

# Learning Activity Plan

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## Fuel Cell Technology

(FCEL 2330 / INTC 2372)  
**FUEL CELL INSTALLATION,  
COMMISSIONING, TROUBLESHOOTING,  
AND REPAIR**

## ACKNOWLEDGEMENTS

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**Authorizing Agency:**

Texas Higher Education Coordinating Board, 1200 East Anderson Lane, Austin, TX 78752 ([www.thecb.state.tx.us](http://www.thecb.state.tx.us))

**Funded by:** Carl D. Perkins Vocational Education Act

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# Classroom Setup Requirements

The following table lists the materials required for this course:

DEPARTMENT	COURSE	DATE
ECR	FCEL 2330/INTC 2372	9/1/04

TEXTBOOK TITLE	AUTHOR	PUBLISHER	EDITION
Fuel Cell Technology Handbook	Gregor Hoogers	Wiley Publishing	Current
Fuel Cell Systems Explained	James Larminie	Wiley Publishing	Current
National Electric Code	NFPA	NFPA	Current
OSHA Standards CFR29 1910	OSHA	Mancomm	Current

NOTE: The service manual provided with the fuel cell system and equipment purchased will be used as a reference in this course.

STUDENT MATERIALS/EQUIPMENT	QUANTITY
Scientific calculator (TI 36X or equiv.)	1
3-Ring Notebook Binder and Paper	500 sheets
Pens/Pencils	3 each
6" Steel Ruler/Straight Edge	1
Standard Hand Tools	Purchased for use in previous labs
Digital Multimeter (DMM) Wavetak or equivalent	1

Classroom materials and equipment include white board, videotapes, computer with projector.

**NOTE:**

Technical manuals, manufacturer operations service manual, schematics, diagrams, and drawings that will be used will be dependent upon the fuel cell systems purchased as laboratory equipment. Unit equipment requires specific fuel cell system technical data provided by the manufacturer for that piece of equipment at the time of purchase.

# Lab Room Setup Requirements

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The Fuel Cell and Renewable Energy Laboratory will be set up with a hydrogen gas distribution system. The laboratory equipment will include industry grade fuel cell devices and renewable energy equipment used by students to gain optimum 'hands-on' experience. The laboratory will also be equipped with associated safety equipment, personal protection equipment, hand tools, test equipment, and appropriate work area devices.

Note: Laboratories and equipment will vary dependent on local needs and equipment available.

## Learning Activity 1

### Definitions, Terms, and Acronyms

#### Learning Outcome

1. Given a list of terms and acronyms related to fuel cell system diagnostics, troubleshooting, and repair, the student will define each term. (Knowledge acquisition)

#### Recommended Resources for Learning Activity

- *Fuel Cell Technology Handbook* by Gregor Hoogers, CRC Press, Chapters 4, 5, 6, 8 and 12.
- *Fuel Cell Systems Explained* by James Larminie/Andrew Dicks, Wiley, Chapters 6, 7, 8 and 9.
- Technical manuals specific to the equipment available in the lab.

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Terms and Acronyms
  - System Diagnostics
  - Troubleshooting
  - Repair
  - Fuel Cells and Fuel Cell Systems

##### *Outline for Laboratory:*

- Review fuel cells and fuel cell system components

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Acquiring the jargon of terms and acronyms introduced in this course will help you communicate effectively with professionals in the fuel cell industry.
- **Develop Learning Activity:**  
*Lecture:* Present lecture. Discuss the terms and acronyms used by technicians in the fuel cell industry. Identify the acronyms for fuel cells and fuel cell system devices.  
*Laboratory:* Review the various parts of a fuel cell (PEM). Review the subsystem devices in a fuel cell system.
- **Conclude Learning Activity:**  
*Lecture:* Review for Written Assessment #1.  
*Laboratory:* Restore lab to specified criteria.

## Learning Activity 2

### Safety and Code Standards

#### Learning Outcome

2. The student will describe specific safety issues dealing with fuel cell installation, operation, troubleshooting, diagnostics, and repair. (Comprehension)
3. When working with specialized equipment, mechanical devices, and hazardous chemicals, the student will use proper personal protection equipment, employ proper handling procedures, and employ lock out tag out procedures as suggested by the fuel cell manufacturer. (Application)
4. The student will describe the OSHA and NEC code standards and hazards related to working with fuel cell equipment, flammable gasses, and electrical powered/generating equipment. (Comprehension)

#### Recommended Resources for Learning Activity

- *Fuel Cell Technology Handbook* by Gregor Hoogers, CRC Press, Chapter 5.
- *Fuel Cell Systems Explained* by James Larminie/Andrew Dicks, Wiley, Chapters 7 and 9.
- OSHA CFR 29 1910 subpart H (Flammable Gasses) and Appendix A (Personal Protection Equipment).
- NEC art. 692 (fuel cells and chapter 5 (classified locations)).
- Fuel cell technical service manual.

#### Recommended Instructor Preparation for Learning Activity

1. Prepare lecture as outlined below.
2. Generate copies of Written Assessment #1

#### *Outline for Lecture:*

- Safety Issues Specific to Fuel Cells
  - Installation
  - Operation
  - Troubleshooting
  - Diagnostics
  - Repair
- Safety Procedures
  - Use and Storage of Hydrogen and Cryogenic Liquids
  - Electrical Power and Shock Hazards
  - Hazards of Thermal Burns
- Personal Protection Equipment
  - Mechanical Devices
  - Chemicals
- Lockout/Tagout Procedures

#### *Outline for Laboratory:*

- Review lab safety procedures

**Recommended Instructor/Student In-class/Lab Activity**

- **Capture Student Attention:**  
*Lecture:* Cite the latest statistics for electrical accidents.
- **Develop Learning Activity:**  
*Lecture:* Distribute Written Assessment #1. Present lecture.  
*Laboratory:* Review the technical manuals for suggested safety concerns.  
Review the technical manuals for suggested personal protection equipment.  
View the equipment for actual devices and layout of safety concerns.  
List actual equipment, devices, and areas of safety concerns relative to the fuel cell system.
- **Conclude Learning Activity:**  
*Lecture:* Review for Written Assessment #2.  
*Laboratory:* Restore lab to specified criteria.

## Learning Activity 3

### Specialized Tools and Meters

#### Learning Outcome

5. The student will describe the function of the following tools and meters needed for the operation and calibration of fuel cells, systems, and support equipment: (Comprehension)
  - a. pH Meters
  - b. Flow Meters
  - c. Volt-ohm-amp Meters
  - d. DC and AC Amp Clamp Meters
  - e. Thermocouples
  - f. Digital Thermometers
  - g. Torque Wrenches
  - h. Gas Analyzer Meters
  - i. Leak Detection Meters and Monitors

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, and suggested specialized tools and meters to be used when operating, maintaining, troubleshooting, and repairing a fuel cell system.

#### Recommended Instructor Preparation for Learning Activity

1. Prepare lecture as outlined below.
2. Generate copies of Written Assessment #2.

#### *Outline for Lecture:*

- Tools and Meters
  - pH Meters
  - Flow Meters
  - Volt-ohm-amp Meters
  - DC and AC Amp Clamp Meters
  - Thermocouples
  - Digital Thermometers
  - Torque Wrenches
  - Gas Analyzer Meters
  - Leak Detection Meters and Monitors

#### *Outline for Laboratory:*

- Use the tools and meters mentioned above to become familiar with the operation, proper connection, calibration, care, and safety for special tools to be used to install, commission, startup, maintain, troubleshoot, repair, and decommission the fuel cell system.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**

*Lecture:* <http://www.h2fc.com/industry/related/index.shtml>  
Fuel Cell Test Equipment

- **Develop Learning Activity:**

*Lecture:* Return Written Assessment #1. Discuss results and provide clarification.  
Distribute Written Assessment #2. Present lecture.

*Laboratory:* Highlight the tools and meters that will be used during the installation, operation and repair of fuel cell systems. Safe use of the tools and meters, calibration of the meters and proper care of the tools and meters will be discussed.

- **Conclude Learning Activity:**

*Lecture:* Provide an overview of the next lecture.

*Laboratory:* Restore lab to specified criteria.

## Learning Activity 4

### Specialized Diagnostic Equipment

#### Learning Outcome

6. The student will describe the function of specialized diagnostic equipment used with the installation, operation, troubleshooting, and repair of the fuel cell system.  
(Comprehension)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, and suggested specialized diagnostic equipment to be used when operating, maintaining, troubleshooting, and repairing a fuel cell system.

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Specialized Diagnostic Equipment
  - Hydrogen Leak Detector
  - Oscilloscope
- Proper use and calibration of specialized diagnostic equipment

##### *Outline for Laboratory:*

- Use the specialized diagnostic equipment for troubleshooting fuel cell system and support equipment.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**

*Lecture:* [Hydrogen Leak Detector](http://www.omega.ca/techref/ph-4.html)

*http://www.omega.ca/techref/ph-4.html#statement*

From soap solutions to electronic hydrogen leak detectors.

[Oscilloscope](http://www.beta-dyne.com/resources/custprof001/)

*http://www.beta-dyne.com/resources/custprof001/*

10-Cell Fuel Cell DC/DC Converter

- **Develop Learning Activity:**

*Lecture:* Return Written Assessment #2. Discuss results and provide clarification. Present lecture. Discuss the proper use, safety precautions, calibration and appropriate care of the diagnostic equipment.

*Laboratory:* Guide the students as they operate and calibrate the diagnostic equipment.

- **Conclude Learning Activity:**

*Lecture:* Review for Written Assessment #3.

*Laboratory:* Restore lab to specified criteria.

## Learning Activity 5

### Site Planning and Design Considerations

#### Learning Outcome

7. When planning an installation of a fuel cell system, the student will: (Application)
  - a. Identify the installation procedures outlined in the manufacturer's technical manual.
  - b. Assess the site to identify the placement of the fuel cell system noting obstacles or obstructions.
  - c. Identify design criteria and site requirements including site foundation, piping, electrical, utilities and security requirements.
  - d. Assess the fuel distribution to be connected to the fuel cell system.
  - e. Assess the electrical distribution for connection to the fuel cell system.
  - f. Identify the permitting agencies that need to be notified of the intention to install a fuel cell system.
  - g. Identify the national, state and local code standards that will require reference before installation can begin.

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.

#### Recommended Instructor Preparation for Learning Activity

1. Prepare lecture as outlined below.
2. Generate copies of Written Assessment #3

#### *Outline for Lecture:*

- Planning an Installation
  - Manufacturer's Installation Procedures
  - Identify Placement of Fuel Cell System
  - Identify Site Requirements
  - Fuel Distribution Requirements
  - Electrical Distribution Requirements
  - Agencies to be Notified
  - National, State, Local Codes

#### *Outline for Laboratory:*

- Provide technical manuals

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**

*Lecture: [http://www.distributedenergy.com/de\\_0409\\_top.html](http://www.distributedenergy.com/de_0409_top.html)*

College Considers Going Green with campus Fuel Cell Power.

R.W. Beck Inc. fuel cell feasibility study concluded that incorporation of fuel cell power generation technology into a campus utility system is technically viable and can provide synergy with a campus system

- **Develop Learning Activity:**

*Lecture:* Distribute Written Assessment #3. Present lecture.

*Laboratory:* Review the technical service manuals for a specific fuel cell system and view an installed fuel cell system. List concerns related to the planning for installation. Review all fuel distribution connections to the fuel cell system from the source of supply. Discuss all pre-installation issues with the students and instructor. Note this lab will be a continued effort through several lab periods.

- **Conclude Learning Activity:**

*Lecture:* Review for Written Assessment #4.

*Laboratory:* Restore lab to specified criteria.

## Learning Activity 6

### Installation Techniques

#### Learning Outcome

8. Adhering to the manufacturer's installation requirements and guidelines, the student will go through the installation process with the fuel cell system on its foundation. (Application)
9. Adhering to the manufacturer's installation requirements and guidelines, the student will install the fuel cell system's fuel piping components. (Application)
10. Adhering to the manufacturer's installation requirements and guidelines, the student will install the fuel cell system's electrical power connections. (Application)
11. Adhering to the manufacturer's installation requirements and guidelines, the student will install the fuel cell system's controls. (Application)
12. Adhering to the manufacturer's installation requirements and guidelines, the student will install the fuel cell system's water treatment system. (Application)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.

#### Recommended Instructor Preparation for Learning Activity

1. Prepare lecture as outlined below.
2. Generate copies of Written Assessment #4.

#### *Outline for Lecture:*

- Review the service manual regarding specific installation instructions and suggestions.
- Discuss the installation process.
- Discuss any safety considerations.
- Discuss the required personal protection equipment to be worn during installation.

#### *Outline for Laboratory:*

- Review the service manual for specific instructions for installation of the fuel cell system.
- Discuss safety issues.
- Wear all personal protection equipment as set fourth by the instructor.
- Follow the suggested installation procedures found in the fuel cell service manual.
- Review the installation procedures with the instructor.
- Install the fuel cell system on its foundation.
- Install the fuel cell system fuel piping.
- Install the fuel cell system electrical power connection.
- Install the fuel cell system controls.
- Install the fuel cell system water treatment system.

**Recommended Instructor/Student In-class/Lab Activity**

- **Capture Student Attention:**

*Lecture:* [http://www.idatech.com/technology/publications/2000fc\\_ell.pdf](http://www.idatech.com/technology/publications/2000fc_ell.pdf)  
Residential applications in fuel cell systems for primary power of heat and electricity

- **Develop Learning Activity:**

*Lecture:* Return Written Assessment #3. Discuss results and provide clarification. Distribute Written Assessment #4. Present lecture. Students will be guided through the process of drafting a plan to install a fuel cell system.

*Laboratory:* Using the facilities in the outdoor laboratory, the students will use their plan to install a fuel cell system to simulate the installation of a fuel cell.

- **Conclude Learning Activity:**

*Lecture:* Provide an overview of the next lecture.

*Laboratory:* Restore lab to specified criteria.

## Learning Activity 7

### Fuel Cell Commissioning and Startup

#### Learning Outcome

13. Adhering to the manufacturer's commissioning and startup requirements, the student will perform the recommended commissioning procedures. (Application)
14. Prior to system startup, the student will identify the emergency procedures for system shutdown, and fuel and electrical isolation. (Application)
15. Adhering to the manufacturer's commissioning and startup requirements, the student will conduct a pre-start check and startup the fuel cell system. (Application)
16. After system startup, the student will check the system for proper operation. (Application)
17. After system startup, the student will document any concerns or problems noted with the startup process or operation of the system in the Startup and Operation Log Book. (Application)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Identify manufacturer's commissioning and startup requirements
- Identify the emergency procedures for system shutdown, and fuel and electrical isolation.
- Identify the startup procedures.
- Identify areas to check the system for proper operation.
- Discuss the documentation needed to identify concerns or problems noted with the startup process or operation of the system.

##### *Outline for Laboratory:*

- Perform the recommended commissioning procedures.
- Identify the emergency procedures for system shutdown, and fuel and electrical isolation.
- Start the fuel cell system.
- Check the system for proper operation.
- Document any concerns or problems noted with the startup process or operation of the system.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**

*Lecture:* [http://www.distributedenergy.com/de\\_0501\\_exploring.html](http://www.distributedenergy.com/de_0501_exploring.html)  
Showcasing fuel cell technology in a real-world installation.

- **Develop Learning Activity:**

*Lecture:* Return Written Assessment #4. Discuss results and provide clarification. Present lecture. As the system pre-start and commissioning are discussed, the student will create a commissioning checklist.

*Laboratory:* Using the pre-start and commissioning checklist, the student will prepare for commissioning a newly installed fuel cell system. Upon successful completion of all the checks, the student will commission and startup the fuel cell system. Once the system is operating properly, the student will document the startup and commissioning process.

- **Conclude Learning Activity:**

*Lecture:* Provide an overview of the next lecture.

*Laboratory:* Restore lab to specified criteria.

## Learning Activity 8

### Operating and General Maintenance

#### Learning Outcome

18. Adhering to the manufacturer's operating and general maintenance requirements, the student will perform the required system checks. (Application)
19. Adhering to the manufacturer's operating and general maintenance requirements, the student will observe a functioning fuel cell system noting any irregularities in its performance in the Operation Log. (Application)
20. Adhering to the manufacturer's operating and general maintenance requirements, the student will devise a plan for scheduling periodic maintenance of the fuel cell system. (Application)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Identify manufacturer's requirements for a system check.
- Identify the components of the system to be observed for proper performance.
- Identify manufacturer's requirements for a maintenance plan.

##### *Outline for Laboratory:*

- Operate the fuel cell system noting carefully the condition of the system during operation, especially any suspected abnormal problems.
- Document the system operation in the operation log book, noting any problems.
- Plan a strategy for system regular general maintenance, to be documented in the maintenance log book.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* <http://www.uscg.mil/systems/gse/energy/FuelCell/Fuel-Cell-Consolidate-Status-Report-2003.pdf>  
 Monthly Status Report: USCG Air Station Cape Cod Fuel Cell Project
- **Develop Learning Activity:**  
*Lecture:* Present lecture. As the system maintenance and operational irregularities are discussed, the student will create a general maintenance schedule.  
*Laboratory:* Using the general maintenance schedule, the student will conduct maintenance at predetermined time schedules. The student will document any abnormal operations or operation concerns in the appropriate log books. If any

perceived hazards are present, the student will immediately shut down and lockout the system.

- **Conclude Learning Activity:**

*Lecture:* Provide an overview of the next lecture.

*Laboratory:* Performance Test 4 – Commissioning and Startup next week.

## Learning Activity 9

### Fuel Cell Diagnostics and Troubleshooting

#### Learning Outcome

21. Using the manufacturer's diagnostic and troubleshooting techniques, the student will identify typical operational problems of a fuel cell system. (Application)
22. Using the manufacturer's suggested diagnostic and troubleshooting techniques, and the student's maintenance plan, the student will plan logical strategies for system diagnostics and troubleshooting the system. (Application)
23. Given a defective fuel cell system, the student will perform the required system diagnostic and troubleshooting procedures to identify the defect. (Evaluation)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.
- Student's Maintenance Plan

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Operational Problems on Fuel Cell Systems
- Strategies for system diagnostics and troubleshooting the system

##### *Outline for Laboratory:*

- Follow the proper safety techniques and use proper personal protection.
- Perform various troubleshooting techniques on the fuel cell system.
- Diagnose problems that have been inflicted on the machine by the instructor.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Provide information on the latest use of fuel cells for powering devices.
- **Develop Learning Activity:**  
*Lecture:* Present lecture. Discuss a logical progression of system troubleshooting.  
*Laboratory:* Conduct Performance Test 4-Commissioning and Startup.
- **Conclude Learning Activity:**  
*Lecture:* Provide an overview of the next lecture.  
*Laboratory:* Restore lab to specified criteria.

## Learning Activity 10

### Fuel Cell Repair and Support Equipment

#### Learning Outcome

24. After performing system diagnostics and troubleshooting procedures on a defective fuel cell system, the student will refer to the manufacturer's technical manual/troubleshooting guide to develop a plan for proper system repair. (Application)
25. After the system repair plan has been approved, the student will implement repair procedures adhering to all safety precautions and procedures. (Application)
26. The student will note the repair procedures implemented in the Diagnostic/Repair Log. (Application)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system to be installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.
- Student's Maintenance Plan

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Developing a Repair Plan
- Implementing the Repair Plan
- Documenting the Repair Process

##### *Outline for Laboratory:*

- Developing a Repair Plan
- Implementing the Repair Plan
- Documenting the Repair Process

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Provide information on the latest use of fuel cells for powering devices.
- **Develop Learning Activity:**  
*Lecture:* Present lecture.  
*Laboratory:* Direct the students to repair damaged fuel cell components. Impress that warranty equipment/devices are normally not repaired, but sent back to the manufacturer for warranty exchange.
- **Conclude Learning Activity:**  
*Lecture:* Review for Written Assessment #5.  
*Laboratory:* Review for Performance Text 5 – Troubleshooting and Repair.

## Learning Activity 11

### Documentation of Installation and "As Built" Information

#### Learning Outcome

27. The student will identify the proper procedures for documentation of an installation and "As Built" information. (Comprehension)
28. Using the manufacturer's technical information, the student will identify the types of document log books required and the type of information to be recorded. (Comprehension)
29. The student will describe the function of technical service bulletins (TSB). (Comprehension)
30. The student will construct the proper documentation of a fuel cell system installation and complete "As Built" drawings and information. (Application)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.
- All associated national and local code references for documentation of the installation.

#### Recommended Instructor Preparation for Learning Activity

1. Prepare lecture as outlined below.
2. Generate copies of Written Assessment #5.

##### *Outline for Lecture:*

- Proper procedures for documentation of installation and "As Built" information.
- Types of document log books specified by the manufacturer's technical information.
- Importance of Recordkeeping
- Technical Service Bulletins (TSB)

##### *Outline for Laboratory:*

- Develop a log book for site planning, commissioning and startup, equipment operation, troubleshooting and repair, and decommissioning of the system.
- Document the "As Built" and installation information.
- Record and file the manufacturer technical service bulletins for the equipment.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Provide information on the latest use of fuel cells for powering devices.
- **Develop Learning Activity:**  
*Lecture:* Distribute Written Assessment #5. Present lecture. Discuss the importance of "As Built" documentation.  
*Laboratory:* Conduct Performance Test 5 – Troubleshooting and Repair.
- **Conclude Learning Activity:**

*Lecture:* Provide an overview of the next lecture.  
*Laboratory:* Restore lab to specified criteria.

## Learning Activity 12

### Maintenance of Operation and Technical Logs

#### Learning Outcome

31. Using the plan for the maintenance of the fuel cell system the student devised, the student will perform system checks on a functioning fuel cell system. (Application)
32. During system checks, the student will make notations in the Operation/Technical Log of any system irregularities. (Application)
33. When system irregularities are identified, the student will determine if the system needs to be shut down to implement repair procedures. (Application)
34. The student will shut down the fuel cell system and perform maintenance procedures to correct the irregularities. (Application)
35. Following startup procedures, the student will startup the fuel cell system and perform system checks. (Application)
36. The student will record the completed maintenance in the Operation/Technical Log. (Application)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system installed including all technical data, plans, drawings, suggested special considerations, all national and local code references for site planning.
- All national and local code references for the maintenance and operation of the technical logs.

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Performing a System Check
  - Notations in the Technical Log
- Implementation of Repair Procedures
  - System Operating
  - System Shutdown
  - Conducting Updates from Technical Service Bulletins (TSB)
- Operation/Technical Log Notations

##### *Outline for Laboratory:*

- Lab continued from previous lab.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Provide information on the latest use of fuel cells for powering devices.
- **Develop Learning Activity:**  
*Lecture:* Return Written Assessment #5. Discuss results and provide clarification. Present lecture.

*Laboratory:* Use Technical Service Bulletins (TSB) to illustrate how the fuel cell system is updated. Demonstrate how the Operation and Technical Logs reflect new Technical Service Bulletin updates.

- **Conclude Learning Activity:**

*Lecture:* Provide an overview of the next lecture.

*Laboratory:* Restore lab to specified criteria.

## Learning Activity 13

### Documentation of Diagnostics and Repair Logs

#### Learning Outcome

37. The student will develop a Diagnostic/Repair Log for a fuel cell system. (Application)
38. During the maintenance and repair process, the student will record repair procedures in the Diagnostics/Repair Log. (Application)
39. The student will discuss the ordering of parts and documenting warranty work, and warranty part returns. (Comprehension)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system installed including all technical data, plans, drawings, suggested special considerations.
- All national and local code references for the maintenance and operation of the technical logs.

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Diagnostic/Repair Log
  - Notations in the Diagnostic/Repair Log
- Ordering Parts
- Documenting Warranty Work
- Warranty Part Returns

##### *Outline for Laboratory:*

- Lab continued from previous lab.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Provide information on the latest use of fuel cells for powering devices.
- **Develop Learning Activity:**  
*Lecture:* Present lecture.  
*Laboratory:* Demonstrate how to update Repair Logs after Technical Service Bulletins updates and general repairs have been performed.
- **Conclude Learning Activity:**  
*Lecture:* Review for Written Assessment #6.  
*Laboratory:* Restore lab to specified criteria.

## Learning Activity 14

### Specialized Fuel Cell Devices

#### Learning Outcome

40. The student will review the specialized fuel cell control devices dedicated to equipment for connection of the fuel cell system to fuel processing systems including anaerobic digesters, the electrical grid (DG) and applications of controls and equipment dedicated for connections to combined heat and power (CHP) systems and building energy management systems. (Comprehension)

#### Recommended Resources for Learning Activity

- Fuel cell service manual of the fuel cell system installed including all technical data, and specialized fuel cell devices and controls for connection as islanding or anti-islanding in distributed generation and combined heat and power applications.

#### Recommended Instructor Preparation for Learning Activity

1. Prepare lecture as outlined below.
2. Generate copies of Written Assessment #6.
3. Arrange for tour

#### *Outline for Lecture:*

- Specialized control equipment and devices associated with fuel cell systems
- Control strategies for connection to building energy management systems
- Schematic Diagrams
- Distributed generation as related to primary and backup power
- Combined heat and power as related to providing electrical power, thermal energy, and cogeneration to designed distribution systems for buildings.

#### *Outline for Laboratory:*

- Use the fuel cell manufacturer service manual to discuss suggested piping, wiring, and control strategies for installation of distributed generation systems and combined heat and power systems to building distribution systems.
- Draw basic plan sketches for installation of piping, wiring, and control diagrams for distributed generation and combined and heat power equipment for building distribution systems.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Provide information on the latest use of fuel cells for powering devices.
- **Develop Learning Activity:**  
*Lecture:* Distribute Written Assessment #6. Present lecture. Discussions will focus on distributed generation interface equipment, combined heat and power, and interface equipment, and building energy management system (EMS) interface.

*Laboratory:* Tour a facility where a fuel cell system is connected as DG, CHP, and EMS systems are interfaced to a building.

**Conclude Learning Activity:**

*Lecture:* Provide a review of the next lecture.

*Laboratory:* Review for Performance Test 7 – Decommissioning a Fuel Cell System

## Learning Activity 15

### Fuel Cell System Overview and Decommissioning

#### Learning Outcome

41. The student will discuss the overall fuel cell system as designed and installed, as primary or backup power, in a building distribution system. (Comprehension)
42. The student will discuss the overall fuel cell system as designed and installed, with the use of combined heat and power. (Comprehension)
43. The student will identify safety concerns and hazards regarding fuel cell system decommissioning. (Comprehension)
44. Adhering to the manufacturer's steps to decommission the fuel cell system, the student will decommission the fuel cell system. (Application)

#### Recommended Resources for Learning Activity

- Fuel cell system service manual of the fuel cell system installed including all technical data, plans, and drawings.
- All national and local code references for the fuel cell system as a complete application of an integrated power system into a building utility distribution system.

#### Recommended Instructor Preparation for Learning Activity

- Prepare lecture as outlined below.

##### *Outline for Lecture:*

- Overall fuel cell system as designed and installed, as primary or backup power, in a building distribution system.
- Overall fuel cell system as designed and installed, with the use of combined heat and power.
- Safety concerns and hazards regarding fuel cell system decommissioning.
- Decommissioning the fuel cell system

##### *Outline for Laboratory:*

- Decommission the fuel cell system.

#### Recommended Instructor/Student In-class/Lab Activity

- **Capture Student Attention:**  
*Lecture:* Provide information on the latest use of fuel cells for powering devices.
- **Develop Learning Activity:**  
*Lecture:* Return Written Assessment #6. Discuss results and provide clarification. Present lecture.  
*Laboratory:* Conduct Performance Test 7 – Decommissioning a Fuel Cell System
- **Conclude Learning Activity:**  
*Lecture:*  
*Laboratory:*