

**ASHRAE Guideline 4-2008**  
**(Supersedes ASHRAE Guideline 4-1993)**



# **ASHRAE GUIDELINE**

## **Preparation of Operating and Maintenance Documentation for Building Systems**

Approved by the ASHRAE Standards Committee on June 21, 2008, and by the ASHRAE Board of Directors on June 25, 2008.

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#### NOTE

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(This foreword is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

## FOREWORD

*Originally published in 1993, Guideline 4 has been updated in this edition to reflect the changing technology of building systems and the increased use of computer programs since 1993. It provides a greater focus not only on the content of the operating and maintenance (O&M) documents but also on how to prepare and update the documents utilizing electronic storage and presentation tools.*

*As new and renovated buildings have become progressively more technologically complex, documentation needs have grown. Many of these buildings contain sophisticated systems to control indoor environments in an energy-efficient manner. To sustain the required level of performance of HVAC&R systems throughout the service life of these buildings, it is essential that these systems be documented appropriately.*

*Accurate and relevant O&M documentation is also essential for the safe, reliable and efficient operation of systems. Timely delivery of O&M documentation is important. It should be used for commissioning and training of building management, operating, and maintenance personnel before the building is taken over by the owner.*

*This guideline is directly applicable to HVAC&R systems but can also be used for other building systems. It complements ASHRAE Guideline 1.1, HVAC&R Technical Requirements for The Commissioning Process.*

## 1. PURPOSE

To guide those responsible for the design, construction, and commissioning of building HVAC&R systems in the preparation and delivery of operating and maintenance (O&M) documentation that

- a. is simple to prepare and update,
- b. is delivered on time,
- c. is easy to use, and
- d. provides accurate and relevant information.

## 2. SCOPE

This guideline covers the format, content, delivery, and updating of building HVAC&R systems O&M documentation that is normally provided by the design and construction team members.

## 3. DEFINITIONS

Many of the terms used in this guideline and recommended for use in the O&M documents are defined in *ASHRAE Terminology of Heating, Ventilating, Air-Conditioning & Refrigeration*.<sup>1</sup> Others are defined in *ASHRAE Guideline 0, The Commissioning Process*,<sup>2</sup> and *ASHRAE Guideline 1.1, HVAC&R Technical Requirements for The Commissioning Process*.<sup>3</sup> Additional terms are defined below:

**Basis of Design:** a document that records the concepts, calculations, decisions, and product selections used to meet the Owners Project Requirements and to satisfy the applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

**building project:** a task with the objective of delivering a base building or a building shell that must be fitted-out before it is suitable for occupancy.

**commissioning authority:** an entity identified by the owner who leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process.

**design authority:** a prime consultant, usually an architect, responsible for the quality of the design that is proposed to meet the owner's requirements.

**design intent:** see *Basis of Design*. Both terms are commonly used.

**designer:** a member of the project team involved in providing design solutions to meet the owner's requirements and in preparing construction and O&M documents during the conceptual design, the completion of construction documents (the design), the construction, and the operational stages of the project delivery.

**electronic documentation:** as used in this guideline, a compilation of electronic files relevant to all components and systems of a project. The documentation adheres to the content requirements described by this guideline and has an overall structure and search capabilities that allow navigation, access, and search of all files contained through networked, stand-alone, and/or portable devices.

**fit-out project:** a project through which furnishings, including partitions, furniture, and tenant equipment (e.g., copy machines, fax machines, personal computers) are delivered.

**O&M designer:** a designer specializing in the O&M aspects of a project.

**O&M documentation:** a comprehensive set of documents providing information pertaining to a specific facility, including information regarding the design, operation, and maintenance of the facility.

**owner:** the person or legal entity that will own the delivered facility or an agent representing the owner. The owner defines the project requirements.

**Owner's Project Requirements:** a written document that details the functional requirements of a project and the expectations of how it will be used and operated. This includes project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. The term *Project Intent* is used by some owners for their commissioning process instead of Owner's Project Requirements.

**Preliminary Operating Manual:** an elaboration of the design intent that includes operating information developed during the construction documents (design) stage.

**project brief:** see *Owner's Project Requirements*. Both terms are commonly used.

**project delivery stages:** the progressive stages in the development of a project marking the delivery of a distinct product: planning, conceptual design, construction document preparation, construction, operation, and evaluation.

**Systems Manual:** a system-focused composite document that includes the operations manual, the maintenance manual, and additional information of use to the owner during the occupancy and operations phases.

## 4. IMPLEMENTATION

**4.1 Use of the Guideline.** Participants in the planning, design, construction, commissioning, operation, and maintenance activities should use this guideline to complete the following tasks:

- a. The owner and the planning team
  - specify the scope and process of development, delivery and upkeep of the O&M documentation
- b. The design team
  - prepares its portion of the O&M documentation
  - specifies O&M documentation requirements for equipment suppliers and system installers
  - reviews O&M information prepared by others and assembles it into an O&M documentation package
  - delivers the O&M documentation package to the owner
- c. The equipment suppliers
  - prepare and submit their O&M information to the installers
- d. The installers
  - prepare their portion of the O&M documentation
  - collect and assemble O&M documentation from the equipment suppliers and submit it to the designer
- e. The commissioning authorities
  - verify the correctness and relevancy of the O&M documentation
  - guide the delivery of commissioning reports in a "record document" and "as-commissioned" form
- f. The building management, operating and maintenance personnel
  - maintain and use the O&M documentation
  - revise outdated O&M documentation for existing buildings

All of the above participants contribute to the O&M documentation to various degrees. Organizing the preparation and delivery of O&M documentation should be the responsibility of the designer. The designer should have continuing involvement in the design, construction, and commissioning and, where possible, ongoing involvement in the operation and maintenance of the building.

**4.2 Uses of O&M Documentation.** O&M documentation, prepared in accordance with this guideline, can be used for the following commissioning-related and O&M-related activities:

- a. training of building management, operating, and maintenance personnel
- b. preparation and modification of operating program elements, including schedules and strategies for ventilation, energy management, etc.
- c. preparation and modification of any type of maintenance program, whether predictive, preventive, or breakdown, or any combination of these types
- d. preparation of the O&M budget, including utility budgets
- e. assessment of compliance with the operating and maintenance program requirements and annual O&M budgets
- f. preparation of asset management reports and plans
- g. preparation of energy audits
- h. management of energy or building retrofit projects

**4.3 O&M Manual Media.** Building owners should specify in the Owners Project Requirements that the O&M documentation be provided in electronic format, as well as printed, and organized in binders. Contractor documentation requirements for the O&M manual shall be clearly stated in the construction documents.

The primary advantage of electronic documentation is reduced costs and increased versatility of viewing the data by the owner. An electronic O&M manual could be represented as a static electronic or Web-type document that has hyperlinks to O&M manual components such as equipment lists, drawings, bill of material items, and individual product references. These hyperlinks could be a collection of individual files that are maintained under version and revision control.

An electronic O&M manual could be shared among several users if it is posted on an internal (or external) Web page. Electronic document access enables the owner to quickly reference a building system or equipment to determine information such as operation, maintenance procedures, or replacement components. Electronic document features include search routines that make it easy to find information in the document, access help systems, and perform product searches.

Electronic documentation makes it easier for the owner or contractor to update the document as aspects of the building change over its life. A centrally maintained electronic document updated with version control is a more reliable source for current information than a printed manual, which requires the updating and replacing of individual pages in multiple copies.

**4.4 Process of O&M Manual Development and Delivery.** To support the above uses effectively, the O&M information should be developed and made available to the owner on a timely basis so that the owner is able to assist in such processes as building construction, system commissioning, training, and building operation. Table 1 suggests a process of development, delivery, and use of O&M documentation related to the usual stages of delivery of a building project.

The process outlined in Table 1 applies to new building projects, building renovation projects, and retrofit projects. Since fit-out projects are usually delivered in a different time interval than the base building project, the process of development and delivery of O&M documentation for fit-out projects should utilize the format of O&M documentation for the

**TABLE 1 Development and Delivery of O&M Documentation**

Activity	O&M Documentation
Planning	The owner or the owner's representative defines the scope, format, level of detail, and process of O&M documentation development, delivery and use, in a project brief, making reference to ASHRAE Guideline 4.
Conceptual Design	The designer prepares and delivers to the owner a design intent based on the Owner's Project Requirements that describes an operation and maintenance program for the facility.
Construction Document Preparation	The designer prepares specifications regarding the content, format, and delivery of O&M documentation and prepares the Preliminary Operating Manual section on design intent. The commissioning authority updates the commissioning plan, including testing procedures or protocols that the designer includes in the project specifications.
Construction	The equipment suppliers and installers prepare and include operation and maintenance documents with the shop drawing submittal. The designer reviews these documents for conformity with the construction documents, the Owner's Project Requirements and the Basis of Design and revises the preliminary O&M manuals.
Construction Completion	The designer oversees the assembly and consolidation of the relevant documents into a draft O&M documentation package with separate parts relating to design, construction, and operation, and maintenance for the facility. The designer delivers the draft O&M documentation package to the owner, preferably in stages, as soon as the individual documents or their sections become available. The commissioning authority may assist in review of O&M documentation for completeness and relevancy. The designer also prepares a training program for training of the building's O&M and management staff.
Documentation or Commissioning	The designer includes approved changes to design documents in record documents to update the O&M manuals. The designer compiles test reports, reviews them, and submits them to the commissioning authority. The designer or commissioning authority implements a training program for training of building O&M and management staff. The designer gathers and certifies all the records of tests from the installers and suppliers and incorporates them into the O&M documentation package. The designer prepares and submits the as-commissioned O&M documentation package to the owner. The commissioning authority verifies the completeness of the documentation and prepares an interim commissioning report to be included in the O&M manuals.
Occupancy & Operation	The commissioning authority prepares and submits seasonal reports during the first full cycle of seasons after building occupancy. All these reports are added to the O&M manuals. See ASHRAE Guideline 0 <sup>2</sup> for details.
Continuous Commissioning Process	Upon completion of the project, the owner assumes responsibility for the facility. Should the owner choose to implement a continuous commissioning process, the periodic commissioning will occur during the life of the building. To be successful, the O&M manual needs to be updated as changes are made to the facility. See ASHRAE Guideline 0, Section 8.2.8. <sup>2</sup>

building that already exists. For more information, see Section 4.5 below.

#### **4.5 Revisions to and Upkeep of O&M Documentation.**

O&M documentation needs to be complete before occupancy and operation and should be under revision control throughout the service life of the building. Otherwise, it loses its value, and building occupancy and operational quality will decline. The owner's representative tasked with updating the documentation shall review the O&M documentation to ensure that it reflects changes in the use and operation of the facility, changes to systems due to renovations, or changes to

the Owner's Project Requirements. See ASHRAE Guideline 0, Section 8.2.8,<sup>2</sup> for more detailed information on the continuous commissioning process.

Electronic documentation can simplify the task of making revisions and should be available to the person tasked with updating the documentation.

Revisions to the O&M documentation can be broadly classified as resulting from:

- a. fit-out
- b. renovations and retrofits

- c. changes to operating procedures
- d. changes to maintenance procedures
- e. retesting, rebalancing, or recommissioning
- f. changes to building systems such as lighting retrofits, changes to heating/cooling loads, or envelope changes, including the roof and fenestration

**Fit-out.** Office space usually is delivered through two separate, but interdependent, delivery processes: building delivery and one or more fit-out deliveries.

Fit-outs may be delivered in either new buildings or existing buildings. In either case, O&M information describing the fit-out (including the tenant's equipment) should be integrated into the O&M documentation. Commissioning of building systems completed during the fit-out should be done as part of the fit-out, and the reports should be added to the O&M manuals.

**Renovations, Retrofits.** Any renovation or retrofit project, however small, that involves adding, removing, or modifying a building system or changing the design intent and/or operation of the building should be fully recorded in the O&M documentation. Renovations and retrofits, especially those that change tenant equipment load and/or the number of occupants, will affect sensible and latent loads. The corresponding effects to the building systems should be reviewed to ensure the change can be accommodated without detriment to operation or to occupant comfort in other areas.

**Changes to Operating Procedures.** Initially, O&M documentation is based on the requirements of the building design brief, a predefined occupant density, and the O&M staff. As building parameters change during the building's service life, the documentation should be updated accordingly. Changes in the document should be in accordance with good operating practice and should not be made without justification. Building O&M staff should contact the designer regarding proposed changes to system configuration or operation to ensure that they comply with the design intent and do not have an adverse impact on building operation. Changes should not be made to convenience the operator without the approval of the designer.

**Changes to Maintenance Procedures.** Changes to the scope and content of maintenance procedures may be required when problems are observed in systems or equipment, when availability of spare parts is altered, when the maintenance budget is modified, or when any other factor affecting maintenance is changed. Evaluation of the scope and content of the maintenance program should be tied to the inspection schedule of a preventive maintenance program. Ensure that maintenance procedures, and changes to maintenance procedures, are approved by the designer and are updated in the O&M documentation. Maintenance procedures should be specific to the building and its systems, rather than relying upon generic published material from equipment cut sheets.

**Retesting, Rebalancing, Recommissioning.** Retesting, rebalancing, or recommissioning is often carried out due to renovations, occupant complaints or changes, or equipment replacement. Records of these activities should be included in the O&M documentation with associated dates. A review of

their impact on overall building performance should be conducted in some instances.

**Other Changes.** Changes to building systems (such as lighting and HVAC retrofits), changes to heating/cooling loads, and envelope changes (including the roof and fenestration) should be documented with dates. O&M documentation updates due to changes to building systems or loads should be carried out at the time of the change. Such information provides the history of the HVAC&R (or other) equipment that is necessary for management of the operating and maintenance procedures.

**4.6 Restoration of O&M Documentation.** Where the O&M documentation of an existing building is substantially out of date or incomplete, regular upkeep may no longer be an option. In such cases, the development of new O&M documents may be required. Development of such new information should follow the same format as recommended in this guideline and may be included in the scope of an individual renovation or retrofit project or undertaken on its own by a specialist in preparing O&M documentation.

## 5. O&M DOCUMENTATION LIBRARY

Building documentation requirements fall into three main categories: design and construction, operation, and maintenance. Building size and complexity will dictate whether all of these components are included or whether additional components are added. Table 2 identifies the recommended components of each category. Each component of the O&M document is described in the following sections.

A complete O&M documentation library, also referred to as a *Systems Manual*, is prepared by the O&M designer with contributions from the planning team, design team, construction team, and operations and maintenance management.

### 5.1 Planning, Design, and Construction Documents

**5.1.1 Owner's Project Requirements.** Documentation begins with the Owner's Project Requirements for the design team. This document, prepared by the owner or the planning team, details the expectations of the owner and how the building is to function (see Section 3, Definitions).

With respect to the O&M documentation, this document defines the scope of the O&M documentation and stipulates what is expected of the designer directly, what the designer should ask the construction team to deliver, and what input is expected of the O&M team.

**5.1.2 Basis of Design.** This document describes and documents details of the intended design solution used to meet the Owner's Project Requirements. This document intent includes the building design parameters relative to type of use, occupancy, and equipment selection. Special features should also be identified (see Section 3, Definitions).

**5.1.3 Energy Budget.** Many buildings have energy budgets developed at the time of design, using either building simulation programs or manual calculations. Input and output reports from this process should be included in the building documentation.

**5.1.4 Submittals.** Submittals to be included in the design and construction documentation include approved shop

**TABLE 2 Components of Documentation Library**

<b>Part 1: Planning, Design &amp; Construction</b>	<b>See Section</b>
Owner's Project Requirements	5.1.1
Basis of Design	5.1.2
Energy Budget	5.1.3
Submittals	5.1.4
Record Documents	5.1.5
Commissioning	5.1.6
<b>Part 2: Operations</b>	<b>See Section</b>
Owner's Project Requirements	5.2.1
Basis of Design	5.2.2
Energy Budget	5.2.3
Submittals	5.2.4
Commissioning Documents	5.2.5
Operations Manual	5.2.6
Emergency Procedures	5.2.7
Training Manuals	5.2.8
<b>Part 3: Maintenance</b>	<b>See Section</b>
Maintenance Manual	5.3.1
Maintenance Procedures	5.3.2
Maintenance Budget	5.3.3
Maintenance Tasks	5.3.4
Maintenance Reports	5.3.5
Emergency Procedures	5.3.6
Quality Control	5.3.7

drawings, co-ordination drawings, and equipment documents specific to the installed equipment.

**5.1.5 Record Documents.** Drawings and specifications shall be updated at the end of construction to convert them into a set of record documents. The record documents shall include all changes approved during construction.

Refer to Appendix A to see a sample format for construction documentation.

**5.1.6 Commissioning Documents.** O&M documentation includes all commissioning reports. Include all reports related to the commissioning process as described in ASHRAE Guideline 1.1.<sup>3</sup>

The commissioning document should report on

- a. the compliance of the installed systems and equipment with the functional requirements stipulated in the Owner's Project Requirements;

- b. the delivery of the O&M documentation package; and
- c. training of building management, operating, and maintenance staff based on the information contained in the O&M documentation package.

The initial commissioning report should be submitted at the time specified in the professional services agreement or as specified in ASHRAE Guideline 1.1,<sup>3</sup> including additional commissioning reviews and reports during the operations phase of the building.

**5.1.7 Retrofits and Upgrades.** To remain current, O&M documentation must be updated with information relating to building retrofits and upgrades. Care should be taken to ensure that changes do not conflict with overall system performance and that changes are properly commissioned.

## **5.2 Operations Documents**

**5.2.1 Owner's Project Requirements.** The portion of the Owner's Project Requirements that refers to the operational expectations of the constructed building should be included in the operation documentation as a guide to the staff.

**5.2.2 Basis of Design.** It is important that the building O&M staff has a good understanding of the design intent of building systems and the parameters used for systems design. Information from the Basis of Design and Construction Documentation should be referred to or included.

**5.2.3 Energy Budget.** The initial energy budget can be useful for the O&M team in setting the operation budget and future comparisons to actual performance. Input data regarding loads and schedules shall be included so that changes over time can be factored into comparisons.

**5.2.4 Submittals.** Shop drawings provide the equipment suppliers' and installers' interpretation of the information presented in drawings and specifications. The shop drawings should describe each individual specified piece of equipment or each specified HVAC&R system and provide a complete set of installation instructions. Approved submittals should be included in the operation documentation.

**5.2.5 Commissioning Documents.** O&M documentation should include all commissioning reports and include all reports related to the commissioning process as described in ASHRAE Guideline 1.1.<sup>3</sup>

**5.2.6 Operations Manual.** The operating manual should provide information for two types of users with different backgrounds. The first type is the building manager whose activities normally do not require technical knowledge. The second type is the building operator, who should be technically skilled enough to fully understand the functions of HVAC&R systems installed in the building.

A suggested format for presenting the operating information is provided in Appendix B.

**5.2.7 Emergency Procedures.** Both nontechnical and technical users of the building systems need emergency information. The document should be organized according to types of emergencies and should clearly define the roles and procedures for each responsibility.



A suggested format for presenting the emergency operating information is provided in Appendix C.

**5.2.8 Training Materials.** The operating manual should include information presented in such a way that a new building operator will be able to use it for self-directed study and understand the design and operation of all systems to the degree that he can properly operate them.

Supplemental materials, such as a manufacturer's CDs on specific equipment installed in the building, should be stored with the manual. A videotape recording for training on the operation and maintenance of the building equipment, narrated by the building designer or commissioning authority, can be very useful in helping an operator understand how system components interact. This is especially useful for complex systems or equipment requiring operating changes in various seasons.

Training materials can also be included electronically using the building-automation-system operator interface.

### 5.3 Maintenance Documents

**5.3.1 Maintenance Manual.** The maintenance manual should normally be prepared and submitted by the construction team. It should contain the following information:

- a. Description of the equipment or system: this should consist of easy-to-read drawings accompanied by a clear description of each component.
- b. Description of function, as applicable: the function of the equipment, functional parameters (input, output) at the design load and at part loads, procedures before start-up, and performance verification procedures.
- c. Recommended maintenance procedures and their recommended frequency for the site-specific application.
- d. Recommended list of spare parts, part numbers, and place(s) from which they can be obtained.
- e. Original purchase order number; date of purchase; name, address, phone, and fax number of the vendor; and warranty information.
- f. Installation and repair information: any other information needed for preparation of documents supporting management of operation and maintenance programs.

The designer should review maintenance information provided by the supplier or the installer for completeness. The information should focus only on the model installed. It should then be supplemented by project-specific information developed by the designer.

The designer should properly identify each item of maintenance information uniquely. This information is essential for the preparation of documentation in support of a maintenance management program that may be guided by predictive, preventive, breakdown, or any other maintenance philosophy.

Appendix D provides an example of maintenance-related information provided by the supplier and supplemented by the designer that is necessary for preparation of a maintenance manual and a preventive maintenance program.

**5.3.2 Maintenance Procedures.** This document should include all the forms necessary for management of operation and maintenance programs, including operating logs, inspection sheets, inspection and maintenance schedule, work order forms, and material purchasing forms. This documentation is normally prepared by the O&M team during the first year of operation.

**5.3.3 Maintenance Budget.** The initial maintenance budget can be useful for the O&M team in setting future budgets and making comparisons to actual costs. Input data regarding labor and material rates and schedules must be included so that changes over time can be factored into comparisons.

**5.3.4 Maintenance Tasks.** The maintenance manual should provide all relevant information needed for the day-to-day maintenance of the HVAC&R systems. Frequency of maintenance procedures for each system component should be described.

A suggested format for presenting the maintenance information is in Appendix D.

**5.3.5 Maintenance Reports.** Examples of all maintenance reports and logs are to be included in the manual. These should be supported with examples.

**5.3.6 Emergency Procedures.** The purpose of this document is to present the emergency procedures as they relate to the maintenance personnel. The document should be organized according to types of emergencies and should clearly define the roles and procedures for each responsibility.

A suggested format of presenting the emergency procedures is provided in Appendix C.

**5.3.7 Quality Control Report.** The purpose of this document is to provide copies of the test protocols used in construction and commissioning, to provide the history of the tests performed before the completion of commissioning, and to assist in conducting ensuing tests.

A suggested format for test reports is provided in Appendix E.

## 6. REFERENCES

1. *ASHRAE Terminology of Heating, Ventilating, Air-Conditioning & Refrigeration, 2<sup>nd</sup> Edition, 1991*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329.
2. *ASHRAE Guideline 0-2005, The Commissioning Process*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329.
3. *ASHRAE Guideline 1.1-2007 HVAC&R Technical Requirements for The Commissioning Process*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329.

(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

## APPENDIX A CONSTRUCTION DOCUMENTS

Following is a suggested table of contents for the construction documentation package.

### *Example: Construction Documents*

#### **Part 1: Record (As-built) Drawings**

<u>Drawing No.</u>	<u>Drawing Title</u>
XX	.....
XX	.....

#### **Part 2: Specifications**

<u>Section No.</u>	<u>Section Name</u>
XX	.....
XX	.....

#### **Part 3: Approved Product Data and Shop Drawings**

XX	.....
XX	.....

#### **Part 4: Equipment Identification Charts**

#### **Part 5: Warranty Certificates**

#### **Part 6: Inspection Certificates**

#### **Part 7: Commissioning Reports**

These documents may also be provided on microfilm or microfiche for owners who have equipment to read or reproduce these images. These documents may also be provided electronically.

(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

## APPENDIX B OPERATIONS MANUAL

As recommended in Section 5.2.6, information in the operating manual should be divided into sections and organized into two parts (general information and technical information). The following example provides a detailed description of the table of contents and each section of the manual:

<b>Example: Table of Contents, Operating Manual</b>	<b>Page No.</b>
Part 1: General Information	XX
Section 1: Building Function	XX
Section 2: Building Description	XX
Section 3: Operating Standards and Logs	XX
Part 2: Technical Information	XX
Section 4: Systems Descriptions	XX
Section 5: Operating Routines and Procedures	XX
Section 6: Seasonal Start-up and Shutdown	XX
Section 7: Special Procedures	XX
Section 8: Basic Troubleshooting	XX

#### **Section 1, Building Function**

This section should provide a description of the following functional requirements:

- a. type of occupancy

- b. tenants' functional requirements, including a list of services to be provided in response to these requirements, the levels of these services, a timetable of delivery, and the reliability of delivery
- c. municipal requirements, including information about ambulance services, fire department response, garbage removal, snow removal, water use policy, public transportation, etc.
- d. utility information, including names, addresses, and phone numbers of utility companies for normal and emergency purposes and electrical, gas, water, sanitary, steam, chilled-water rates, etc.

## **Section 2, Building Description**

This section depicts the building layout and provides a brief description of each building area. It should also provide an overview of the building systems, using a short text description and simplified single-line schematics. The design intent for each building system also should be placed in this section.

This section should also show utility cut-offs on small-scale floor plans with a description of each building area supplied by the utility.

## **Section 3, Operating Standards and Logs**

This section should provide the standards of performance for the building and operating procedures for each system. The operator must understand how to operate each system to achieve the desired standard of performance. Standards may include such parameters as

- a. space temperature;
- b. space humidity;
- c. ventilation rate;
- d. levels of various contaminants in the air;
- e. chilled-water supply temperature;
- f. hot water temperature schedule;
- g. domestic water temperature; and
- h. energy efficiency targets, etc.

The section also should provide inspection procedures and operating logs required to monitor performance. Information on performance standards, operating procedures, and logs must be understandable by both building operators and building managers.

All reporting requirements for system licensing and inspections should be provided for each system, as applicable. The responsibility for each license and inspection should be documented together with other relevant information such as the date of inspection/renewal and the name and telephone number of the inspection/licensing authority.

## **Section 4, Systems Descriptions**

This section should begin with a list of all systems followed by a detailed description of each system listed.

The descriptions should identify the areas of the building that the systems serve, the locations of monitoring checkpoints (meters and gauges), the expected performance readings at the design-load conditions and, where applicable, at part-load conditions. The systems' operation during the day, night, and weekend, as well as seasonal start-up and turndown, safety devices and their function, control devices and their function, pollution control devices, etc., should also be described.

It is recommended that the function of the controls for individual systems be described alongside the description of the system function and that an overview of the entire control system be described separately.

Following is a listing of systems typically found in buildings:

Fire and Safety	Chemical Water Treatment
Heating	Controls (EMCS)
Cooling	Refrigeration
Air Distribution	Plumbing
Lighting	Special Purpose

A sample system description is included as Exhibit B1 at the end of this appendix.

## **Section 5, Operating Routines and Procedures**

This section should identify activities associated with normal operation of systems and equipment. The operating checklists and operating logs should be provided for each system and all performance standards should be identified.

## **Section 6, Seasonal Start-up and Shutdown**

This section should list seasonal startup and shutdown procedures.

## Section 7, Special Procedures

In some cases, special procedures related to environmental control, health and safety, productive work environment, etc., are codified; therefore, they must be followed. Such procedures should be shown in this section.

## Section 8, Basic Troubleshooting

Troubleshooting procedures are important tools. They may include elementary questionnaires or sophisticated diagnostic or expert systems, depending upon the degree of system complexity. These tools allow appropriate personnel to isolate probable causes in an efficient manner.

Troubleshooting tips and procedures can markedly improve the reliability of a system, saving in the capital cost of standby equipment, and can improve tenant-owner operator relationships. They should be presented here on a system-by-system basis.

Troubleshooting procedures should be cross-referenced to the maintenance manual, part 1.

### Exhibit B1: System Description

#### HVAC System AH VS-5

##### *System Type:*

Single-zone air-handling system with steam heating, ventilating, and cooling capability. Provide reference to equipment data sheets.

##### *Area Served:*

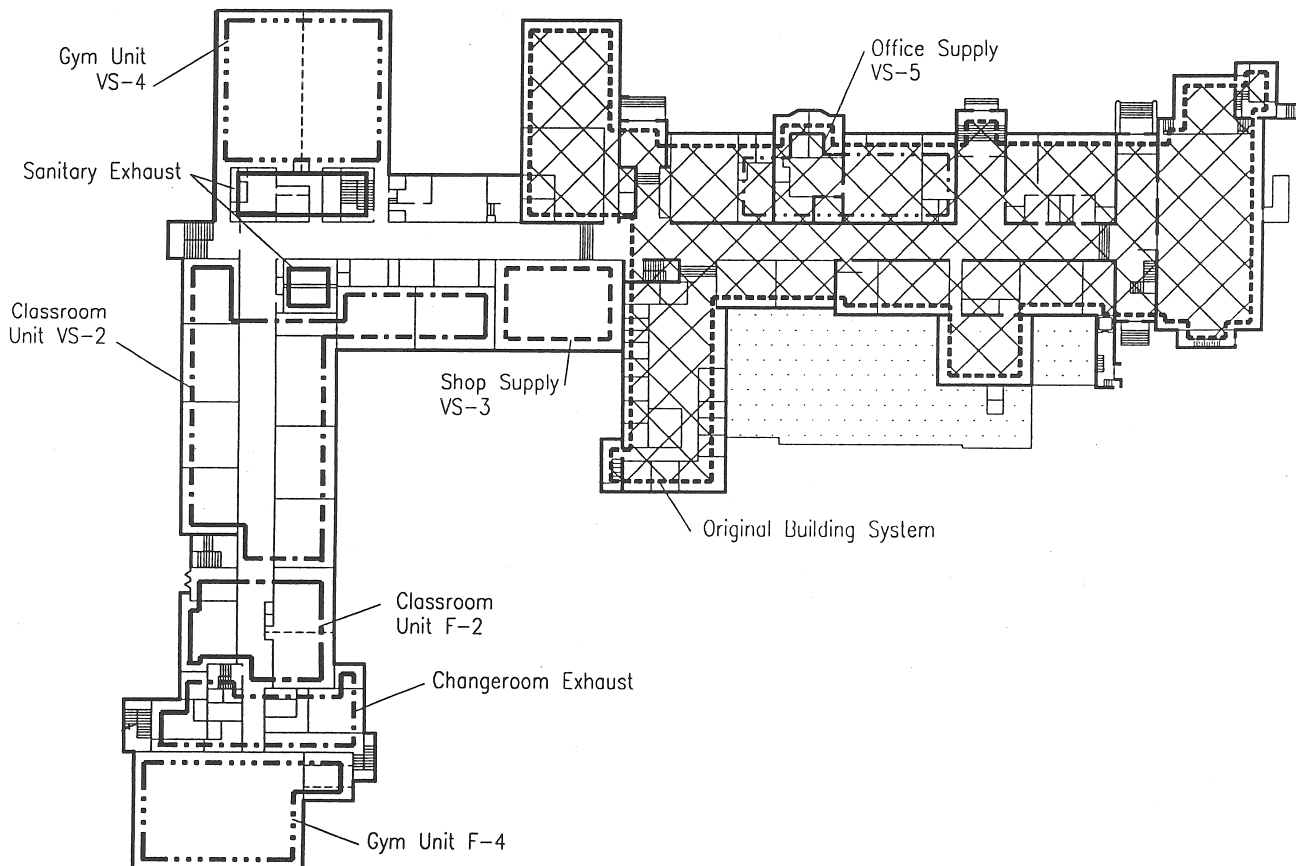
Office Wing (see Figure B-1)

Depending on the type of building, the complexity of its systems, and the competence of the in-house and on-site personnel, thermostat locations, air-handling and cooling unit locations, and duct locations may be added to suit the needs of the users.

##### *Switch Location:*

Photocopy Room

Provide additional information about the switch in the photocopy room: fused or nonfused, circuit breaker, wall mounted, or in overhead.



**Figure B-1** New collegiate institute, first floor, AH VS-

*Description:*

The system is equipped with a steam heating coil, face and bypass dampers, and a direct expansion-cooling coil. It provides necessary heating and cooling that is controlled by one thermostat located in \_\_\_\_\_. The system is a recirculating ventilation system with the ability to deliver necessary outside air (see Figure B-2).

A thermostat, located in the mixed-air section, acts as a low-limit setpoint, modulating the ventilation air damper to maintain a minimum temperature of air entering the heating coil at 14°C (57.2°F).

The direct digital control system modulates the outdoor air damper, the heating coil control valve, and the face and bypass damper in response to a signal from the space thermostat located in Room \_\_\_\_\_.

At an outdoor temperature above 21°C (69.8°F), the outdoor air damper assumes a position to provide minimum ventilation, and mechanical cooling is enabled. When the fan is off, the outside air damper is fully closed.

*System Design Parameters:*

Design Load: Winter -21°C (-5.8°F) Summer 31°C dry-bulb (87.8°F) 22°C wet-bulb (71.6°F)

Mixed-Air

Temperature: Winter ... °C (°F) Summer ... °C (°F) dry-bulb

Supply Air

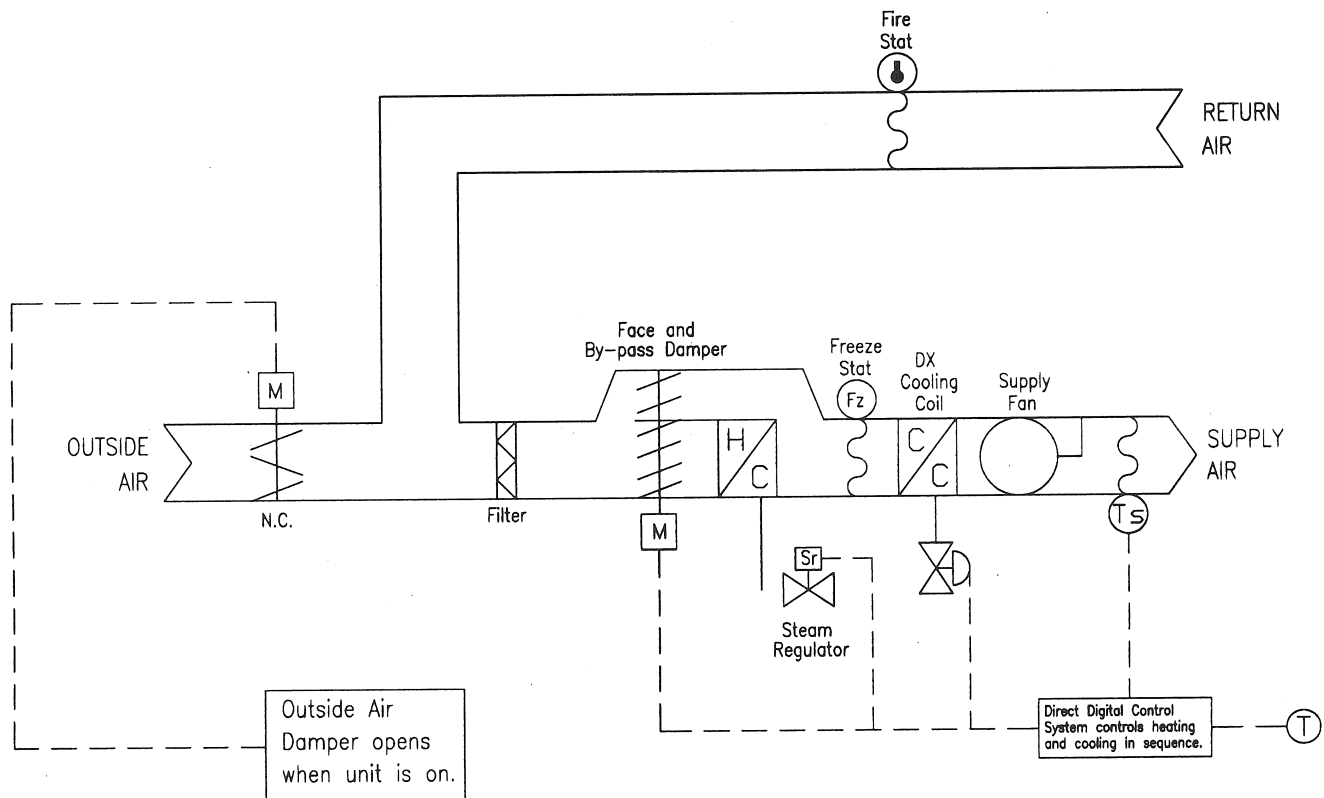
Temperature: Winter ... °C (°F) Summer ... °C(°F)

Space Temperature

Temperature: Winter ... °C (°F) Summer ... °C(°F)

Humidity: Winter ... % RH Summer ... % RH

Airflow: ... L/s (cfm)



**Figure B-2** New collegiate institute, single-zone system schematic, AH VS-5 serving office.

(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

## APPENDIX C EMERGENCY PROCEDURES INFORMATION

Both nontechnical and technical users of building systems need emergency information. Nontechnical users include building management staff, security guards, ambulance personnel, etc. Technical users include building operators, maintainers, fire fighters, municipal and utility company technicians, etc.

The following example shows a typical table of contents for an emergency information document. An example section for fire emergencies follows the table of contents, showing a suggested format for each section:

### Table of Contents

Type of Emergency	Page No.
Fire	xx
Security	xx
Flood	xx
Gas	xx
Power Failure	xx
Water Outage	xx
Plumbing Overflow	xx
Elevator	xx
Heating	xx
Cooling	xx
Refrigerant Release	xx
Chemical Spill	xx

The table of contents should indicate all types of emergencies for which emergency procedure information is available.

For some buildings, the owner, or other authority, may have strict safety requirements, and this information may have to conform to a format already defined.

The information needed for each type of emergency should be presented in separate sections. Each section should detail the scope of the emergency, the notification activities, and the responsibility of, and actions required by, building personnel. Each section should also note the specific equipment items involved in each type of scenario and response.

### **Example: Emergency Information, Fire**

**Page 1**

#### **Scope:**

An actual fire or smoke condition that requires the response of professional fire fighters and/or evacuation of occupied space.

#### **Notification:**

Security Guard shall

1. immediately notify the fire department by pull box or telephone (telephone # \_\_\_\_\_), whichever is quicker, upon report of fire or smoke or an activation of an alarm;
2. notify building employees on duty who comprise the fire response team;
3. notify supervisor; and
4. notify building manager.

Building Manager shall

1. notify affected tenants,
2. notify corporate property director, and
3. notify insurance carrier.

#### **Response:**

Security Guard shall

1. immediately report to the Elm Street entrance to admit fire fighters and direct them to the affected area; and
2. stand by at fire control panel in lobby to assist fire fighters.

Security Guard Supervisor shall deploy additional guards to prevent unauthorized access or theft from the affected area.

Building Operator shall

1. report to fire control panel in lobby and await instructions from the fire fighters regarding activation of smoke exhaust;
2. restore fire and smoke alarm system, when fire is secured; and
3. remove water from flooded areas.

Custodial Staff shall minimize water damage using mops, buckets, “wet vacs,” and plastic sheeting.

Building Manager shall take charge at a safe location, in or near the building, determine the extent of personal injuries and property damage, and start a loss prevention and restoration effort. This includes use of barricades, warning tape, boarding of broken windows, etc.

### **Location of Equipment**

<u>Equipment</u>	<u>Location</u>	<u>Page No.</u>
Hydrants		
Siamese Connections		
Firefighters’ Elevator		
Main Power Switch		
Main Gas Valve		
Fire Hose Cabinets		
Fire Extinguishers		
Sprinkler Zone Valves		
Fire Pump		
Emergency Generator		
Heating Plant/Steam Shutoff Valve		
Chiller Plant/Refrigerant Vents		
Domestic Water Service Entrance		

Locations of the above equipment should be shown on the pages following this table, with each item shown on a floor plan drawn to a suitable scale.

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## **APPENDIX D MAINTENANCE MANUAL**

The following are examples of a table of contents and an equipment data sheet. Instructions for the data sheet describe the information needed in documentation that will be useful for management of a maintenance program.

### **Table of Contents**

<u>System</u>	<u>Equipment</u>	<u>Name</u>	<u>(O&amp;M Number) Page No.</u>
AC1	Air Compressor	CTL	xx
AC2	Air Compressor	CTL	xx
AH1	Air-Handling Unit	(packaged system)	xx
HUM1	Humidifier	AH1	xx

The description of equipment includes two parts, the first containing generic information prepared by the supplier and the second containing project-specific information developed by the O&M designer. A sample equipment data sheet showing this organization is provided at the end of this appendix as Exhibit D1.

This document should contain information that describes either individual pieces of equipment that form part of a built-up system or individual packaged systems. Each piece of information should be identified with an O&M number and should be placed in the document in alphabetical or numerical order.

### **Equipment Data Sheet**

It is desirable to have an equipment data sheet prepared for each piece of equipment that will require operation or maintenance or both. The use of standardized equipment data sheets is recommended as an effective method for collecting operation and maintenance information from the equipment suppliers in a form that is effective for preparation of operation and maintenance programs.

The O&M designer should sort information obtained using this form shown in the sample equipment data sheet (Exhibit D1) at the end of this appendix. Information from this sheet describing the equipment inventory should be shown in part 1 of the maintenance manual; maintenance-program-related information should be shown in part 2 of the maintenance manual. Operating instructions should be shown in the operation manual, and performance-testing information should be shown in part 1 of the test report.

The data sheet should be prepared for insertion in a binder. Alternatively, it may be prepared in the form of a data entry, possibly forming part of a computer-based maintenance management system. Such a maintenance management system should have the capability to link the necessary information from the equipment data sheet with additional information needs by the maintenance department.

The following information is useful to maintenance personnel and can be included on the equipment data sheets.

### **Maintenance Program Information Requirements**

Whether the maintenance management is manual or computer-based, the equipment data sheets containing information provided by the supplier and the O&M designer can be fully developed into sheets suitable for management of a preventive maintenance program. The fully developed sheets should provide the information necessary for a technician to assess the scope of an assigned maintenance task, the location of the equipment to be visited, the time allotted for the task, the O&M instructions available from the O&M documentation package, the specific tools and appliances required to perform the task, the spare parts and consumables required, whether the spare parts and consumables are in the stock room inventory, and the worksheet needed for the task.

Equipment data sheets should also provide the information necessary for the maintenance supervisor to schedule technicians effectively and to prepare an O&M labor and materials budget. These sheets should also provide information for the stock room purchasing agent to predict requirements for spare parts and consumables, to obtain pricing and delivery quotations from vendors, and to place orders for spare parts and consumables.

### **Equipment Data Sheet Structure**

Equipment data sheets for different types of equipment should contain much of the same general data but should vary in content of secondary data depending upon the complexity of the piece of equipment.

Each field or blank in the data sheet should be planned for a specific purpose. If there is no purpose for a field, it should not be provided. The following paragraphs discuss the rationale for each of the information fields on the equipment data sheet, a sample of which is in Exhibit D1 at the end of this appendix.

**Equipment Name** should be either the name of a piece of equipment that is installed in a system (pump, chiller, cooling tower, etc.) or the name of a packaged system (rooftop unit, heat pump, packaged-water chiller, etc.).

**Designation** should be an assigned unique equipment number for each piece of equipment.

**Location** should be a description of where the piece of equipment is located, with an indication of how to gain access to the location. An example is “Basement, C Building, Room B1001, Sump at the Door.”

**Associated System** should be the name and number of the system the piece of equipment serves, unless the piece of equipment is a package system.

**Manufacturer, Model Number, and Serial Number** should provide specific information from the equipment nameplate. Changes, such as revised operating and maintenance instructions, require retrofit project documentation providing information on new equipment parts that will be required in the future for operation and maintenance. An example is: “Mfgr: ABC Pump Company; Model No: HSC IO × 8 × 13; Serial No: 870015,” where the leading “87” might be the year of manufacture.

**Vendor/Agent, Invoice or Purchase Order Number, and Purchase Order Date** should provide the specific information from the contractor or vendor’s files that is necessary to identify the order when obtaining information from the vendor/agent. Many vendors maintain their files for a limited time, particularly when a change of agent occurs. Therefore, it is desirable to provide information that would allow access to the manufacturer’s files. This field may be modified to provide the manufacturer’s order number or contractor’s purchase order number as necessary to suit the circumstances of the original equipment order. In the recommissioning of an existing building, this may be the only way to obtain the needed information. An example is “Hydronic Sales Ltd.; Invoice No: 871201; Date: 05 December, 1987.”

**New or Rebuilt, Warranty Term** should provide information on the initial status of the equipment and the length and terms of the manufacturer’s or builder’s warranty. The new or rebuilt information fields may not be applicable to new projects but may be useful for commissioning work. Warranty terms vary from manufacturer to manufacturer and on different equipment items from the same manufacturer. In some cases, extended warranties are purchased as part of the construction contract and, without this entry, may not be known to the maintenance supervisor. An example is “Status: New (X); Warranty: 90 Days on Parts and Labor: One Year, Parts Only, FOB Plant.”



**Installation, Operation, Maintenance (I/O/M) Instructions, Name and Number, and Date** should provide a listing of the manufacturer's bulletins (contained in part 1 of the maintenance manual) that apply to the equipment, giving the title, publication number, and date of issue of revision. In many cases, the warranty terms include a provision that the equipment be installed and started up in accordance with specific I/O/M instructions. Failure of the installing contractor to follow those terms may void the manufacturer's warranty and cause needless problems in the event of equipment malfunction or failure. The maintenance supervisor and his/her technicians should familiarize themselves with the applicable publications, verify that the publications are in the maintenance department's reference library, and inspect the equipment installations and start-up report to verify that the manufacturer's conditions for warranty coverage have been met.

**I/O/M Instruction Videotapes Available, Name and Number, and Source of Tapes** provide information for the maintenance supervisor on the training aids that are available for the equipment item, the name and number of each tape, and the source for ordering the tapes. The videotape approach to training O&M personnel in the specific equipment installed in a building is cost-effective in that it tends to instill a disciplined approach to maintenance of other items that may not be covered by video tapes.

An example is "*Installation, Operation, and Maintenance of Series HSC Pumps*, No: TA-HCS-100, July 1977, ABC Pump Company; *Selection and Installation of Mechanical Shaft Seals*, No. VT-301, April 1978, Jim Derrik Co.; *Selection and Alignment of Shaft Couplings*, No. SIT 123, June 1972, The Spyder Corporation."

**Spare/Repair Parts, Part List, Minimum Inventory List** should provide information about the applicable spare parts list and inventory list, including the designation and date of each list. For some equipment, this field should be modified to provide information about specific spare parts required, such as belts, filters, and repair kits, and should note which parts are carried in inventory and which should be specially ordered.

An example follows: "Seals two each JDC C/CI 1.5; Bearings two each Rolfast 1A2B3C 1.5-in. bore; Shaft coupling insert only TSC Model XYZ-1.5." Where equipment items have minor and major overhaul action listed, the specific publication for each overhaul type is listed along with data on lists of material and equipment needed for the overhaul, including outside services such as honing cylinders.

**Preventive Maintenance Actions and Time Required** should provide, for each of the listed actions, the standard time allotment for each action. Where more than one technician category and skill level are required to perform the task, the hours for each category and skill level should be entered separately to allow the cost of work to be determined and the time to be budgeted for future actions. The listed actions should be modified for the specific equipment item covered. For example, a closed-circuit liquid cooler may require chemical treatment, coil and pan cleaning, lubrication, motor starter service, power contactor service, pump seals, and v-belt drive service.

**Scheduled Routine Operation and Maintenance Actions, and Time Required** should provide information on the labor requirements for each routine maintenance action for an equipment item for the maintenance supervisor to use in allocating manpower, planning staffing requirements, scheduling routine maintenance operations, and budgeting maintenance costs. A typical list of routine frequencies might include daily, weekly, monthly, quarterly, semiannual, annual, and preseason hours and pressure drop basis. The equipment overhaul requirements usually are on the basis of operating hours or performance parameters, such as low oil pressure or low differential pressure.

The routine actions listed below are additive, in the sense that each calendar-based action includes the task on the previous action level. A general description of the routine action for a pump might include the following:

Daily	Observe shaft seal for excessive leakage and listen for bearing noise.
Weekly	Feel pump and motor bearing housing for excessive heat buildup.
Monthly	Measure and record suction and discharge pressure.
Quarterly	Verify lubrication.
Semiannually	Remove drive guard and check alignment of shaft coupling.
Annually	Check motor amperes drawn at full load; check motor shaft run-out; and perform thermographic scan of motor starter, motor, and pump.
Preseason	Quarterly jobs plus clean and paint drip pan.
Pressure Drop Basis	When pump suction-to-discharge differential pressure develops, drop to 85% of original start-up values, open pump housing, check pump wearing rings, and replace worn wearing rings.

Each action should have a listing of the technician categories and skill levels required and number of hours for each technician. Much of the basic information for these entries is available from the fields "Preventive Maintenance Actions" and "Time Required" above and "Routine O&M Action Description, Skill Level, Tools, and Consumables" below.

**Routine O&M Action Description, Skill Level, Tools, and Consumables** should provide a fairly detailed description of each action, giving the action name, the technician(s) category and skill level, the special tools and appliances required, the consumables required, and the service cart type containing the basic tools and supplies needed for the task. The O&M action description should be tailored to the O&M department's philosophy, whether for predictive, preventive, routine, or breakdown maintenance.

A typical action description would be "Name—Measure amperage drawn by pump motor; Technician Category and Skill Level—HVAC Technician, Level III; Tools/Appliances Required—Hand tools, volt/ohm/multimeter, Class II protective gloves; Consumables—None; Time Allotted—0.8 h; Cart Name—Electrical Testing; Description of Task—Advise Building Automation System operator that pump may be shut down at an approximate time for an approximate length of time; take work order to tool room, draw cart and special tools; go to task location; stop pump motor from the hand-off automatic switch on starter face and open starter enclosure; restart pump with enclosure open; carefully draw load-side wires from enclosure as required to use multimeter; place sensor jaws around each conductor in turn, and read and record phase leg amperage; connect probes to multimeter, read voltage on each phase leg, and record with amperage for same leg; stop pump motor, carefully place load-side conductors in enclosure, close enclosure, and restart pump motor; verify that pump is running; return to shop; and analyze test results. If amperage or voltage imbalance is greater than 10% between any two legs, notify supervisor."

With the action description given in this much detail, the quality of work can be enhanced, but the record-keeping task is significant. Realistically, a program this detailed should be in a computer-based maintenance management system.

**Maintenance History—List for Each Maintenance Action** should provide a means for obtaining feedback from the technician(s) and include the date the data are recorded; the work order number; a description of the operation performed, if different from the action description; cost for operation performed, to be completed by an O&M clerk; technician name(s); and comments. The intent of this section is to get comments from the technicians while the work is fresh in their minds. The subjects of comments are expected to be wide-ranging, from the usual complaining about why the work has to be done at all to constructive comments such as, "Annually is too often. Do this work when problem is found," or, "The overload heaters are too large for the measured amperage and should be changed."

In the first case, the maintenance supervisor can explain that the comment is based on a breakdown maintenance philosophy, while the building is being operated on a predictive maintenance philosophy. In the second case, the supervisor can issue a work order to replace the oversized heater relays.

This approach requires that the maintenance supervisor read all of the maintenance histories to make full use of the information. It is desirable to have the equipment data sheet copy turned in with the completed work order so that the O&M clerk can collect the sheets with comments for the supervisor's review and monthly status reports.

#### ***Exhibit D1: Equipment Data Sheet Sample***

Equipment Name:

Designation:

Location:

Associated System:

Manufacturer:

Model No.:

Serial No.:

Date of Mfr.:

Vendor/Agent:

Purchase Order No.:

Date:

Status: New ( ) Rebuilt ( )

Warranty Term:

Start-up: By

Date:

O&M Instruction Videotapes Available: Yes ( ) No ( )

Name and Number:

Source of Tapes:

Spare Parts:

Complete List: Yes ( ) No ( ); Name and Date

Inventory List: Yes ( ) No ( ); Name and Date

#### Preventive Maintenance Actions and Time Required

Chemical Treatment:

Filter Changing:

Motor Starter:

Pump Seal:

Coil and Pan Cleaning:

Lubrication:

Power Contactor:

V-Belt Drive:

#### Scheduled Routine Operation and Maintenance Actions, and Time Required

Daily:

Semiannually:

Preseason:

Overhaul: Minor

Major

#### Routine O&M Action Description, Skill Level, Tools, and Consumables

Action Name:

Technician(s) Skill Level:

Special Tools/Appliances Required:

Consumables Required:

Service Cart Type:

#### Maintenance History—List for Each Maintenance Action

Date:

Work Order No.:

Description of Maintenance Action Performed:

Cost of Maintenance Action Performed:

Technician Name(s):

Comments:

Technician Report (Comments and Recommendations):

**(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)**

## APPENDIX E TEST REPORTS

This document is the “health file” of the facility. It documents the observed performance during start-up and commissioning and allows the observed performance documentation to be compiled throughout the service life of the facility.

The following example provides a guide to organizing this document:

### Table of Contents

#### Part 1: Performance Targets

Indoor Environment

Page No.

xx

Building Energy Budget

xx

System Output at Design Load and Part Load

xx

Systems:

xx

Equipment Output at Design Load and Part Load

xx

Equipment:

xx

#### Part 2: Testing Protocols

Systems

xx

Air Balancing (System by System)

xx

Water Balancing (System by System)

xx

Equipment

xx

Fans

xx

Pumps

xx

### **Part 3: Test Results**

Since tests will continue to be performed as the operation of the facility continues, causing this part of the document to grow in time, it is suggested that a summary sheet of tests be prepared, indicating the type of test, specifying each piece of equipment or system, the date, and the name of the person and/or company that performed the test.

**POLICY STATEMENT DEFINING ASHRAE'S CONCERN  
FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES**

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

