INSTRUCTOR GUIDE

BEB Familiarization Course:

Battery Electric Bus Familiarization

TWC • TRANSIT WORKFORCE CENTER

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Course Preparation

Checklist for Instruction

✓	Confirm the training dates, location, and number of participants.
	Ensure you have all materials listed in the section **Materials for Instruction**.
	Ensure you have all that is listed in the section **Supplies, Audio-Visual Equipment,** and **Internet Access.**
	Have an attendance sign-in sheet printed for each day of class.
	Read and study the Instructor Guide, PowerPoint presentation, and any State or local documentation pertaining to the local environment.
	If using case studies, review the case studies ahead of time and, where applicable, select the most appropriate cases studies for your audience.
	Familiarize yourself with the Participant Guide.
	Collaborate with local host/coordinator to determine who will print the Certificate of Completion for each participant.

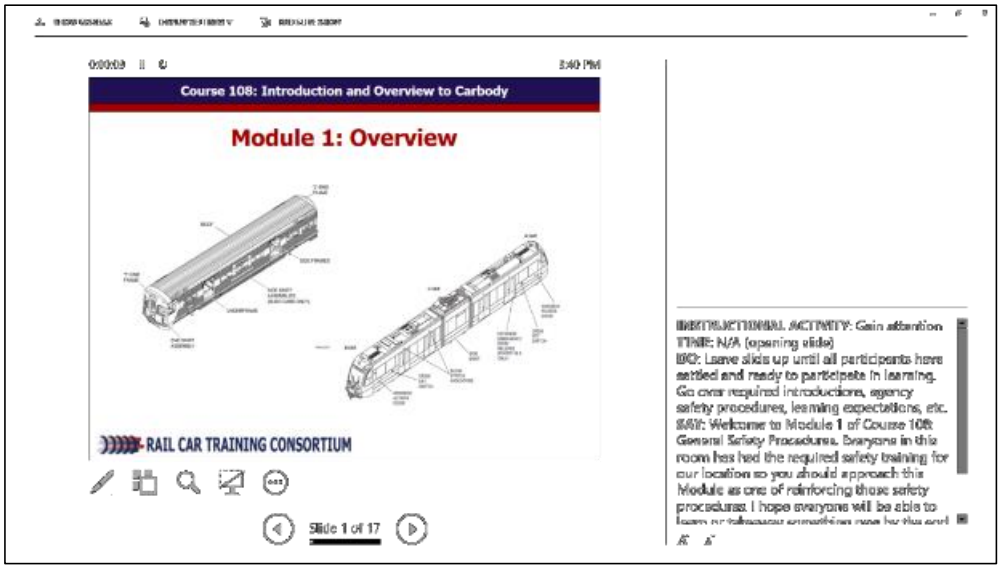
Supplies, Audio-Visual Equipment, Internet Access

The following is important for the adequate delivery of this course:

✓	LCD projector compatible with a notebook computer and cables for proper connection.
	Computer with software to run Microsoft PowerPoint.
	Electronic remote device to advance slides in PowerPoint presentation, if available.
	Projection screen (at least 6’ x 6’).
	Pointer (preferably laser type).
	20-foot or longer extension cord.
	Dry erase board with dry erase markers and eraser.
	Flip chart with markers.
	Supplies such as pencils, note pads, markers, highlighters.
	Access to a lab, rail car maintenance facility, rail car for hands-on lessons.
	Internet access.
	Room audio.
	Test all equipment placed in the training room. The instructor should check at least one hour prior to the start time on the first day of the course.

Best Practices for Delivering Training

1. Read this entire Instructor Guide. Make your own notes as necessary.
2. Preview the PowerPoint presentation that comes with this course and practice what you will say and do during each slide. Note the ways that you will customize how you deliver training to the participants. For example, you may have comments to add, additional take-aways, and other ways you can enhance and optimize learning.
3. When presenting, use PowerPoint's **Presenter View option**, this feature allows you see your notes as you present while the participants will only see the slides. When your computer is connected to the projector and you start the slide show, Presenter View appears on your computer's screen, while only the slides appear on the projector screen.



4. If you prefer printed instructor notes below each slide, you can create your own notes via PowerPoint's **Create Handouts option**.
5. Learning Objectives: At the beginning of each course Module, review the Module's learning outcomes. Make sure participants are fully aware of the topics in the module. At the end of the Module, review the outcomes again and use the review questions or an activity/exercise to ensure that the class meets the learning outcomes.
6. Some modules of this course may contain **Hands-on Learning Activities**. Use the Recommended Hands-on Learning Activities table in the Module guide to select activities that are appropriate for your location, and then use the template provided in the end of this Instructor's Guide to build out details of the activity. Use your location's Standard Operating Procedures, Job Cards, or OEM Maintenance Manuals as a reference for the safety precautions, equipment/tools/materials needed, and tasks. Review and rehearse all hands-on demonstrations.
7. Make sure that embedded links to videos work.
8. Arrive at least an hour early on class day. Give yourself plenty of time to organize the training before the participants arrive.

9. Circulate an attendance sign-in sheet each day and make sure that all participants sign into the class to mark their attendance.
10. Always start on time, even if only one participant is in the room. Stay on track by keeping exercises within the time limit provided in the PowerPoint presentation. However, use your judgement when determining when to move on as activities/discussions may last longer than anticipated.
11. End discussions when they cease to be productive to the learning objectives of the Module. Lead participants away from tangents and focus their attention back to the lesson.
12. Be available for questions during breaks, after class, and during the lab or hands-on learning activities.
13. Mentor participants during each Module activity. Walk amongst the groups in class and during the labs as participants work on activities, and answer questions and offer guidance as appropriate. Ensure that participants are on track as they work. Give constructive feedback during the presentations and participant activities.
14. Review Questions: Review the content of each lesson throughout the course to reinforce the learning outcomes for that lesson and connect the upcoming material. Avoid YES or NO questions and try to use open-ended questions to draw participants into the material. Sample the review questions that are available in the Instructor's Guide and feel free to develop additional questions, as appropriate. Make sure that all questions directly relate to and support the learning outcomes for the Module.

Course Description

This course is a two day course that provides participants with an overview and familiarization to battery electric bus (BEB) basics. This will include an overview of what a BEB is, and what makes it both similar and different from its standard transit counterparts. The course will include sections on BEB components and systems, details on its internal functions (CAN, High Voltage systems, battery packs, etc.), the management systems and a quick glance at preventive maintenance tasks.

The course will follow up with a module on some electrical fundamentals, safety features, considerations, risk and hazard assessment, PPE and comes with demonstrations of actual technicians performing de-energization (LOTO) of a Proterra and New Flyer model bus, and conclude with the third module introducing details involved with BEB charging, including the details of current BEB charging technologies, emerging charging technologies and opportunities, electric vehicle charging standards and common considerations in charging maintenance and charger safety precautions.

It should be noted that while this is a comprehensive course regarding BEBs, this is ultimately a familiarization course and is intended to supplement base knowledge, training and additional learning.

Participants engage in a series of activities and course content supplemented with examples to support participants' successful application to their work.

This course consists of **three** modules. Within each module, there may be several learning application activities, exercises and demonstrations. Before beginning instruction, participants are expected to complete a **Pre-Course Assessment** to assess their knowledge of the subject. Similarly, after instruction of all the modules, participants will complete a **Post-Course Assessment** as well as a course evaluation for the participants as well as the instructor.

This Guide also offers the directions for including hands-on exercises for example activities to run should you have access to and the ability to go out and examine a bus and have the proper equipment and PPE available. These can be gauges for your participants on subjects such as BEB components, PPE, and the de-energization procedures for your agency.

A breakdown of course components with approximate times are:

Pre-Course (0.50 hours)

1. Battery Electric Bus Overview: Fundamentals (~6 hours)
2. Electrical Safety & Personal Protective Equipment (~6 hours)
3. Battery Charging Technologies (~2 hours)

Post-Course (0.75 hours)

Times will vary based on available equipment and pacing of modules.

The breakdown of course topics and time allotment is shown in the following table:

Module	Course Focus	Course Length (hours)
	Pre-Assessment	~ .5 hours
1	**Battery Electric Bus Overview: Fundamentals**	~6 hours
2	**Electrical Safety & Personal Protective Equipment**	~6 hours
3	**Battery Charging Technologies**	~2 hours
	Post-Assessment	~ .75 hours

Course Materials

At least one week before class, the instructor should download, review, and print the materials for instructor and class participants. The following materials are available on BEB Familiarization Course Materials. Check Module notes for details on Learning Applications 2F and 2G

START

Pre-Course

- For Instructor:
  - BEB Familiarization Outline and Objectives by Module
  - BEB Instructor Guide [Full course]
  - BEB INSTRUCTOR Pre-Course Assessment [Full]
  - Daily Sign in sheet
- For Each Participant:
  - BEB Participant Guide [Full Version]
  - BEB Participant Pre-Course Assessment [Full]

1

Module 1: Battery Electric Bus Overview: Fundamentals

- For Instructor:
  - BEB Familiarization Course M1 Slides with IG Notes
- For Each Participant:
  - Copies of Hands-On Exercise 1B – BEB Components for each participant
  - Copies of Hands-On Exercise 1D – HV Awareness for each participant

2

Module 2: Electrical Safety & Personal Protective Equipment

- For Instructor:
  - BEB Familiarization Course M2 Slides with IG Notes
  - Hands-On Exercise 2D 2E – PPE Demo and voltage testing
- For Each Participant:
  - Copies of Participant Instructions for Hands-On Exercises 2D 2E for each participant

Module 3: Battery Charging Technologies

- For Instructor:
  - BEB Familiarization Course M3 Slides with IG Notes
  - Hands-On Exercise 3B – Charger Connect-Disconnect
- For Each Participant:
  - Participant Instructions for Hands-On Exercise 3B

Post-Course

- For Instructor:
  - BEB INSTRUCTOR Post-Course Assessment [Full]
  - BEB Instructor Course Survey
  - BEB Pilot Log Edit (WORD or EXCEL)
- For Each Participant:
  - BEB Participant Post-Course Assessment [Full]
  - BEB Course Participant Evaluation

Course Delivery

Pre-course

Duration: 30 minutes

1. Welcome participants to the course. Facilitate introductions, review agency safety procedures, learning expectations, and other requirements.
2. Each participant should complete a **Pre-Course Assessment**. These will be in the folder under "Assessments".
3. Allow participants up to 30 minutes to complete the written assessment.
4. Call time after 30 minutes. If participants need more time, allow another 5 or 10 minutes.
5. Gather all Pre-Course Assessments. Store these in a binder and wait to score them when you have time during or after the course.
6. Give each participant a copy of the Participant Guide.

Your Notes

Module 1: Battery Electric Bus Overview: Fundamentals

Outcome: This module gives an overview of what a BEB is, what the similarities and differences are between them and traditional bus types, a review of the common components and their functions, a review of risk assessment and high voltage awareness, battery management systems, and an overview look at preventive maintenance for BEBs.

Duration of this Module: 230 minutes

Number of Slides: 93

This Module does not include videos

Learning Objectives

Following the completion of this Module, the participant should be able to complete the objectives with an accuracy of 80% or greater:

1-1 BEBs vs. ICE vs. Hybrid Buses

1) Compare and contrast differences and similarities between BEBs and other current bus types
2) Explain the general advantages and disadvantages of each propulsion type

1-2 Details of BEB Systems and Components

1) Describe the process of power flow on a BEB
2) Identify the components and subsystems that make up a standard BEB
3) Describe the primary function(s) of each subsystem and component in the overall process of BEB operation

1-3 BEB High-Voltage, System Cooling, and Data Communications

1) Identify the areas of high voltage risk associated with each subsystem of a BEB
2) List the BEB subsystems that utilize a coolant loop
3) Explain why various subsystems utilize a coolant loop
4) Describe the communication protocols on a BEB

1-4 Battery Management & Cooling

1) Describe ESS/battery makeup and how to identify them
2) List the battery safety systems and devices
3) Describe the purpose and operation of Battery Thermal Management System [BTMS]

1-5 Maintenance

1) Identify the purpose of preventive maintenance
2) List the typical tasks and maintenance intervals for BEBs
3) Differentiate between maintenance tasks on BEBs vs. traditional buses
4) Identify typical diagnostic equipment and their functions

Order of Instruction

Section	Topic	Slides	Duration (minutes)
1-1	Overview	1-8	15
1-2	BEBs vs. ICE vs. Hybrid Buses	9-17	30
1-3	Details of BEB Systems and Components	18-38	48*
1-4	BEB High-Voltage, System Cooling and Data Communications	39-56	54*
1-5	Battery Management & Cooling	58-77	48
1-6	Preventive Maintenance	78-92	30
1-7	Summary	93	5
	TOTAL *(instruction time may vary with demonstrations included)	93	~230 minutes*

1. Begin instruction using the PowerPoint that accompanies Module 1. Each slide has notes to guide the instructor in the slide comments.
2. Exercises labeled in orange are hands-on exercises that should be conducted at the depot with access to a BEB. However, should access to a BEB not be possible at your agency then have the participants go through the provided exercises as written in the Participant Guide. SECTIONS WITH AN ASTERISK* MAY HAVE DIFFERENT TIME ALLOTMENT DUE TO AT-BUS OR EXERCISES.
    a. **Learning Application 1B** – Use the document "Hands-On Exercise 1B" as a guide for your use. Print out enough copies of this document to allow participants to use and refer back to.
        i. Take participants to an on-site BEB and demonstration the locations, functions and visual for each major component of a BEB.
        ii. A recommended suggestion is to run through the 1-3 Details of BEB Systems and Components section in the Participant Guide, then using the at-bus walkthrough to supplement the content
    b. **Learning Application 1D** – Use the document "Hands-On Exercise 1D" as a guide for your use. Print out enough copies of this document to allow participants to use and refer back to.

i. After reviewing the major BEB components, while still at the bus run through the exercise reviewing the high voltage and risk assessments around the bus. Review with participants the areas and potential risks/hazards present with each.

ii. This can be the time to review preventive maintenance walkthroughs if able to (with time permitting).

Please note: times may vary as learning applications, exercises or content can have flexibility to be discussed and reviewed.

2

Module 2: Electrical Safety & Personal Protective Equipment

Outcome: This module gives an overview of electrical fundamentals and safety precautions relevant to BEB technicians, an introduction to PPE and the NFPA70E standard ratings, common testing and safety equipment used, and it ends with a video demonstration of the de-energization process for two bus manufacturer models.

Duration of this Module: ~245 minutes

Number of Slides: 92

This Module includes videos

Learning Objectives

Following the completion of this Module, the participant should be able to complete the objectives with an accuracy of 80% or greater:

2-1 Safety Considerations

1) Recall the formula for calculating voltage
2) Define high voltage risk and shop safety conditions
3) Recall the SAE standards pertaining to BEBs
4) Identify primary built-in safety features and recall their function

2-2 Personal Protective Equipment [PPE]

1) Identify typical PPE involved with BEB maintenance
2) Recall the primary functions of each PPE introduced
3) Recall the procedures for testing and inspecting HV gloves

2-3 Safety & Testing Equipment

1) Explain the purpose of the appropriate safety and testing equipment
2) Identify when to use the appropriate safety and testing equipment

2-4 De-Energizing or LOTO [Lock-Out/Tag-Out] of BEB Electrical Systems

1) Recall the proper de-energization procedure for an 800-volt Proterra bus
2) Demonstrate the ability to perform a LOTO on an 800-volt Proterra bus (only applicable to in-person training with qualified personnel)
3) Recall the proper de-energization procedure for a New Flyer bus
4) Demonstrate the ability to perform a LOTO on a New Flyer bus (only applicable to in-person training with qualified personnel)

Order of Instruction

Section	Topic	Slides	Duration (minutes)

2-1	Overview	1-6	11
2-2	Safety Considerations	7-60	126
2-3	Personal Protective Equipment [PPE]	61-72	27*
2-4	Safety & Testing Equipment	73-85	20*
2-5	De-energizing or LOTO [Lock-Out/Tag-Out] of BEB Electrical Systems	86-92	55*
2-6	Summary	92	5
	TOTAL *(instruction time may vary with demonstrations included)	92	~245 minutes*

1. Begin instruction using the PowerPoint that accompanies Module 2. Each slide has notes to guide the instructor in the slide comments.
2. Exercises labeled in orange are hands-on exercises that should be conducted at the depot with access to a BEB. However, should access to a BEB not be possible at your agency then have the participants go through the provided exercises as written in the Participant Guide. SECTIONS WITH AN ASTERISK* MAY HAVE DIFFERENT TIME ALLOTMENT DUE TO AT-BUS OR EXERCISES.
    a. Slide 70 is hidden as a supplemental resource if additional glove testing procedure demonstration is needed.
    b. Slide 83 is hidden as an additional learning application if tools or equipment is not available.
    c. **Hands On Exercise 2D and 2E**– Use the document "Hands-On Exercise [2D 2E] -PPE Demo and voltage testing" as a guide for your use. Print out enough copies of this document to allow participants to use and refer back to.
        i. Exercise 2D
            1. With your set(s) of PPE available, display each item and make sure each is visible to participants.
            2. Go through each item, highlighting the use/function and how to properly put on each.
            3. Once you have demonstrated this, go through the inspection process for the PPE that is there.
                a. Once this has been done, have each participant come up and repeat the process you demonstrated.

4. With another set of PPE, have an item with a known defect (preferably HV gloves), ask students to perform the inspection and describe/identify the defect to the full group.

ii. Exercise 2E

1. Have a digital multimeter ready with test leads (as provided in PPE kit)
2. If you have access to a BEB and a qualified individual to perform a reading demonstration, have them demonstrate the multimeter use on a known good voltage source
3. If no BEB is available, secure a low voltage source – a 9-volt battery from the PPE kit – and perform the "verify test verify" sequence using the battery.

d. Learning Application/Hands On Exercise 2F and 2G – Proterra and New Flyer Lock-Out/Tag-Out Demonstrations

i. IF YOUR AGENCY HAS ONE OR BOTH OF THESE MODELS:

1. Move class to the on-site bus vehicle shop/location
2. Have a second qualified agency technician demonstrate the process of LOTO on each available bus
3. Ask and have the participants answer the questions for each respective LOTO bus demonstration from document "LOTO Exercises 2F 2G".

ii. IF YOUR AGENCY DOES NOT HAVE ONE OR BOTH MODELS:

1. Use Learning Applications 2F and 2G in the Participant Guide as a supplement to the course.
2. Proterra LOTO Demo Video: Proterra High Voltage LOTO.mp4 (vimeo.com) Video length: 6:07
3. New Flyer LOTO Demo Video: New Flyer HV LOTO Procedure.mp4 (vimeo.com) Video length: 6:00

Please note: times may vary as learning applications and content may have flexibility to be discussed and reviewed. After reaching the End of Day 1, allow participants to leave and make sure to reiterate the start time for the next day.

3

Module 3: Battery Charging Technologies

Outcome: This module introduces the different charging methods for BEBs, current and emerging technology to improve quality, SAE charging standards, and offers brief precautions for charger safety.

Duration of this Module: ~120 minutes

Number of Slides: 38

This Module does not include videos

Learning Objectives

Following the completion of this Module, the participant should be able to complete the objectives with an accuracy of 80% or greater:

3-1 Overview

3-2 Charging Overview

1) Describe the three primary charging methods for BEBs
2) Calculate an anticipated charge time for each method of charging

3-3 Electric Vehicle Charging Standards

1) Explain the purposes of SAE J1772, SAE J3105 and SAE J2954-2

3-4 Details of Charging Technologies

1) Explain the general process of how a charger and battery communicate
2) Identify the purpose of a switchgear
3) Define smart charging

3-5 Brief Charging Precautions

1) List at least three opportunities for emerging charging technologies
2) Describe safety precautions for charging equipment

3-6 Summary

Order of Instruction

Section	Topic	Slides	Duration (minutes)
3-1	Overview	1-5	10
3-2	Charging Overview	6-12	16
3-3	Electric Vehicle Charging Standards	13-18	13

3-4	Details of Charging Technologies	19-33	~45*
3-5	Brief Charging Precautions	34-37	5
3-6	Summary	38	5
	TOTAL *(instruction time may vary with demonstrations included)	38	~120 minutes*

1. Begin instruction using the PowerPoint that accompanies Module 3. Each slide has notes to guide the instructor in the slide comments
2. Exercises labeled in orange are hands-on exercises that should be conducted at the depot with access to a BEB. However, should access to a BEB not be possible at your agency then have the participants go through the provided exercises as written in the Participant Guide. SECTIONS WITH AN ASTERISK* MAY HAVE DIFFERENT TIME ALLOTMENT DUE TO AT-BUS OR EXERCISES.
    a. **Learning Application 3B** – IF A BUS IS AVAILABLE AT YOUR LOCATION, TAKE PARTICIPANTS ON-SITE AND DEMONSTRATE THE PROCESS OF CONNECT/DISCONNECT WITH A CHARGE PLUG.
    b. **IF A BUS IS NOT ACCESSIBLE** - Use the document "Hands-On Exercise 3B" as a guide for your use. Print out enough copies of this document to allow participants to use and refer back to.
        i. Take the participants back to the on-site bus location.
        ii. Review and demonstrate the procedure of how a charger is plugged into a BEB and the communication sequence is run between the two.
        iii. After reviewing this, ask each participant to demonstrate the process with both the connection and disconnection of the charger.

After students have completed Module 3, allow a break of up to 30 minutes. Once break is over, hand out the Post-Course Assessment in your folder marked "Post-Assessments" and move to the next page in your Instructor Guide.

END

Post-Course

Duration: 45 minutes

1. Thank everyone for participating in the course. Answer or review questions participants may have about content.
2. Ask participants to close and put away all course materials.
3. Give each participant his or her own copy of both the **Post-Course Assessment** and **Course Evaluations.**
4. Allow participants 45 minutes to complete the written assessment.
5. After 45 minutes, call time. If participants need more time, allow another 5 or 10 minutes.
6. Gather all participant Post-Course Assessments and Post-Course Surveys as they are completed. Store these in a binder and wait to score assessments when you have time during or after the course.
7. Complete the Instructor Course Evaluation and the course pilot edit log if this course is taught as a pilot.
8. When you have scored the Pre- and Post-Course assessments, send the following to bliu@transportcenter.org:
    a. Copies of class roster and sign-in sheet which include:
        i. Participant Name
        ii. Position
        iii. Agency
        iv. Date of Class
        v. Email
    b. Copies of all quizzes with scores.
    c. Copies of all Pre-Course assessments with scores.
    d. Copies of all Post-Course assessments with scores.
    e. Copies of completed Participant Course Evaluations.
    f. Copies of completed Instructor Course Evaluations.
    g. Copies of all course pilot edit logs, if applicable.

APPENDIX: Hands-on Learning Activity for Individual Assessment

Vital to this course is to have participants engage in hands-on learning. Below is an example of a hands-on learning activity specific to this course on which you will assess each participant. For additional learning activities, the instructor is encouraged to use the templates that follow these examples.

Topic:	**3B - Charger Connect-Disconnect Demonstration**
Hands on Learning Objective(s):	Explain the general process of how a charger and battery communicate
Courseware Reference:	Pages 96-98

1. **Preparation:** Make sure the bus is properly positioned next to the charging receptacle, that the charge port can be accessed and the charge cable can be plugged in.

Tools, Equipment and Materials Required (including PPEs):

Battery Electric Bus [BEB] and charging depot with charge cable plug

Instructional Method

	Role Play		Role Play		Role Play
	Drills		Drills		Drills

Application Feedback Level

X	Full Class	X	Full Class	X	Full Class

The Instructor will perform the following task lists and then ask participants to perform the tasks.
Task Steps for Connecting a Charger:

1. Locate the charge port of a BEB and open any charge port access panels (if applicable)
2. Remove the charge cable from stowage
3. Insert the charge cable into the charge port or receptacle
4. Monitor the bus-charger interaction

The Instructor will perform the following task lists and then ask participants to perform the tasks.
Task Steps for Disconnecting a Charger:

1. Press the "Stop Charge" or "End Charge" push button on the charger dispenser or bus
2. Wait /Listen for the locking pin to retract
3. Depress the charge cable push button
4. Remove charge cable from the charge port
5. Stow charge cable and close any open access panels (if applicable)

1.

Maximum Time Allowed:	*Up to 2 minutes per person (total time may change)*

Topic:

APPENDIX: Hands-on Demonstration Template

Topic:	
Hands on Learning Objective(s):	
Courseware Reference:	
Preparation:	
Tools, Equipment and Materials Required (including PPEs):	

Instructional Method

☐ Role Play	☐ Demonstration	☐ Critical Incident
☐ Drills	☐ Simulations	☐ Case Study

Application Feedback Level

☐ Full Class	☐ Small Group	☐ Individual

The Instructor will perform the following task lists and then ask participants to perform the tasks. Task Steps:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Maximum Time Allowed:	

Other Notes:

Hands-On Assessment Form Template

Participant Name			
Date of Assessment			
Topic:			
Hands on Learning Objective(s):			
Courseware Reference:			
Task Steps		**S**	**U**
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
Comments:			