

## Learner's Guide

### Course 6: Operations, Maintenance, and Commissioning

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## Background on the FEMP First Thursday Seminars

The First Thursday seminars are designed for Federal Energy Managers but are open to anyone whose scope of responsibility involves influencing decisions to increase energy efficiency, conserve water resources, and meet other Federal sustainability goals.

There are three ways to participate in the seminars.

1. Live streaming video available on the day of the event over the internet to a desktop computer or via a projection system in a conference room;
2. Digital and Analog Satellite downlink technology for group showings; and,
3. Archived streaming video available after the event over the internet on a desktop computer or via a projection system in a conference room.

To learn more about accessing specific seminars, access <http://www.femp.energy.gov/training>.

The seminar **Operations, Maintenance, and Commissioning** is being offered live on Thursday, July 1, 2010 at 1:30 p.m. Eastern Time. For access and other course information, access: <http://www.femp.energy.gov/training>.

## Course Description

This course will consider various aspects of Operations and Maintenance (O&M), and Commissioning including:

- the scope of O&M today
- commissioning as an integral component of O&M
- overcoming barriers to effective O&M
- O&M performance metrics
- effective operations, maintenance, engineering support, training, and administration (OMETA)
- life cycle considerations
- reactive, preventative, predictive, and reliability centered maintenance
- case studies
- resources in O&M

## Audience

**Operations, Maintenance, and Commissioning** is designed for federal energy managers and other facility, energy, and environmental professionals who want to know more about best practices in building operations and maintenance including commissioning, effective operations, maintenance, engineering support, and life cycle considerations.

## Learner Objectives

Upon completion of this seminar, you will be able to:

1. Give an up-to-date definition of operations and maintenance today.
2. Explain the relationship of O&M and commissioning.
3. Discuss the benefits of a well-run O&M program.
4. Explain some of the common barriers to O&M and how to overcome those barriers.
5. List 5 performance measures for an effective O&M program.

## Learner Objectives *(continued)*

6. Explain O.M.E.T.A. in terms of a complete O&M program.
7. Explain lifecycle implications in O&M from new component design to replacement.
8. Discuss the benefits of each of these types of maintenance: reactive, preventative, predictive, and reliability centered.
9. Locate resources to support you in O&M.

## Learning Resources

### Glossary of Terms

**Absorption chiller** – A refrigeration machine using heat as the power input to generate chilled water.

**Adjustable speed drive** – A means of changing the speed of a motor in a step-less manner. In the case of an AC motor, this is accomplished by varying the frequency.

**Aerator** – A device installed in a faucet or showerhead that adds air to the water flow, thereby maintaining an effective water spray while reducing overall water consumption.

**Air changes** – Replacement of the total volume of air in a room over a period of time (e.g., 6 air changes per hour).

**Ambient temperature** – The temperature of the air surrounding an object.

**Base** – A selected period of time with consumption levels or dollar amounts, to which all future usage or costs are compared.

**Baseline** – The “before” data that is used in a “before & after” comparison. Baseline data may refer to energy consumption values, efficiency parameters, or other indications of building (or system) performance.

**BLCC** – Building Life Cycle Costing

**British thermal unit (Btu)** – The amount of heat required to raise the temperature of one pound of water 1 degree Fahrenheit at or near 39.2 degrees Fahrenheit.

**Building commissioning** – A systematic process of assuring that a building facility performs in accordance with design intent and the owner’s operational needs. Verification and documentation that all building facility systems perform interactively in an efficient manner and that operations and maintenance personnel are well trained.

**Building envelope** – The exterior surfaces of a building that are exposed to the weather, i.e., walls, roof, windows, doors, etc.

**Centrifugal fan** – A device for propelling air by centrifugal action.

**cfm** – Cubic feet per minute usually refers to the volume of air being moved through an air duct.

**Chiller** – A refrigeration machine using mechanical energy input to drive a centrifugal compressor to generate chilled water.

**Coefficient of performance** – Ratio of tons of refrigeration produced to energy required to operate equipment.

**Coefficient of utilization** – Ratio of lumens on the work surface to total lumens emitted by the lamps.

**Cold deck** – A cold air chamber forming a part of an air conditioning system.

**Commissioning** - Systematic process of assuring by verification and documentation, from the design phase to a minimum of one year after construction, that all facilities perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs, including preparation of operational personnel.

**Condensate** – Water obtained by changing the state of water vapor (i.e., steam or moisture in air) from a gas to a liquid usually by cooling.

**Condenser** – A heat exchanger that removes heat from vapor, changing it to its liquid state. In refrigeration systems, this is the component that rejects heat.

**Conduction** – Method of heat transfer in which heat moves through a solid.

**Control Strategy** - An approach to controlling equipment. Usually this term refers to automated routines implemented through an energy management system that are designed to control equipment while providing maximum energy efficiency.

**Convection** – Method of heat transfer in which heat moves by motion of a fluid or gas, usually air.

**Cooling tower** – A device that cools water directly by evaporation.

**Damper** – A device used to limit the volume of air passing through an air outlet, inlet, or duct.

**Datalogger** - A stand-alone, electronic data-gathering device that utilizes sensors to collect equipment information over time. Data collected could include temperature, pressure, current, humidity, or other operational information.

**Degree days** - The degree day for any given day is the difference between 65 degrees and the average daily temperature. For example, if the average temperature is 50 degrees, the degree days is  $65 - 50 = 15$  degrees days. When accumulated for a season, degree days measure the severity of the entire season.

**Demand factor** – The ratio of the maximum demand of a system to the total connected load on the system.

**Demand load** – The maximum continuous requirement for electricity measured during a specified amount of time, usually 15 minutes.

**Diagnostic Monitoring** - The practice of collecting data on equipment operation over a period of time for the purpose of assessing the equipment performance. This data may be obtained through a datalogger or an energy management system. This data may consist of time-series or change-of-value (COV) data that can be collected for digital points such as temperature, pressure, or status.

**Double bundle chiller** – A condenser usually in a refrigeration machine that contains two separate tube bundles allowing the option of rejecting heat to the cooling tower or to another building system requiring heat input.

**Dry bulb temperature** – The measure of the sensible temperature of air.

**Economizer cycle** – A method of operating a ventilation system to reduce refrigeration load. Whenever the outside air conditions are more favorable (lower heat content) than return air conditions, outdoor air quantity is increased.

**Efficacy** – Ratio of usable light to energy input for a lighting fixture or system (lumens per watt).

**Efficiency Curve** - For some equipment, the efficiency varies with the load on the equipment. In those cases the efficiency is plotted against load. This efficiency curve illustrates the performance of the equipment over its range of operational conditions.

**Energy Accounting** - The process of tracking and analyzing energy use for the purpose of detecting problems, trends, or savings opportunities. Typically, energy accounting is performed for an entire building. In the analysis process, adjustments may be made for variations in weather, space use, or other variables from year to year.

**Energy Assessment (audit)** - An investigation of systems in existing buildings with the goal of replacing or retrofitting equipment. This is a quick process that may include building simulation and results in a list of energy conservation measures that involve significant capital investment.

**Energy management system** – A microprocessor-based system for controlling equipment and monitoring energy and other operating parameters in a building.

**Energy requirement** – The total yearly energy used by a building to maintain the selected inside design conditions under the dynamic impact of a typical year's climate. It includes raw fossil fuel consumed in the building and all electricity used for lighting and power. Efficiencies of utilization are applied and all energy is expressed in the common unit of Btu.

**Energy utilization index** – A reference which expresses the total energy (fossil fuel and electricity) used by a building in a given period (month, year) in terms of Btu's/gross conditioned square feet.

**Enthalpy** – The total heat content of air expressed in units of Btu/pound. It is the sum of the sensible and latent heat.

**Equipment Efficiency** - A measure of the output of some piece of equipment as it relates to the energy input. Higher efficiency indicates that a machine can produce more heating, cooling, etc. for each unit of fuel (electricity, gas, etc.) consumed. For some equipment, the efficiency varies with the load on the equipment. In those cases the efficiency is plotted against load. This efficiency curve illustrates the performance of the equipment over its range of operational conditions.

**Evaporation** – The act of water or other liquids dissipating or becoming vapor or steam.

**Evaporator** – A heat exchanger in which a liquid evaporates while absorbing heat, expressed in Btu's per hour.

**Existing Building Commissioning** - is “commissioning applied to an existing facility, whether previously commissioned or not, to help the facility and its systems meet the Owner's current and anticipated future requirements (not necessarily original design).”

**Foot candle** – Illumination at a distance of one foot from a standard candle.

**Gross square feet** – The total number of square feet contained in a building envelope.

**Heat gain** – As applied to HVAC calculations, it is that amount of heat gained by space from all sources including people, lights, machines, sunshine, etc. The total heat gain represents the amount of heat that must be removed from a space to maintain indoor comfort conditions.

**Heat loss** – The heat loss from a building when the outdoor temperature is lower than the desired indoor temperature it represents the amount of heat that must be provided to a space to maintain indoor comfort conditions. This is usually expressed in Btu/hour.

**Heat pump** – A refrigeration machine possessing the capability of reversing the flow so that its output can be either heating or cooling. When used for heating, it extracts heat from a low temperature source.

**Heat transmission coefficient** – Any one of a number of coefficients used in the calculation of heat transmission by conduction, convection, and radiation through various materials and structures.

**Horsepower (hp)** – British unit of power, 1 Hp = 746 watts or 42,408 Btu's per minute.

**Hot deck** – A hot air chamber forming part of a multi-zone or dual duct air handling unit.

**Humidity, relative** – A measurement indicating the moisture content of the air.

**IAQ** – Indoor Air Quality

**IEQ** – Indoor Environmental Quality

**Indoor Environmental Quality (IEQ)** - A term that refers to the total environment of a building and includes thermal comfort, proper illumination, adequate outside air ventilation, and control of indoor air pollutants.

**Infiltration** – The process by which outdoor air leaks into a building by natural forces through cracks around doors and windows.

**Investment Grade Audit** - An audit that incorporates the aspects of a traditional energy audit plus a risk assessment that evaluates the impact that occupancy, management, maintenance and operational behavior will have on energy-efficiency measures.

**Latent heat** – The quantity of heat required to effect a change in state of a substance.

**Life cycle cost** – The cost of the equipment over its entire life including operating costs, maintenance costs, and initial cost.

**Load profile** – Time distribution of building heating, cooling, and electrical load.

**Lumen** – Unit of measurement of rate of light flow.

**Luminaire** – Light fixture designed to produce a specific effect.

**Maintenance practices** - The aggregate of direct and supporting actions that detect, preclude or mitigate the degradation of a system or component functionality, or restore that function to an acceptable level of performance following failure.

**Makeup** – Water supplied to a system to replace that lost by blowdown, leakage, evaporation, etc. Air supplied to a system to provide for combustion and/or ventilation.

**Modular** – System arrangement whereby the demand for energy (heating, cooling) is met by a series of units sized to meet a portion of the load.

**Nameplate Information** - For a piece of equipment, the information that gives the make, model, size, capacity, electrical draw and other relevant factory data. This information is sometimes found imprinted on a plate affixed to the equipment.

**Operations and Maintenance** - The coordinated integration of the operations, maintenance, engineering support, training, and administrative areas (OMETA) of any process in order to maintain and/or increase the efficiency, reliability, and safety of the process.

**O&M Assessment** - A systematic method for identifying ways to optimize the performance of an existing building. This assessment involves gathering, analyzing, and presenting information based on the building owner or manager's requirements.

**Orifice plate** – Device inserted in a pipe or duct, which causes a pressure drop across it. Depending on orifice size, it can be used to restrict flow or form part of a measuring device.

**ORSAT apparatus** – A device for measuring the combustion components of boiler or furnace flue gasses.

**Payback** - The length of time that an energy-efficiency improvement will take to provide the full return on investment. For example, if a \$1,000 investment will yield \$1,000 in energy or maintenance savings by the end of the first year, that investment has a 1-year payback.

**Performance Tracking** – The ongoing procedure of obtaining data that gives an indication of a system's performance. This data could include information on energy efficiency, energy consumption, or run-time. As part of the process, performance data is often compared to the system's baseline.

**Piggyback operation** – Arrangement of chilled water generation equipment whereby exhaust steam from a steam turbine driven centrifugal chiller is used as the heat source of an absorption chiller.

**Plenum** – A large duct used as a distributor of air from a furnace.

**Power factor** – Relationship between KVA and KW. The power factor is one when the KVA equals the KW.

**Pressure reducing valve** – A valve designed to reduce a facility's water consumption by lowering supply-line pressure.

**Preventive Maintenance Program** - A program that is implemented to address equipment maintenance issues proactively. The goal of such a program is to perform maintenance tasks on a regular schedule so as to maximize the operational efficiency and lifetime of the equipment.

**R Value** – The resistance to heat flow of insulation.

**Radiation** – The transfer of heat from one body to another by heat waves without heating the air.

**Re-commissioning** - An application of the Commissioning Process requirements to a project that has been delivered using the Commissioning Process. This may be a scheduled re-commissioning developed as part of an Ongoing Commissioning Process, or it may be triggered by use change, operations problems, or other needs.

**Retro-Commissioning** - The Commissioning Process applied to an existing facility that was not previously commissioned. This guideline does not specifically address retro-commissioning. However, the same basic process needs to be followed from Pre-Design through Occupancy and Operations to optimize the benefits of implementing the Commissioning Process philosophy and practice.

**Seasonal efficiency** – Ratio of useful output to energy input for a piece of equipment over an entire heating or cooling season. It can be derived by integrating part load efficiencies against time.

**Sensible heat** – Heat that results in a temperature change, but no change in state.

**Source meter** – A water meter that records the total water flow into a facility.

**Sub meter** – A meter that records energy or water usage by a specific process, a specific part of a building, or a building within a larger facility.

**Therm** – A unit of gas fuel containing 100,000 Btu's.

**Ton (of refrigeration)** – A means of expressing cooling capacity: 1 ton = 12,000 Btu/hour cooling (removal of heat).

**Trend Log** - A log of data that is collected through an energy management system. This data may consist of time-series or change-of-value (COV) data that can be collected for digital points such as temperature, pressure, or status.

**U Value** – A coefficient expressing the thermal conductance of a composite structure in Btu's per (square foot) (hour) (degree Fahrenheit difference).

**Vapor barrier** – A moisture impervious layer designed to prevent moisture migration.

**Variable frequency drive** – See “Adjustable speed drive”

**Variable speed drive** – See “Adjustable speed drive”

**Veiling reflection** – Reflection of light from a task or work surface into the viewer's eyes.

**Wet bulb temperature** – The lowest temperature attainable by evaporating water in the air without the addition or subtraction of energy.

**Xeriscaping** – The selection, placement, and care of water-conserving and low-water-demand ground covers, plants, shrubs, and trees in landscaping.

## Resources

### Commissioning

[http://www1.eere.energy.gov/femp/pdfs/commissioning\\_fed\\_facilities.pdf](http://www1.eere.energy.gov/femp/pdfs/commissioning_fed_facilities.pdf)

[https://www1.eere.energy.gov/femp/pdfs/OM\\_7.pdf](https://www1.eere.energy.gov/femp/pdfs/OM_7.pdf)

### Operations and Maintenance Best Practices Guide

[http://www1.eere.energy.gov/femp/pdfs/omguide\\_complete.pdf](http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf)

### Other Helpful Resources - Online

#### [www.reliabilityweb.com](http://www.reliabilityweb.com)

Reliabilityweb.com is a information and research firm publishing practical information for maintenance and reliability professionals.

#### [www.mt-online.com](http://www.mt-online.com)

MT-online.com is a source of capacity assurance and best practice solutions for manufacturing, process and service operations worldwide. Resources include the Maintenance Technology magazine.

#### [Plant-maintenance.com](http://Plant-maintenance.com)

Plant-maintenance.com provides resources and information related to Plant Maintenance.

### Helpful Reference Documents

#### *An Introduction to Reliability and Maintainability Engineering*

By: Charles E. Ebeling

Published by: McGraw Hill College Division

Publication date: September 1996

#### *Maintenance Engineering Handbook*

By: Lindley R. Higgins, Dale P. Brautigam, and R. Keith Mobley (Editor)

Published by: McGraw Hill Text, 5th Edition

Publication date: September 1994

#### *Condition-Based Maintenance and Machine Diagnostics*

By: John H. Williams, Alan Davies, and Paul R. Drake

Published by: Chapman & Hall

Publication date: October 1994

#### *Maintenance Planning and Scheduling Handbook*

By: Richard D. (Doc) Palmer

Published by: McGraw Hill

Publication date: March 29, 1999

(continued)

**Helpful Reference Documents** (continued)

*Maintainability and Maintenance Management*

By: Joseph D. Patton, Jr.

Published by: Instrument Society of America, 3rd Revision

Publication date: February 1994

*Reliability-Centered Maintenance*

By: John Moubray

Published by: Industrial Press, 2nd Edition

Publication date: April 1997

*Reliability-Centered Maintenance*

By: Anthony M. Smith

Published by: McGraw Hill

Publication date: September 1992