

DEPARTMENT OF THE AIR FORCE  
HEADQUARTERS UNITED STATES AIR FORCE  
WASHINGTON, D. C. 20332

REPLY TO  
ATTN OF: LEEDP

SUBJECT: Engineering Technical Letter (ETL) 89-2:  
Standard Guidelines for Submission of Facility Operating and  
Maintenance Manuals

TO: Distribution List

1. Purpose. This letter provides "Standard Guidelines for Submission of Facility Operating and Maintenance Manuals" (attachment 1) and "Technical Provisions For Preparation of Facility Operating and Maintenance Manuals" (attachment 2).

a. Efficient operation and effective performance of maintenance on complex facilities and subsystems require adequately prepared operation and maintenance (O&M) manuals together with the proper training of plant personnel.

b. This letter levies the requirement for the preparation and submission of O&M documentation on both the designer and contractor for complex designated facilities. Military Construction Program (MCP) funds may be utilized for the preparation of O&M manuals provided this item is included in the approved DD Form 1391, paragraph 86-1. This ETL is authorized in accordance with AFR 8-7, Air Force Engineering Technical Letters (ETL) dated 9 January 1986, and is to be implemented accordingly. Waivers will be processed in accordance with the procedures established by the Model Installation Program.

c. This ETL supersedes ETL 88-1 dated 5 January 1988. It adds paragraphs 1. e. "Delivery of Manual," 1. f. "Training," and 2. a. (6) to attachment 2 to satisfy one of the recommendations of TIG Report on Functional Management Inspection of Maintainability in Facility Design, PN 87-638.

2. Effective date: This ETL is to be implemented as of the date of this letter for those projects which have not reached the ten percent design stage.

3. Referenced publications:

a. AFR 89-1, Design and Construction Management.

b. AFR 86-1, Vol I, Programming Civil Engineering Resources Appropriated Funds Resources.

4. Description/Implementation: The preparation of system operating manuals and equipment operating, maintenance, and repair manuals developed jointly by the designer and construction

contractor will enhance our ability for operating and maintaining complex designated facilities. The availability of detailed O&M documentation in the civil engineering maintenance shops will provide the craftsmen and technicians with the technical data and procedures to better accomplish their O&M tasks.

5. The action officer for this ETL is Mr. Julian Ius, AFESC/DEMM, Autovon 523-6236.

FOR THE CHIEF OF STAFF

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1. Standard Guidelines
2. Technical Provision
3. ETL Index

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AFRCE-WR/RO  
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HQ USAFA/DEMA  
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STANDARD GUIDELINES  
FOR SUBMISSION OF  
FACILITY OPERATING AND MAINTENANCE MANUALS

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 new 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" designated 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  
FACILITY OPERATING AND MAINTENANCE MANUALS

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 large 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 the 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 systems 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 systems and equipment operating manuals will 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 or 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 pneumatic gages, voltmeters, ammeters; frequency meters; or signal generators. The listing must show methods of use or application, range of scales, and specific minimum tolerances or percentages of accuracy.

(4) Emergency operating instructions to include emergency procedures for equipment malfunctions to permit a short period of continued operation or to shut down equipment, if required, to prevent further damage. Include emergency shutdown instructions for fire, explosion, spills, or other contingencies. Provide guidance on emergency operations of all utility systems, including valve locations and portions 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 contractor, 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, condenser, 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 provisions 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 Systems. 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 locations 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 component 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 the performance parameters 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-referenced to the control schematic piping or wiring diagram and to the elementary diagram.

(d) A functional description of each control component 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 hot water, steam and fuel piping, including indication of directions of flow and locations 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 provisions 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 requirements?

(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.

g. 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 functional 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) Definitions 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 sequency 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 system. The following information shall be included:

(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 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 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 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 locations 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 device.

(4) Copies of the manufacturer's recommended inspection, test, and maintenance instructions/guidance for each different device 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 Fuels 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 drawings including:

(a) Color coded piping plan for liquid fuel, water, and drainage. The plan will show indication of directions of flow, and locations 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 insulation 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 chargers:
  - (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 Installations. This manual covers permanently installed active solar systems (flat plate or concentrator plates). The following information 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-boostered 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, regulators, 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 catalogs or 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, adjustments 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 the 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 in chart form or in tabular format with appropriate headings.

(6) Parts lists and names 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, tanks (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 controller, 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 descriptions 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 preventers, 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, excitors, 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.

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### ENGINEERING TECHNICAL LETTERS (ETL)

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82-2	Energy Efficient Equipment	10 Nov 82
82-6	Normal Passive Solar Applications	30 Dec 82
82-7	Unique Passive Solar Applications	30 Nov 82
83-1	Design of Control Systems for HVAC	16 Feb 83
	Change No. 1 to ETL 83-1, U.S Air Force Standardized Heating, Ventilating & Air Conditioning (HVAC) Control Systems	22 Jul 87
83-3	Interior Wiring Systems, AFM 88-15, Para 7-3	2 Mar 83
83-4	EMCS Data Transmission Media (DTM) Considerations	3 Apr 83
83-6	Solar Applications in Medical Facilities	24 May 83
83-7	Plumbing, AFM 88-8, Chapter 4	30 Aug 83
83-8	Use of Air-to-Air Unitary Heat Pumps	15 Sep 83
83-9	Insulation	10 Nov 83
84-2	Computer Energy Analysis	27 Mar 84
	Change 1 Ref: HQ USAF/LEEEU Msq 031600Z MAY 84	1 Jun 84
84-3	AF Petroleum Fuel Facility Criteria and Standards	21 Mar 84
84-7	MCP Energy Conservation Investment Program (ECIP)	12 Jun 84
84-10	Air Force Building Construction and the Use of Termiticides	1 Aug 84
86-2	Energy Management and Control Systems (EMCS)	5 Feb 86
86-4	Paints and Protective Coatings	12 May 86
86-5	Fuels Use Criteria for Air Force Construction	22 May 86
86-8	Aqueous Film Forming Foam Waste Discharge Retention and Disposal	4 Jun 86
86-9	Lodging Facility Design Guide	4 Jun 86
86-10	Anti terrorism Planning and Design Guidance	13 Jun 86
86-12	Prewired Workstations and Systems Furniture	3 Jul 86
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86-16	Direct Digital Control Heating, Ventilation and Air Conditioning Systems	9 Dec 86
86-17	Power Conditioning and Continuation Interfacing Equipment (PCCIE)	17 Dec 86
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87-4	Energy Budget Figures (EBFs) for Facilities in the Military Construction Program	13 Mar 87

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### ENGINEERING TECHNICAL LETTERS (ETL)

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87-5	Utility Meters in New and Renovated Facilities	13 Jul 87
87-7	1987 Energy Prices and Discount Factors for Life-Cycle Cost Analysis	14 Oct 87
	Change 1: 1987 Energy Prices and Discount Factors for Life-Cycle Cost Analysis	30 Dec 87
87-8	Built-Up Roof Repair/Replacement Guide Specification	19 Oct 87
87-9	Prewiring	21 Oct 87
88-1	Standard Guidelines for Submission of Facility Operating and Maintenance Manuals	05 Jan 88
88-2	Photovoltaic Applications	21 Jan 88
88-3	Design Standards for Critical Facilities	15 Jun 88
88-4	Reliability & Maintainability (R&M) Design Checklist	24 Jun 88
88-5	Cathodic Protection	2 Aug 88
88-6	Heat Distribution Systems Outside of Buildings	1 Aug 88
88-7	TEMPEST & High Altitude Electromagnetic Pulse (HEMP) Protection for Facilities	24 Aug 88
88-8	Chlorofluorocarbon (CFC) Limitation in Heating, Ventilating and Air-Conditioning (HVAC) Systems	4 Oct 88
88-9	Radon Reduction in New Facility Construction	7 Oct 88
89-1	1988 Energy Prices and Discount Factors for Life-Cycle Cost Analysis	6 Feb 89

#### SECTION B - OBSOLETE ETLs

No.	Date	Status
82-1	10 Nov 82	Superseded by ETL 83-10, 86-1, 87-4
82-3	10 Nov 82	Superseded by ETL 83-5, 84-2
82-4	10 Nov 82	Superseded by ETL 84-7
82-5	10 Nov 82	Superseded by ETL 84-1, 86-13, 86-14
83-2	16 Feb 83	Superseded by ETL 84-3
84-4	10 Apr 84	Superseded by ETL 86-7, 86-15, 87-5
84-5	7 May 84	Superseded by ETL 84-8, 86-11, 86-18, 88-6
84-6	Not Issued	Cancelled/Not Used
86-3	21 Feb 86	Superseded by ETL 86-4
86-6	3 Jun 86	Superseded by ETL 86-11, 86-18, 88-6
87-3	12 Mar 87	Superseded by ETL 87-6, 88-5
84-9	5 Jul 84	Superseded by ETL 88-7
88-1	5 Jan 88	Superseded by ETL 89-X