critical load: communications equipment, ventilation, emergency lighting, etc., and capable of automatic starting, as well as manual starting.

(e) The generator engine may be water or air cooled. (The air-cooled generator may be preferable based on geographical locations.) Consideration should be given to providing for heat-recovery, for space and domestic hot water heating.

(f) The generator must have the same electrical characteristics as the main power source. In addition, radio interference suppressors should be provided.

(g) Supplying natural gas through standard underground distribution lines is not considered reliable under emergency conditions due to line breakage possibilities.

b. __Lighting__ In **EOC's,** the various emergency operations will require a fairly high level of visual acuity. **A** higher level of illumination will be necessary in some areas. In the emergency operations room, maps, chalkboards, tackboards, etc., will be displayed to show the status of emergency conditions and operations: and it will be necessary that these be easily visible from any place in the room. In dual-purpose facilities, the lighting levels may be greater in the EOC when activated for emergency purposes than when operated under normal conditions.

(1) Fluorescent lamps can produce radio frequency interference (RFI) which can be significant in an EOC. This occurs in one or all of the following ways: direct radiation from lamp to antenna circuits; direct radiation from electric supply line to antenna circuit; and line feedback from the lamp fixture through the electric supply line to the receiver. FM radio is not as seriously affected, and there is no interference above 200 megacycles.

(a) Direct radiation from the lamp can be minimized by distance. Lamps should be kept at least 10 feet from radio receivers and aerials. Direct radiation from the line is also minimized by distance.

(b) Line feedback can be reduced by filters.

(c) Direct radiation can be reduced by the design of the lamp fixtures and by proper grounding.

(2) Some or all of these preventive measures should be considered if fluorescent lamps are selected for the EOC and are to be used near any radio receiving facility. Thus, it would be advisable to obtain expert advice concerning **RFI** when considering the lighting of any radio communication facility.

(3) Battery-powered lights would not be suitable as a primary source of light for an EOC because they are not designed for long-term operation. However, emergency battery operated lights with trickle chargers should be placed

in all stairwells, corridors, equipment, and communications rooms as well as kitchen and medical areas.

(4) All lighting required in a fully activated EOC should be tied into the emergency power circuits to ensure continuous operation.

(5) Electrical wiring requirements should be based on applicable local and national electric codes.

c. Communication and Warning. This CPG contains information about communication and warning which might impact on the designing and planning of the EOC. The following functions should be considered by the A/E when designing appropriate space or selecting specific equipment to meet the EOC communication and warning requirements:

(1) Receipt and dissemination of attack warning, including operation of sirens, public address systems, **or** other methods available to alert the public;

(2) Conveyance of other emergency instructions or information to the public, e.g., Emergency Broadcast System **(EBS);**

(3) Maintenance of contact with other **EOC's,** including city, county, or state governments, as appropriate, and with public shelters:

(4) Two-way communications with police, fire, rescue, health, engineering, and other operating units of government, as well as with EBS Stations:

(5) Receipt and dissemination of radiological data;

(6) Provisions to measure, plot and predict radioactive fallout conditions: and

(7) Staff alerting (paging systems, etc.)

d. Antennas. The design of the antennas required will be based on the types of communication equipment used in the EOC. Communication equipment may become inoperative due to lack of power or damaged components. Most vulnerable are the outside radio antennas, which generally are not designed to withstand the large drag forces resulting from air blast or impact by heavy. airborne debris. Redundant antennas that can be erected after the blast occurrence should be provided either in "stowed" position or stored in protected locations. Based on the site selected for the EOC and the quantity of free space around the buried structure, a retractable antenna may be appropriate.

e. Electromagnetic Pulse (EMP) Protection Considerations The radiated electromagnetic fields from a nuclear detonation, especially a high altitude nuclear detonation, may result in faulty operation of electrical/electronic equipment, permanent damage to certain kinds of components and cables and, in some cases, serious shock hazard to personnel. The way in which the energy is collected is often complex; but in general, the longer the conductor, the greater the amount of energy collected. The energy appearing in the electromagnetic environment is converted, often in a complex fashion, into high-level currents and voltages flowing on any metallic conductor. To cause damage, it is necessary that these currents and voltages encounter a sensitive component such as a transistor. In the case of an antenna, this would be the normal consequence of the function or purpose of the antenna, but it will render the antenna useless. In the case of other metallic structures, various obscure details (such as quality of welds) control the situation.

(1) Collectors of EMP Energy. Typical collectors of EMP energy include:

(a) Long cable runs, piping, or conduit;

(b) Large antennas, antenna feed cables, metallic guy wires, or metallic antenna support towers:

(c) Overhead power or telephone lines:

(d) Metallic structural building members, such as girders, corrugated metal roofs, expanded metal lathe, rebars;

(e) Buried pipes or cables;

(f) Long runs of electrical house or building wiring, conduit, etc.:

(g) Metallic fencing, railroad tracks.

(2) EMP Damage to Electrical Systems. Electrical systems exposed to EMP may suffer degradation in two ways generally known as functional damage and operational upset. It is essential that the A/E understand these types of damage in order to evaluate the potential impact of selected mitigation and countermeasure design techniques.

(a) If sufficiently large electric transients are introduced, a component or a subsystem may become permanently inoperative until some part or parts are replaced. If a system is permanently damaged in this manner, it is said to have suffered FUNCTIONAL DAMAGE.

(b) Small electrical transients may temporarily impair the performance of a system. This impairment may last for only a few microseconds or could be hours. This temporary impairment of the system's operation is known as OPERATIONAL UPSET. The importance of either FUNCTIONAL DAMAGE or OPERATIONAL UPSET within the system depends upon the specific characteristics of the system.

(3) Examples of Functional Damaae and Onerational Upset.

(a) Beginning with these definitions of degradation, it is useful to consider examples of each type of effect. Burnout of a transistor or the opening of a fuse are clearly two examples of functional damage.

(b) Examples of operational upset are the erasures of magnetic core memories of computer systems or the opening of circuit breakers. Depending on system design, the unanticipated opening of circuit breakers or temporary malfunctioning of a number of control devices could range from insignificant to catastrophic.

(c) Electronic components are often very sensitive to functional damage or burnout. These are listed in the order of decreasing sensitivity to damage effects:

(i) microwave semiconductor diodes:

(ii) field-effect transistors;

(iii) radio-frequency transistors;

(iv) audio transistors;

(v) silicon-controlled rectifiers:

(vi) power rectifier semiconductor diodes:

(vii) vacuum tubes.

(4) EMP Damaae Susceptibility. Tests have indicated that many electronic systems and items of equipment are more susceptible to EMP damage than *others.*

(a) The more susceptible categories include:

(i) Low power, high speed digital computers; and

(ii) Systems employing transistors or semiconductor rectifiers (either silicon or selenium), such as:

a. Computers;

b. Computer power supplies:

c. Transistorized power supplies:

d. Semiconductor components terminating long cable runs, especially between sites;

e. Alarm systems:

f. Intercom systems:

g. Life-support system controls:

h. Some partially transistorized telephone equipment;