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	Military Publications SYSTEMS OPERATION AND MAINTENANCE DOCUMENTATION	
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DEPARTMENT OF THE ARMY
U. S. Army Corps of Engineers
Washington, D. C. 20314-1000

CEMP-CE

Regulation
No. 25-345-1

31 January 91

Military Publications
SYSTEMS OPERATION AND MAINTENANCE DOCUMENTATION

1. Purpose. This regulation establishes general policies for preparing documentation and providing other support related to the operation and maintenance of facilities designed and constructed by the US Army Corps of Engineers.

2. Applicability. This regulation applies to HQUSACE/OCE elements, major subordinate commands, districts, laboratories, and separate field operating activities having any type of military design and construction responsibilities and/or support for others' design and construction responsibilities.

3. References.

a. AR 25-30

b. AR 37-100

c. AR 210-50

d. AR 415-15

e. AR 420-10

f. ER 415-345-38

g. AFR 89-1

4. General. Technical documentation and training support shall be provided on each new facility designed and constructed by the Corps of Engineers for its customers. The provision of this documentation and training support for major rehabilitation, alteration, and renovation projects shall be considered and established on a case-by-case basis. The efficient operation and effective performance of maintenance on complex facilities

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This regulation supersedes ER 310-3-11, 15 February 1985

systems and subsystems require adequately prepared operation and maintenance (O&M) documentation together with the proper training of operations and maintenance personnel. This requires Corps/User interface throughout the design, construction, post-construction/transition stages of all complex stand alone facilities (e.g., waste treatment, water treatment, industrial process, major medical facilities, armament production, large heating/cooling plants, flight simulators and laboratories). Complex systems within major facilities (e.g., Heating Ventilation and Air Conditioning (HVAC), elevator, Energy Management Control Systems (EMCS), security systems, uninterrupted power systems (UPS) and fire protection systems) should also be included.

5. Guidance.

a. The need for this O&M documentation should be identified on the DD Form 1391, Military Construction Project Data, during project development and early coordination with the Users for MILCON and in the Memorandum of Understanding (MOU) for work for others. On turn-key projects the contract must provide for complete O&M documentation by the design/construct contractor.

b. For complex facilities as described in paragraph 4, Major Subordinate Commands and Districts should require the Architect-Engineer (A-E) to prepare basic O&M documentation such as the design master equipment list (DMEL), the technical concept narrative (TCN) for the systems O∧M manual and training requirements (within the guidelines given in AR 25-30). Appropriate identification of this responsibility must be stated in the A-E contract. Sample A-E contract clauses are set forth in Appendix A. Costs of preparation will be apportioned between design and construction funds. Costs during the design process are to be funded from the AMSCODE 3200 account "Design (Major Construction)" for the Army and P313 funds for the Air Force. Costs for A-E activities after award of a construction contract are to be charged against P6100 account, "Major Construction (Public Works)" in accordance with AR 37-100 for the Army and P-321 (CONUS), P-331 (OCONUS), P-341 (Unspecified Minor) in accordance with AFR 89-1 for the Air Force. If the design is done by in-house personnel then the Division or District is responsible for preparing that portion of the the O&M documentation required by the designer. (Air Force requirements for O&M manuals are described in Engineering Technical Letter (ETL) 89-2: Standard Guidelines for Submission of Facility Operating and Maintenance Manuals. This is attached as Appendix B.)

c. Finalizing basic O&M documentation and training of Government or contractor O&M personnel must be the responsibility of the construction contractor. When such a determination is made and specified in the construction contract, training of user or contractor operating personnel and finalization of O&M documentation will be funded using project funds.

d. The responsibility for operation and maintenance of facilities equipment and systems during the warranty period can remain with the construction contractor if such services are procured as an option to the construction contract and appropriate O&M funds are used. MCA and MCAF project funds cannot be used for operation and maintenance of facilities. If the determination is made to include an option to require the construction contractor to perform the facility O&M during the warranty period, then identification of this requirement must be stated in the A∧E contract for initial design services, so that appropriate documentation may be prepared.

6. O&M Documentation. Preparation of the O&M documentation is a two-step operation shared by the A-E and the construction contractor. The A-E initiates documentation during the design phase and the construction contractor updates and completes the O&M documentation, including equipment manufacturers data, and conducts training during the construction and transition phases. Documentation required based on "complex" or routine facilities includes:

	Routine	Complex
. Technical Concept Narrative		X
. System Operations and Maintenance Manual		X
. Master Equipment List		X
. Training Plan with Training Concept/Specifications		X
. Equipment O&M and Repair Manuals	X	

a. Technical Concept Narrative (TCN). The A-E shall develop a TCN intended primarily for use by the construction contractor responsible for development of the facility systems O&M manuals. The TCN describes the use, operation and interrelationship of the facilities various operational systems and subsystems. A description of the theory of operations of

the facility system and equipment will be provided to the extent necessary for journeyman understanding. System electrical-mechanical requirements and their application will be covered by these manuals and will include design factors and assumptions used in designing the system. As an example, the following type of information should be included for HVAC systems: the U factors of walls, roofs, and floors that separate conditioned from unconditioned spaces; the outdoor temperature and solar and wind conditions assumed; assumptions made with regard to the number of people to occupy various areas and any equipment or exhaust fans expected to be installed; anticipated lighting levels; and indoor environmental conditions to be maintained. In most cases an adequately prepared final design analysis will meet the requirements for the TCN.

b. Systems O&M Manuals. The construction contractor (when specified) is to develop systems O&M manuals for use by the Government or contract personnel in operating and maintaining the facility. The systems O&M manual will be an extension of the TCN. It will describe in detail the equipment provided in the construction contract. Anytime the construction contractor provides a system or portion of a system that differs from the original design, he will be responsible for revising all portions of the draft OM manual, including those originally prepared by the A-E. The manuals shall contain as a minimum an index of the contents of the manual, the functioning of the system, operating instructions, maintenance instructions, trouble shooting and repair instructions, spare parts list, special tools and test equipment list, safety precautions and warranty information. Appendix A gives a more detailed description of the information required.

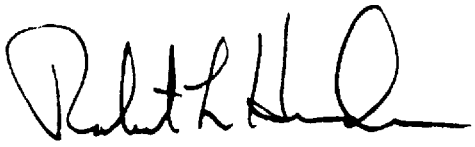
c. Master Equipment List (MEL). The construction contractor will update and complete the DMEL by adding the name of the manufacturer, model number, capacity, and other equipment data for each item identified on the DMEL.

d. Training. The A-E will provide a proposed training concept and schedule and develop contract specifications for those items of equipment and systems for which the contractor is to provide formal training. Requirements for training should be broken down as to the number of hours of operator training and the number of hours of maintenance training for both classroom instruction and hands-on equipment instruction. The A-E shall also identify the number and types of special skills that will be required. If requested by the user during project development, video taping and the training can be included in the construction contract. Effective training requires close coordination with the DEH or BCE during both the design and construction phases of the project.

e. Equipment O&M and Repair Manuals. Continuing attention is needed on specifying appropriate requirements for O&M data in the construction contracts for projects other than those outlined in paragraph 4. Existing regulations require the construction contractor to provide operating instructions describing the starting and stopping procedures which include the sequence of both electrical and mechanical device activation, maintenance instructions and schedules, repair instructions, spare parts data, schematic drawings of the electrical and mechanical systems to include circuit and piping diagrams and training of operators, etc.

7. BCO Reviews. All contract packages should be thoroughly reviewed during the Biddability, Constructability, Operability (BCO) review to assure O&M requirements are appropriately addressed.

FOR THE COMMANDER:



ROBERT L. HERNDON
Colonel, Corps of Engineers
Chief of Staff

2 Appendices
App A - Sample Architect-Engineer (A-E) Statement of Work
App B - Standard Guidelines for Submission of Facility Operating and Maintenance Manuals

APPENDIX A

SAMPLE ARCHITECT-ENGINEER (A-E) STATEMENT OF WORK

1. General. Development of operation and maintenance (O&M) documentation and training requirements for facilities is a two-step operation shared by the A-E and the construction contractor. Since the construction contractor's effort is competitively bid, the A-E must specify in detail what the construction contractor must supply. Several different types of documentation are to be prepared by the A-E. These include:

a. Technical concept narrative (TCN) portion of Systems O&M Manuals (SOMM).

b. Design master equipment list (DMEL).

c. Construction Specifications for O&M Documentation.

d. Training requirements.

2. TCN. The A-E shall develop a TCN (basically, a design O&M manual) for each functional system requiring O&M.

a. The TCN is comprised of Chapters 1, 2, and 3 of the SOMM as outlined in paragraph 2.3.2. For those chapters and appendices to be completed during the construction phase, the A-E shall describe in detail what the construction contractor must provide to achieve comprehensive Systems O&M Manuals (SOMM). The SOMM is intended to provide all the information necessary for the installation engineer to operate and maintain the system, as well as provide overall system checks.

b. The A-E shall describe the intended use and operation of each functionalsystem including its interrelationship with other functional systems and subsystems. A discussion of the theory of operation of the facility system and major pieces of equipment shall be provided, written at the level necessary for journeyman understanding. All system requirements and their application shall be covered.

c. In addition to preparing the TCM, the A-E shall furnish the labeled binders and tab dividers labeled to be used by the construction contractor when completing the SOMM. The A-E shall also prepare introductions for Chapters 4-7 of the SOMM summarizing what the construction contractor is to provide per the specifications developed by the A-E in accordance with paragraph 3.0.

(1) The SOMMs shall be organized by systems. For complex systems, the respective SOMM shall be broken down into volumes

containing one or more subsystem. Additionally, the SOMM shall be structured (into volumes) so as to facilitate use by different installation O&M organizations. If there is more than one O∧M organization involved the Contracting Officer will provide the A-E a list identifying the various O&M organizations and the systems/subsystems for which respective O&M responsibilities require special packaging of the SOMM.

(2) The SOMM arrangement shall be as follows:

Front Matter.

Chapter 1--General Information

Chapter 2--System Description.

Chapter 3--Theory of Operation.

Chapter 4--Operations.

Chapter 5--Preventive Maintenance (PM).

Chapter 6--Trouble Analysis (TA).

Chapter 7--Corrective Maintenance and Checkout Procedures.

Appendix A--Special Tools and Test Equipment List.

Appendix B--Repair Parts List.

Appendix C--Vendor Data/Acceptance Tests.

Appendix D--Warranty Data Information.

(a) Front Matter. The cover, title page, list of effective pages, foreword, table of contents, list of illustrations, list of tables, and list of abbreviations and acronyms should be prepared in accordance with the requirements of MIL-M-38784B, or as otherwise specified in the provisions of the contract.

(b) Chapter 1--General Information. This chapter shall present general information, including, in tabular format, a master index identifying all subject matter covered within each volume.

(c) Chapter 2--System Description. This chapter shall describe the system construction drawings that are essential to support the TCN and shall be referenced. For systems consisting of more than one unit or item of equipment, or where complexity must be explained, an illustration or flow diagram will be

included. If one system interfaces with another system or subsystem, this chapter shall define how they interface. Safety and security topics shall be covered and referenced to the operating procedures, as applicable.A table of capabilities and limitations shall be prepared for the systems. The table will include data such as gallons per minute, transfers per hour, boom capacity, rated ranges, resolution, accuracy, data-handling capability, etc. Such data shall be presented in tabular form. An additional table shall be provided to clearly illustrate the capabilities required of a given system or item of equipment that differ because of its configuration within the system. The word "differ," as used above, is meant to include those capabilities other than normal or usual. The fact that the input, output, feedback, or control levels required are within the design specifications of the system or item of equipment is not a sufficient reason for omitting the system or item of equipment from the table. Major equipment components will be identified and located by describing each component that is significant to O&M, logistics, and safety. A tabular list of leading particulars will be included as necessary to support the description of major components.

(d) Chapter 3--Theory of Operation. This chapter shall contain a discussion of the theory of operation and a listing of all the functions of the system, and shall show how the various facility subsystems functions are tied together to accomplish the overall system function. The description shall include an overall analysis of the principles of operation of the system equipment and its functions, such as control interlocks, where such principles would not be obvious to journeyman technicians. Particular attention shall be paid to the interface between facility systems and other systems. The descriptions shall be sufficiently detailed to provide system personnel with the understanding necessary to adequately perform the system activities and to correctly interpret the results of these activities.

3. Construction Contract Specifications for Contractor Furnished O&M Documentation. The A-E shall prepare the contract specifications for the O&M documentation which is to be added to the TCNs by the construction contractor in accordance with the outline shown in 2.c.(2). The following subparagraphs describe the end products desired from the construction contractor

a. Chapter 4--Operations. This chapter is to include equipment and/or system layouts showing all piping, wiring, breakers, valves, dampers, controls, etc., complete with functional diagrams, schematics, isometrics, and data to explain the detailed operation and control of each individual piece of equipment and/or system, including system components. Layouts should show the location within the facility of controls, valves

switches, dampers, etc., by reference to site locations, wing designation, floor, room number, or other clear and concise directions for locating the item. Operator data may be identical to posted data and framed instructions, but shall be included as part of the O&M manuals. The instructions shall include:

(1) Initial adjustments and control settings.

(2) Precautions and prechecks to be executed prior to start-up or shutdown of equipment and/or system, including safety devices, monitoring devices, and control sequence.

(3) Step-by-step sequential procedures for start-up, shutdown and normal operation checks for satisfactory operation. Safety precautions and instructions that should be followed during these procedures shall be incorporated into the operating instructions and flagged for the attention of the operator. Procedures shall include test, normal, and automatic modes.

(4) Procedures for normal and emergency shutdown of equipment and/or systems. The instructions shall include any procedures necessary for placing the equipment and/or system on standby or preparing the equipment and/or system for start-up at a later time. Procedures shall include test, normal, and automatic modes.

(5) Procedures for isolating individual equipment from the system and bringing individual equipment on-line once the system is operating.

(6) Operational logs and records requirements.

b. Chapter 5--Preventive Maintenance (PM).

(1) Recommended procedures shall indicate PM (e.g., lubrication, checks, adjustments, etc.) and good-housekeeping practices which should be performed by operating personnel, as well as more complex maintenance time-frames or operating hours for specific maintenance to be accomplished. Safety precautions and instructions that should be followed during these procedures shall be incorporated into the maintenance procedures and flagged for the attention of personnel. The procedures shall include necessary operating instructions for taking equipment off-line, putting equipment on-line, or putting equipment on standby. The instructions shall address all material, equipment, and system data needed to perform maintenance work and shall include, but not be limited to, manufacturers' bulletins, catalogs, and descriptive data; certified performance

curves; copies of approved test plans, including logs and records of performance acceptance and inspection; system layouts, including block, wiring, control, and isometric diagrams; schematic items within the facility; and interrelationships with other items of the system.

(2) Schedules indicating time-frames or operating hours for initiating operator maintenance and adjustments and including manufacturer's recommended major maintenance requirements shall be provided. Emergency adjustments shall be included and flagged for the operator's attention. The instructions shall also include procedures for emergency repairs that could be performed by operating personnel.

c. Chapter 6--Trouble Analysis (TA). TA procedures for locating and correcting the trouble shall be presented in a step-by-step format. Repair procedures shall be keyed to a troubleshooting guide outlined in three columns with the following heading:

Column 1--Trouble.

Column 2--Probable Cause(s).

Column 3--Correction.

The procedures shall clearly indicate a major repair activity, which should be performed only in a shop or factory, as opposed to normal repair work, which may be performed on site or with equipment on-line. The procedures shall also clearly indicate the limit of repair work that may be performed by Government personnel during the warranty period without voiding warranty provisions. Safety precautions and instructions that should be followed during these procedures shall be incorporated into the repair procedures and flagged for the attention of personnel.

d. Chapter 7--Corrective Maintenance and Checkout Procedures. Procedures for troubleshooting and isolation, replacement, checkout, and integration of equipment within the system shall be provided.

(1) Troubleshooting. Procedures for troubleshooting of malfunctions that might occur during operation of the system shall be provided. Troubleshooting data, and fault isolation techniques, shall state the following: (a) The indication or symptom of trouble; (b) the instructions, including test hookups, necessary to determine the cause; and (c) procedures, for restoring the system to operating condition. Troubleshooting shall be documented to the extent necessary to locate the faulty piece of equipment within the system.

Information may be in chart form, in logic tree form, or in tabular format with appropriate headings.

(2) Isolation, Replacement, Checkout, and Integration. Procedures for isolation, replacement, checkout, and integration of the equipment within the system shall be provided. Test, adjustment, and checkout data, after replacement, shall be included.

e. Appendix A--Special Tools and Test Equipment List. A list of all special tools and test, diagnostic measurement, and equipment for system level maintenance shall be in this appendix. For the purpose of this specification, the phrase "special tools and test, measurement, and diagnostic equipment" is used to identify all nonstandard tools and equipment designed and developed by the manufacturer and others to perform maintenance, test/calibration, diagnostic/prognostic analysis, and other related support of the equipment and required for installation, acceptance testing, and successful O&M. Frequency and method of calibration shall be indicated for all special tools, equipment, and test equipment items that require calibration. Necessary standards shall be listed immediately after each item that requires calibration.

f. Appendix B--Spare Parts List. A complete list of spare parts and supplies shall be provided. The list shall include all parts and components of individual pieces of equipment and all parts and components of each system and shall identify such items as nomenclature of part, model number, circuit or component identification, etc. Parts and supplies lists shall be included within each volume of maintenance instructions. Further, a master list of spare parts and supplies recommended from each manufacturer for one year of operation, including source of supply, shall be sub-listed with each instruction. The contractor shall also list the sources of supply for all parts and supplies, including name of supplier/manufacturer, address, and telephone number. If the parts and supplies are not normally stocked locally, necessary procurement lead time shall also be a part of the listing.

g. Appendix C--Vendor Data. A complete set of data, provided by the equipment manufacturer, required for operation, maintenance, and checkout shall be included and referenced to the appropriate specifications number. The data may consist of manufacturer's brochures, O&M manuals, catalogs, drawings, service bulletins, and illustrated parts lists necessary to support the O&M of the end item of equipment and assemblies.

h. Appendix D--Warranty Information. In addition to the

general warranty required by the contract, the O&M manuals shall include any specific warranties required by other sections of the Technical Specifications and other warranties normally provided with the particular piece of equipment or system. Warranties that are normally provided by manufacturers and which are beyond the warranty for construction shall be specifically noted.

4. Design Master Equipment List (DMEL).

a. The A-E shall develop a DMEL of facility equipment that is significant to operations, maintenance, and provisioning. The DMEL will identify each major system, subsystem, and equipment item in generation breakdown order to the purchase end item level. The DMEL shall contain as a minimum the following information:

(1) Item nomenclature.

(2) Functional characteristics.

(3) Item identifier (tag number).

(4) Specification number.

(5) Design/construction drawing number. (File number when available).

b. The DMEL is to be provided to the construction contractor, who, by adding the manufacturer's name, manufacturers part number, and manufacturers model/serial number, will create the "as-built" master equipment list (MEL). The A-E shall prepare construction contract specifications to have the contractor submit the completed MEL to the Contracting Officer.

5. Training Requirements. The A-E shall develop an O&M training develop concept. This concept shall be presented in two formats: (a) report for use by the Government in planning for O&M personnel training and (b) contract specifications describing what the construction contractor must furnish/perform to adequately train Government and/or O&M contractor personnel.

a. Training Concept Report.

(1) All systems and subsystems requiring training of qualified personnel to properly operate and maintain those systems shall be identified. A task and skills analysis shall be documented to identify special skill required to operate and/or maintain critical, complex, or specialized systems.

After the skill requirements are identified, the actual training programs shall be defined.

(2) The training concept report shall identify the types (trade skills) of personnel to be trained on which systems. The A-E shall recommend instructional methods, materials and special training devices recommended to support the program of instruction, including appropriate video taping of both factory and/or on site training. Additionally, the training concept shall identify the minimum number of instructor man-hours of instruction for each system and item of equipment requiring specific training, and shall specify the appropriate proportion of the instruction time that shall be used for on-site (classroom) instruction, and for on site instruction during which reference shall be made directly to the observed equipment or system.

(3) The A-E will recommend functional areas of the operating system and/or equipment where a technical representative should be furnished by the manufacturer for training.

(4) The A-E shall prepare a cost estimate for the training services and materials to be provided by the construction contractor as recommended in the training concept report. The estimate shall take into account that information which is usually furnished by the manufacturer/supplier as part of the system/equipment purchase price.

b. Training Specifications. Based on the training concept approved by the Government, the A-E shall prepare training specifications detailing the minimum number of hours and types of instruction to be provided by the equipment manufacturer and/or construction contractor for each system, subsystem, and piece of equipment warranting training. A suggested format for the specifications is shown below.

O&M TRAINING REQUIREMENTS

SYSTEM/EQUIPMENT	INSTRUCTIONAL HOURS	RELATED SECTION NO.
[NOTE: The A-E Shall Enter System/Equipment, Instructional Hours, Both Classroom and Hands-on, and Related Technical Section No.]		

c. General Requirements.

(1) The construction contractor must submit a proposed training schedule at least 60 days prior to the start of the earliest training session. The training schedule shall include the following:

- An outline of all specified training, both classroom and hands-on, describing the presentation of the training.

- A day-to-day schedule showing location of training, time intervals, and the major and subordinate subjects to be covered in each session.

- Identification and qualifications of proposed instructors.

- A list of reference materials to be provided by the contractor to the trainees and a list of training materials such as O&M instructions, other written and visual aids, mock-ups, tools, etc.

(2) Review of Proposed Training Plan. The Contracting Officer will review the contractor's proposed training schedule, and the Contracting Officer's approval of the schedule shall be obtained by the Contractor prior to the start of any training. The training schedule for all required formal training shall be submitted to the Contracting Officer in draft form, four (4) copies in one submittal. The Contracting Officer will require thirty (30) days for review and approval of the schedule or for disapproval and return to the Contractor for resubmission. Upon approval of the schedule, the Contractor shall submit the final schedule, in six (6) copies, incorporating all comments or revisions noted from the Contracting Officer's review of the proposed schedule.

(3) Formal Training: The Contractor shall provide qualified competent personnel for formal training of Government and/or O&M Contractor employees. Classroom training shall be held on-site at the Government installation. Training shall be conducted between the hours of 7:30 a.m. and 4:00 p.m. on non-holiday Mondays through Fridays, unless a different schedule is approved in writing by the Contracting Officer.

(4) Audio-Video Recordings and Audio-Video Tape Player. The contractor shall provide all equipment, material, and trained personnel to visually and audibly record all field instruction training sessions. The proposed recording system shall be of one manufacturer and of studio quality and shall be

approved by the Contracting Officer prior to its use. Upon completion of instructions, the audio-video tape player and recordings shall become the property of the Government. The recordings shall be identified, indexed, and placed in approved storage containers.

d. Training Service Cost Estimate. The A-E shall prepare a cost estimate for the training services and materials specified taking into account that which is usually furnished by the manufacturer/supplier as part of the system/equipment purchase price.

APPENDIX B

STANDARD GUIDELINES FOR SUBMISSION OF FACILITY OPERATIONS AND MAINTENANCE MANUALS (ETL 89-2)

1. Policy: The requirement for development and preparation of systems operating manuals is contained in AFR 89-1, Project Book Construction Technical Letter (CTL), and various standard guide specifications. This guideline has been prepared to further define and clarify the technical details and data required to be submitted by the designer and contractor.

a. Operating and maintenance (O&M) manuals are required for new Air Force facilities and systems. As facilities for new weapons or support systems increase in complexity, improved O&M manuals are required to enhance reliability and maintainability of these facilities. Two types of manuals are to be developed depending upon system complexity. The MAJCOM or AF/LEED will identify "complex" facilities during the programming cycle. Examples of "complex" facilities include large administrative facilities, special processing plants, utility plants, laboratories, etc.

(1) For a "complex" designed facility, two sets of manuals are to be developed. The designer/design agent will develop SYSTEM OPERATING MANUALS and the contractor will provide the EQUIPMENT OPERATING, MAINTENANCE, AND REPAIR MANUALS.

(2) For all other facilities and systems, only the EQUIPMENT OPERATING, MAINTENANCE, AND REPAIR MANUALS are required.

b. The specific requirements for the basic content of each of the O&M manuals are indicated in the attachment. The applicable sections of this guideline will be inserted in the appropriate section of the technical provisions or in the statement of work (SOW) of the design contract to cover the requirements and submission of the manuals. Separate manuals are required for each utility system or subsystem. This will allow each civil engineering work center to have a ready reference manual prepared specifically for their use. It is recognized that some information will be duplicated in more than one manual.

c. When the requirement for system operating manuals is included in the design contract, the designer will provide to the design agent, upon design completion and prior to contract award, the manuals as detailed in the guidelines The design agent will forward the approved manuals to the construction management section to be held until completion of the equipment operating, maintenance, and repair manuals by the construction contractor.

d. Equipment operating, maintenance, and repair manuals are to be prepared prior to construction completion. Copies of the approved manuals will be forwarded by the construction agent to the base construction management section who will forward them, along with the system operating manuals (from their files, to the appropriate operations branch work centers.

e. System Operating manuals and equipment operating, maintenance, and repair manuals should be used as reference material during the O&M training phase prior to facility turnover or beneficial occupancy.

2. The attachment 2 guideline must be tailored for each project with the nonapplicable requirements deleted and/or modified, as appropriate.

TECHNICAL PROVISIONS FOR PREPARATION OF FACILITY OPERATING AND MAINTENANCE MANUAL

SECTION [ ]. SYSTEM OPERATING MANUALS AND EQUIPMENT OPERATING, MAINTENANCE, AND REPAIR MANUALS.

[ ].1. GENERAL REQUIREMENTS

a. Hard Cover Binders. The manuals should be permanently bound and have a hard cover. The following identification shall be inscribed on the cover: the words "SYSTEM OPERATING MANUAL" or "EQUIPMENT OPERATING, MAINTENANCE, AND REPAIR MANUAL;" the name, building number, location, and indication of utility or systems covered. Manuals should be approximately 8 1/2 by 11 inches with larger sheets folded in and capable of being easily pulled out for reference. All manuals for a single facility must be similar in appearance.

b. Warning Page. A warning page must be provided to warn of potential dangers (if they exist), such as high voltage, toxic chemicals, flammable liquids, explosive materials, carcinogens, or high pressures. The warning page shall be placed inside the front cover, in front of the title page.

c. Title Page. The title page must show the name of preparing firm (designer or contractor) and the date of publication.

d. Table of Contents. Provide in accordance with standard commercial practice.

e. Delivery of Manual. Manuals are to be provided at least two weeks prior to the scheduled contractor's training sessions with the base civil engineering personnel.

f. Training. All training of base technicians must be accomplished by qualified personnel who have been certified by the appropriate manufacturers. All training dates and times will be approved by the contracting officer. All training will be done Monday through Friday between 0700-1700. Contractor shall provide___days of training on the operation and use of the system and provide___days of training on maintenance of the various systems. Each day's training shall consist of eight hours of actual training time. The approved system and equipment operating manuals with be used to conduct subject training. Final acceptance of the facility will be contingent upon receipt of the O&M manuals and completion of the training. All training aids, additional drawings. schematics, and

literature necessary to conduct this training will be provided by the contractor at no additional cost to the government.

[ ]]2. SYSTEM OPERATING MANUALS FOR COMPLEX FACILITIES.

a. General. Four (4) bound copies of the SYSTEM OPERATING MANUALS will be provided for each utility system. Manuals must be written so that they can be understood by a graduate of both high school and service school with some practical experience. A separate manual must be provided for each system as defined hereinafter. Generally, all manuals shall include the following information:

(1) A general description of each system to show the type of system installed, its design or specified capacity and performance capabilities, special and unusual features, and relationship to other systems.

(2) A statement of the design intent to include design factors and assumptions.

(3) Operating instructions describing, in detail, system starting and stopping procedures, instrumentation, and adjustments necessary to obtain optimum system performance. The location of test connections and the values expected at these points shall be included, preferably in illustrated form. Data must include a list of the additional equipment required to accomplish the verification such as temperature, vacuum, pressure, hydraulic, or signal generators. The listing must show methods of use or application, range of scales, and specific minimum tolerance or performance of accuracy.

(4) Emergency operating instructions to include emergency procedures for equipment malfunction to permit a short period of continued operation or to shut down equipment, if required, to prevent further damage. Include emergency shutdown instruction for fire, explosion, spills, or other contingencies. Provide guidance on emergency operation of all utility systems, including valve location and portion of systems controlled.

(5) Single line floor plans, to show location of equipment and configuration of systems. floor plans shall be accomplished so that structural features are subdued compared to utility features. Floor plans shall be included in the manual, not as a separate package.

(6) Acknowledging that various design data may not be available during the design process, the designer will use generic information for development of system manuals. When

specific equipment or materials have been selected by the construction agent shall furnish this information to the design agent for inclusion in the system manuals.

b. Facility Heating Systems. This manual covers heating systems and those portions of HVAC systems that provide heat. The following information shall be provided:

(1) A single line floor plan including:

(a) Color coded piping plan for all hot water, steam and fuel piping, including indication of directions of flow and locations of all isolation valves (not balance), air vents and drains.

(b) Location of boundaries of each temperature control zone.

(C) Location of all heating equipment such as fin-tube radiation, heating coils, boilers, and pumps.

(d) Location of all water treatment equipment or provisions for this equipment in exchange softeners such as continuous feeders or other equipment.

(e) Location of all motor starters.

(2) A valve schedule showing the function of each valve shown on the floor plan.

(3) A written description of operation for each component (not to include internal factory installed controls), including its relationship to other components of the heating system.

(4) A narrative description of the seasonal operation requirements For example, should boilers and chillers be operated simultaneously?

(5) A narrative description of chemical treatment, sampling, and testing requirements.

c. Air Conditioning Systems. This manual covers hydronic or forced air air-conditioning systems and those portions of HVAC systems that provide cooling. The following information shall be provided:

(1) Single line floor plans including:

(a) Color coded piping plan for all chilled, ondenser, and make-up water piping showing directions of

flow and locations of all isolation valves (not balance), air vents and drains.

(b) Location of boundaries of each temperature control zone

(c) Location of all air-conditioning equipment (e.g., chillers, cooling towers, pumps, cooling coils, etc).

(d) Location of all water treatment equipment or provision for this equipment feed such as continuous feeders and other equipment.

(e) Color coded air distribution plan including location of all fire and smoke dampers.

(f) Location of all motor starters.

(2) A valve schedule showing the function of each valve shown on the floor plan.

(3) A written description of operation for each component (not to include internal factory installed controls), including its relationship to other components of the air conditioning system.

(4) A narrative description of seasonal operation requirements. For example, should boilers and chillers be operated simultaneously?

(5) A narrative description of chemical treatment, sampling, and testing requirements.

d. Temperature Control and HVAC Distribution System. This manual covers automatic temperature controls and information necessary for air and hydronic balancing. The following information shall be provided:

(1) Single line floor plans including:

(a) Color coded piping plan for all HVAC piping showing directions and quantities of flow and location of all valves and flow measuring stations.

(b) Location of boundaries of each temperature control zone.

(C) Location of all HVAC equipment.

(d) Color coded air distribution plan including

location of all dampers (manual and automatic) and air flow measuring stations and air flow requirements for each duct and air device.

(e) Location of all motor starters.

(2) A valve schedule showing the function of each valve shown on the floor plan.

(3) A written description of operation for each component (not to include internal factory installed controls), including its relationship to other components of the HVAC system.

(4) A narrative description of the seasonal operation requirements. For example, should boilers and chillers be operated simultaneously?

(5) Provide the following information for all automatic temperature control equipment:

(a) A fully labeled control piping or wiring schematic which shows point-to-point piping and wiring and includes all performance parameters such as set points, throttling ranges, actions, spans, proportional bands, and other control components adjustment or setting data. The system schematic piping or wiring diagram must be drawn to a large enough scale to allow ample space to allow enough print to be written in large enough print to be easy to read.

(b) A fully labeled elementary electrical ladder diagram.

(c) A sequence of operation (a narrative statement of how the control system functions). It must be complete, cross-reference to the control schematic piping or wiring diagram and to the elementary diagram.

(d) A functional description of each control components shown on the drawings. Describe the generic performance of each component.

(e) Notation of pneumatic test ports and electronic system terminal strips cross-referenced between the control and the control schematic to facilitate troubleshooting and calibration.

(f) Location of EMCS interface equipment and interaction on EMCS control capabilities.

e. Central Heating Plants. This manual covers the central heat plant (steam or high temperature hot water). The following

information shall be provided:

(1) A single line floor plan including:

(a) Color coded piping plan for all water, steam and fuel piping, including indication of directions of flow and location of all valves, air vents, and drains

(b) Location of all equipment such as boilers, pumps, fans, economizers, heat exchangers, control panels, fuel handling equipment, deaerators, tanks (flash, expansion, return water, etc), water softeners, and pollution control devices.

(C) Location of all steam traps (for steam plants).

(d) Location of all chemical feed equipment or provision for chemical feed such as shot feeders or other equipment.

(e) Location of all motor starters.

(f) Color coded schematic that shows the interrelationship of all components in the heat plant. For example, use of economizer to preheat combustion air or make-up water.

(2) A valve schedule showing the function of each valve shown on the floor plan.

(3) A written description of operation for each component (not to include internal factory installed controls), including its relationship to other components in the central heat plant system.

(4) A narrative description of the seasonal operation requirements. For example, which boilers should be operated to meet different load requirement?

(5) A narrative description of chemical treatment requirements.

f. District Heating Distribution Systems. This manual covers the district heating distribution systems (steam or high temperature hot water). The following information shall be provided:

(1) A single line plan including: Color coded piping plan for all hot water, steam, and condensate return lines; including indication of directions of flow and locations of all valves, manholes, steam traps, pumps, air vents, tanks (expansion,

flash, etc), and drains.

(2) A valve schedule showing the function of each valve shown on the piping plan.

(3) A written description of operation for each component, including its relationship to other components in the district heating distribution system.

q. Exterior Electrical System. This manual covers exterior electrical distribution systems. The following information shall be provided: (1) A single line showing the following. Equipment ratings (continuous and interrupting duty) shall be included.

(a) Location of all switches.

(b) Size and location of all capacitor banks.

(c) Location of all transformers.

(d) Location of all reclosers and breakers.

(e) Location of all lightning arrester and grounding rods.

(f) Location of all guy wires.

(g) Wire sizes and types.

(h) Fuse sizes and types.

(i) Nameplate data of all the above.

(2) A single line of all substations and switching stations to include CT ratios, relay types, and settings.

(3) A written description of operation for each component (breakers, relays, regulators, recloser, etc), including its relationship with other components of the distribution system.

(4) Short Circuit Analysis, Load Flow, and Coordination Study.

(5) Provide the following information on all automatic equipment (breakers, reclosers, regulators, etc).

(a) A fully labeled elementary electrical ladder diagram.

(b) A sequence of operation, cross-referenced to the elementary diagram.

h. Interior Electrical Systems. This manual covers the interior electrical distribution system. The following information shall be provided:

(1) Single-line floor plans including:

(a) Location of all electrical distribution equipment (e.g., panels, disconnects, transformers, switchgear, motor control centers, EPS lighting systems, etc).

(b) Location of all electric motors 1/4 HP or greater and the size of the installed (and required IAW NEC) thermal overloads..

(2) A distribution system single-line diagram with ratings and settings adjacent to major protective devices (IAW Coordination Study) and feeder sizes and types.

(3) Short circuit and coordination study.

(4) Special grounding systems.

i. Energy Management and Control System. Manuals delivered shall include:

(1) Functional Design Manual: The following design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes.

(2) Hardware Manual: A manual describing all equipment furnished, including:

(a) General description and specifications.

(b) Installation and checkout procedures.

(C) Equipment electrical schematics and layout drawings.

(d) System schematics and input/output wiring lists.

(e) Alignment and calibration procedures.

(f) Manufacturer's repair parts list, indicating

sources of supply.

(g) Interface definition.

(3) Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing and operation.

(3.1) The manual shall have separate sections for central control unit and central communications controller software, including:

(a) Definition of terms and functions.

(b) Procedures for system generation.

(C) Description of the algorithms for the applications programs.

(d) Description of implementation of the applications programs.

(e) Description of required sequences using control sequence software.

(f) Data base format and data entry requirements.

(g) Directory of all disk files.

(h) Description of all communications protocols including data formats, command characters, and a sample of each type of data transfer.

(3.2) The manual shall have separate sections for all FID and MUX software including:

(a) Definitions of terms and functions.

(b) Descriptions of algorithms for the applications programs.

(C) Description of implementation of the applications programs.

(d) Description of data base format.

(e) Description of all communications protocols, including data formats, command characters, and a sample of each type of data transfer.

(4) Operator's Manual: The operator's manual shall fully explain all procedures and instructions for operation of the system, including:

(a) Computers and peripherals.

(b) System start-up and shut-down procedures.

(c) Use of system, command, and applications software.

(d) Alarm presentation.

(e) Recovery and restart procedures.

(f) Back-up equipment operations.
(g) Use of reports generator.

(h) Data entry.

(i) Parameter schedules.

(j) Operator commands.

(k) Report generator data format, output format, and content.

(l) Alarm messages and format.

(m) System access requirements.

j. Domestic Water Systems. This manual covers the domestic water supply, treatment, and distribution system. The following information shall be provided:

(1) Single line drawings.

(a) Color coded piping for all treatment facility process lines indicating flow direction and location of all control valves and gates.

(b) Location of all base distribution lines, water source mains, intakes and well systems, storage tanks, pumping stations and other unique facilities connected to the system.

(C) Treatment system process diagrams showing all the components and control points.

(d) Simplified electrical schematic of the control system and electrical equipment.

(e) Specifications for all pumping systems.

(2) Safe drinking water standards and other appropriate state and federal regulations and reporting requirements should be provided.

(3) The normal operating process of each component should be explained along with its relationship to the other components. Process control and monitoring instrumentation should be explained along with control and valve status charts for the various operating modes. Routine operator tasks should be described.

(4) Process theory and laboratory control testing and monitoring should be explained.

(5) A special chapter should be devoted to safety issues and emergency operating procedures. Supporting utility systems and alternate power and water sources should also be described.

(6) The requirements for daily operating logs and maintenance records should be explained.

(7) Manpower requirements, along with job descriptions, training and certification requirements should be provided.

k. Wastewater Treatment Systems. This manual covers the domestic wastewater collection and treatment systems. The following information shall be included:

(1) Single line drawings.

(a) Colored coded piping for all treatment facility process lines including flow direction and location of all control valves and gates.

(b) Location of all base collection lines, lift stations, force mains, manholes, oil/water separators and other unique facilities connected to the system.

(C) Treatment system process diagrams showing all the components and control points.

(d) Simplified electrical schematic of the control system and electrical equipment.

(e) Specifications for all pumping systems.

(2) NPDES Permit requirements along with appropriate state and federal regulations and reporting requirements. Information on local stream standards should also be provided.

(3) The normal operating process of each component should be explained along with its relationship to the other components. Process control and monitoring instrumentation should be explained along with control and valve status charts for the various operating modes. Routine operator tasks should be explained.

(4) Process theory and laboratory control testing and monitoring should be explained.

(5) A special chapter should be devoted to safety issues and emergency operating procedures. Supporting utility systems and alternate power sources should also be described.

(6) The requirements for daily operating logs and maintenance records should be explained.

(7) Manpower requirements, along with job descriptions, training and certification requirements, should be provided.

l. Fire Protection Systems. This manual covers fire suppression systems of the following types: automatic sprinkler and standpipe, foam extinguishing, gaseous extinguishing, and dry chemical.

(1) Single line piping plans for each of the above systems. The plans will show direction of flow and location of manual valves, alarm valves, test connections, storage tanks, pumps, distribution devices, and hydrants.

(2) A valve schedule showing the function of each valve.

(3) An alarm valve schedule showing the location and description of each
devices.

(4) Copies of the manufacturer's recommended inspection, test, and maintenance instructions/guidance for each different devices installed.

m. Fire Detection Systems. The following information shall be provided;

(1) Single-line floor plans including:

(a) Details and location of all detectors.

(b) Location of boundaries of all zones.

(C) Wiring schematic of all control panels, annunciator and detection devices.

(d) Location of interfaces with HVAC and electrical equipment (power and HVAC shutdown, damper operation, etc).

n. Plumbing Systems. This manual covers plumbing, including domestic hot and cold water, wastewater, compressed air, natural and liquefied petroleum gases, medical gases, and vacuum systems.

(1) Single-line piping plans for each of the above systems. The plans will show direction of flow and locations of valves, regulators, backflow preventors, traps and oil/water separators, and plumbing fixtures.

(2) A valve schedule showing the function of each valve and backflow preventer.

(3) A regulator schedule showing the location and regulating pressures of each device.

(4) A trap and oil/water separator schedule showing the location and operation of each.

o. Liquid Fuel Systems. This manual covers liquid fuel storage and distribution systems for aviation and ground petroleum products. The following information shall be provided:

(1) Single-line drawing including:

(a) Color coded piping plan for liquid fuel, water and drainage. The plan show location of directions of flow, location of isolation valves, low point drains and high point vents.

(b) Location of all hydrant outlets and truck fill stands.

(C) Location of all system pumps with capacity and pressure rating.

(d) Wiring schematics for all electrical components.

(2) Electrical and electronic control sequence of operations for pumps, alarms and liquid level control devices.

(3) A valve schedule showing the function of each manual and automatic valve. Valves will be designated as normally open or closed and for maintenance or operation of the system.

(4) Automatic control valve schematics shall be furnished for all regulating valves. Diagrams showing sequence of

operation for each pilot control will be furnished for each type of valve.

p. Cathodic Protection Systems. This manual covers both galvanic sacrificial or impressed current protection systems. The following information shall be provided for either system:

(1) A scaled single-line drawing showing:

(a) Location and depth of the structure being protected.

(b) Location, depth and material composition of any other structure such as, but not limited to, buried tanks, pipelines, natural gas lines, water lines, electrical conduits or telecommunications cables that crosses or is in close proximity to the structure receiving protection.

(C) Location and depth of anodes.

(d) Location of all test stations.

(e) Location of all junction or shunt boxes. If a shunt box is used, a separate detail showing the installation, shunt sizes and resistor sizes (if any) should also be included.

(f) Location and rated capacity of all rheostats, potentiometers or resistors.

(g) Location and depth of anode header cable (galvanic system) or positive and negative header cables (impressed current system). This detail should also include conductor size, material and installation used.

(h) Location and depth of all bonds made to the structure receiving protection.

(I) Location of all pavement inserts.

(j) Location and type of all reference electrodes.

(k) A separate detail showing the typical wiring diagram of test stations installed

(l) A separate cross-sectional view of a typical buried anode indicating weight, dimensions and material. The type of backfill used for the installation should also be indicated on this detail.

(m) A separate detail showing a typical splice

indicating type of connector used and type of material used for a splice coating.

(n) A separate detail showing a typical bond indicating type of bond device (exothermic weld, clamp etc.) and type of material used for a bond coating.

(o) A separate detail showing the rectifier mounting method indicating height and size of supports. This detail should also include the particulars of the rectifier such as the AC input, rated DC output (Impressed Current Systems Only).

(p) Location of isolating flanges and type of material used for dielectric insulation.

(2) Operations manuals for automatic potential control or automatic current regulating rectifiers shall also be included.

q. Generator Installations. This manual covers permanently installed electrical generator systems. The following information shall be provided:

(1) A single-line floor plan including:

(a) Piping plan for the cooling, air start, fuel systems, and lube systems.

(b) Location of all equipment such as generators, switchgear, automatic transfer switches, batteries, starting system, fuel tanks, etc.

(c) Schematic and location of the grounding system.

(2) A written description of operation for each component, including its relationship to other components of the generating system.

(3) A listing of the transient reactance, synchronous reactance, subtransient reactance, negative sequence reactance and zero sequence reactance for each generator.

(4) A narrative description of the operation of governors, exciters, regulators auto/manual synchronizing and other control equipment.

(5) Provide the following information on all protective circuits, switchgear, automatic transfer switches, generator circuits and battery charges:

(a) Fully labeled elementary electrical ladder

diagrams.

(b) A sequence of operation, cross-referenced to the elementary diagram.

(6) A written description of the requirement for and treatment of equipment cooling systems, including cooling system capacity.

r. Active Solar Installation. This manual covers permanently installed active solar systems (flat plate or concentrator plates). The following shall be provided:

(1) A single-line floor plan including:

(a) Piping and fitting including the storage tank, heat exchanger and collector.

(b) Location of all equipment such as valves, pumps, solar collectors, compression tanks, instruments (including any solar tracking equipment), piping specialties, solar storage tanks, heat exchangers and solar-boosted domestic water heaters.

(C) Schematic and location of the electrical and mechanical systems.

(2) A written description of operation of each component, including its relationship to other components of the solar heating or cooling system.

(3) A listing of weak links in the system (valves, pumps, etc) which should be especially checked annually or more often.

(4) A sequence of operation cross-referenced to the elementary diagram.

(5) Troubleshooting instructions.

s. Photovoltaic (PV) Installations. This manual covers permanently installed photovoltaic systems. The following information shall be provided:

(1) A single-line floor plan including:

(a) Wiring plan for the modules, interconnections with the regulator, batteries and AC power source.

(b) Location of all equipment such as modules, regulator and batteries.

(2) A written description of operation for each component, including its relationship to other components of the PV system.

(3) A brief description of the theory of PV which can be understood by high school or trade school graduates.

(4) A troubleshooting guide which will point out the criticalness of the PV system and show how often the components must be inspected.

[ ].3. EQUIPMENT OPERATING, MAINTENANCE AND REPAIR MANUALS.

a. General: Separate manuals shall be provided for each utility system as defined hereinafter. Manuals must include, in separate sections, the following information for each item of equipment:

(1) Performance sheets and graphs showing capacity data, efficiencies, electrical characteristics, pressure drops, and flow rates. Marked-up catalog pages do not satisfy this requirement. Performance information shall be presented as concisely as possible and contain only data pertaining to equipment actually installed.

(2) Catalog cuts showing application information.

(3) Installation information showing minimum acceptable requirements.

(4) Operation and maintenance requirements. Include adequate illustrative material to identify and locate operating controls, indicating devices and locations of areas or items requiring maintenance.

(a) Describe, in detail, starting and stopping procedures for components, adjustment required to obtain optimum equipment performance, and corrective actions for malfunctions.

(b) Maintenance instructions describing the nature and frequency of routine maintenance and procedures to be followed. Indicate any special tools, materials and test equipment that may be required.

(5) Repair information including diagrams and schematics, guidance for diagnosing problems, and detailed instructions for making repairs. Provide troubleshooting information that includes a statement of the indication or symptom of trouble and sequential instructions necessary. Include test hookups to determine the cause, special tools and test equipment, and

methods for returning the equipment to operating conditions. Information may be chart form or in tabular format with appropriate headings.

(6) Parts lists, manes and addresses of closest parts supply agencies.

(7) Names and addresses of local manufacturers' representatives.

b. Facility Heating Systems. Information shall be provided on the following equipment: boilers, water treatment, chemical feed pumps and tanks, converters, heat exchangers, pumps, unit heaters, fin-tube radiation, air handling units (both heating only and heating and cooling), and valves (associated with heating systems).

c. Air-Conditioning Systems. Provide information on chillers, packaged air-conditioning equipment, towers, water treatment, chemical feed pumps and tanks, air-cooled condensers, pumps, compressors, air handling units, and valves (associated with air-conditioning systems).

d. Temperature Control and HVAC Distribution Systems.

(1) Provide the information described for the following equipment: valves, fans, air handling units, pumps, boilers, converters and heat exchangers, chillers, water cooled condensers, cooling towers, and fin-tube radiation.

(2) Provide all information described for the following equipment: control air compressors, control components (sensors, controllers, adapters and actuators), and flow measuring equipment.

e. Central Heating Plants. Provide the information described for the following equipment: boilers, converters, heat exchangers pumps, fans, steam traps, pollution control equipment, chemical feed equipment, control systems, fuel handling equipment, deaerators, tanks (flash, expansion, return water, etc), water softeners and valves.

f. District Heating Distribution Systems. Provide the information described for the following equipment: valves, fans, pumps, converters and heat exchangers, steam traps, tank (expansion, flash, etc) and piping systems.

g. Exterior Electrical Systems. Information shall be provided on the following equipment: power transformers, relays, reclosers, breakers and capacitor bank controls.

h. Interior Electrical Systems. Information shall be provided on the following equipment: relays, motor control centers, switchgear, solid state circuit breakers, motor controllers and EPS lighting systems.

(1) Wiring diagrams and troubleshooting flow chart on control systems.

(2) Special grounding systems.

i. Energy Management and Control System. The maintenance manual shall include description of maintenance for all equipment, including inspection, periodic preventative maintenance, fault diagnosis and repair or replacement of defective components.

j. Domestic Water Systems. The identified information shall be provided on the following equipment: tanks, unit process equipment, pumps, motors, control and monitoring instrumentation, laboratory test equipment, chemical feeders, valves, switching gear and automatic controls.

k. Wastewater Treatment Systems. The identified information shall be provided on the following equipment: tanks, unit process equipment, pumps, motors, control and monitoring instrumentation, laboratory test equipment, chemical feeders, valves, scrapers, skimmers, commutators, blowers, switching gear and automatic controls.

l. Fire Protection Systems. Information shall be provided on the following equipment: alarm valves, manual valves, regulators, foam and gas storage tanks, piping materials, sprinkler heads, nozzles, pumps and pump drivers.

m. Fire Detection Systems. The maintenance manual shall include description of maintenance for all equipment, including inspection, periodic preventive maintenance, fault diagnosis and repair or replacement of defective components.

n. Plumbing Systems. Information shall be provided on the following equipment: water heaters, valves, pressure regulators, backflow preventors, piping materials and plumbing fixtures.

o. Liquid Fuels Systems. Information shall be provided on the following equipment: tanks, automatic valves, manual valves, filter separators, pumps, mechanical loading arms, nozzles, meters, electronic controls, electrical switch gear and fluidic controls.

p. Cathodic Protection Systems. Information shall be provided on the following material and equipment: rectifiers, meters, anodes, anode backfill, anode lead wire, insulation material and wire size, automatic controls (if any), rheostats, switches, fuses and circuit breakers, type and size of rectifying elements, type of oil in oil-immersed rectifiers and rating of shunts.

q. Generator Installations. Information shall be provided on the following equipment: generator sets, automatic transfer panels, governors, exciters, regulators, starting systems, switchgear and protective devices.

r. Miscellaneous Systems. Information shall be provided on the following: communication and ADP systems, security and intrusion alarm, elevators, material handling, active solar, photovoltaic, and other similar type special systems not otherwise specified.