

Human Error Prevention within BGE's System Protection & Control

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Introduction

- Dan Tobin, supervisor Relay & Control, Baltimore Gas & Electric
- Purpose of today's presentation:
 - Provide an overview of how BGE's Relay and Control Isolation Procedure and Human Error Prevention Tool Kit were developed
 - Share some challenges and lessons learned from our procedure and tool kit implementation
 - Share the physical tools in the kit and their use

BGE is . . .

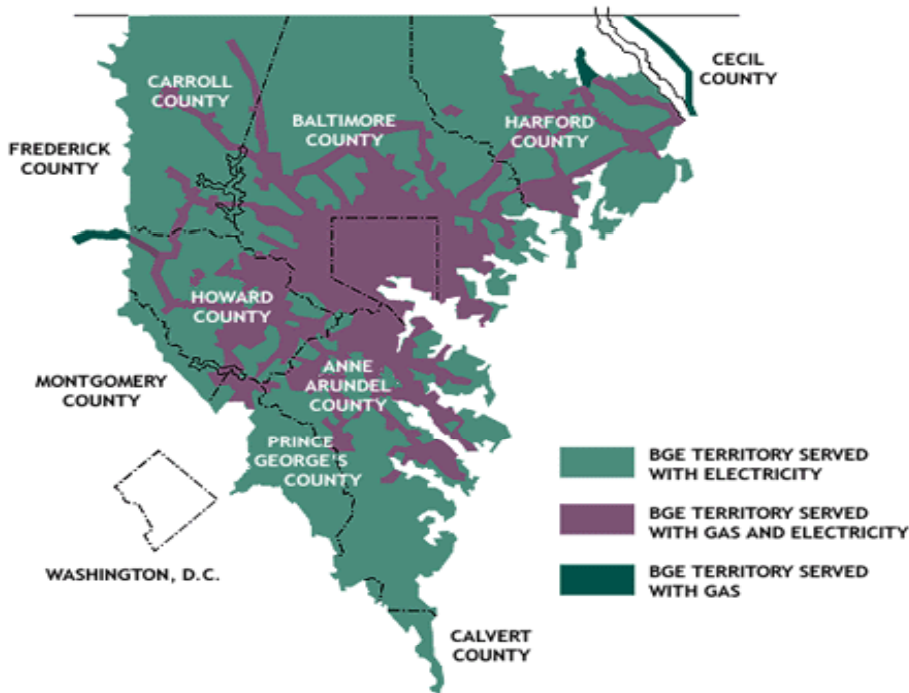
The country's oldest gas utility (1816)



Proud to be Exelon's newest utility (2012)

BGE at a Glance

- **BGE was America's first gas utility**
- **We are an electric transmission and distribution company with a 2,300 square mile service territory serving over 1.2 million electric customers and 650,000 gas customers**
- **We operate and maintain:**
 - 9,400 miles of overhead and 15,600 miles of underground feeders, 244 substations, and 215,000 distribution transformers
 - Over 1,250 miles of electric transmission lines (99 miles underground)
 - Over 6,900 miles of gas main and associated equipment, 164 miles of gas transmission, 9 gate stations, and 3 peak shaving plants
- **We are impacted by numerous stakeholders at the Federal, State, and local levels**
- **We have 3,400 employees**



Background

- In May of 2011, after more than 1 year working error free, System Protection & Automation experienced consecutive human errors in a one week span.
 - Lipins Corner
 - May 14, 2011 – Technician failed to place a control switch in the correct configuration after identifying that it was in the wrong position.
 - Customer Substation
 - May 17, 2011 – Replacing a relay cover, the relay technician inadvertently actuates a relay causing a momentary outage to the customer
 - Monument Street
 - May 18, 2011 – While performing switching, a technician transferred the incorrect feeder to its tie breaker.
 - Perryman
 - May 19, 2011 – While testing stuck breaker, a technician closed the wrong test switch interrupting the 110kV service to generating station.
 - Bestgate
 - May 19, 2011 – Technician opened the incorrect test switch, inadvertently operating a 13 kV feeder
- These errors raised the level of awareness of a need for a robust Human Performance Program for Relay and Control
- Additional awareness was raised through the review of NERC Lessons Learned on events relating to system protection and control

Background

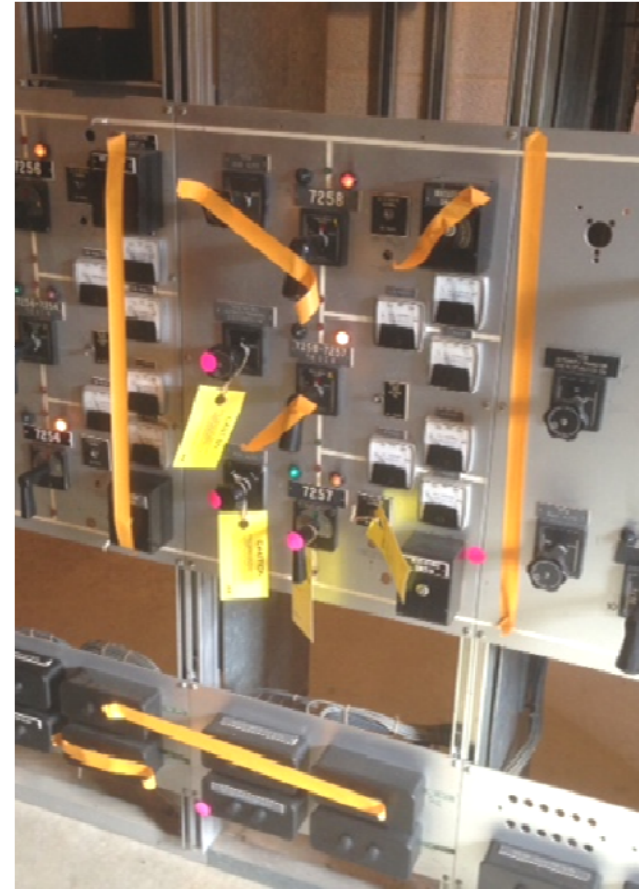
- When performing maintenance and testing on protective relaying, there are a few very important things you want to do correctly. They are:
 - isolate protection,
 - Be sure you are working on the correct equipment at all times
 - Be sure you DO NOT get on the wrong equipment,
 - Be sure that you return your relay isolation to its normal configuration so that the equipment is protected under normal conditions.
- As a result, BGE formed a team to design and develop a Relay Isolation Procedure

Relay Isolation Procedure - Development

- The procedure development team included relay technicians, human performance experts, engineering support, and Relay and Control leadership.
 - Focused on isolation process as the potential for the biggest benefit
- The procedure development took 4 full-day workout sessions to complete. During the sessions participants:
 - Walked through scenarios to see which technique worked best using the simulator
 - Identified best practices for use of error prevention tools: barriers, flagging, and crew expectations for verification
 - Conducted several dry-runs of the new procedure by technicians on relay simulator panels
- In October of 2011, the “Relay Isolation Procedure SPCWP 4700 for Relay and Control Equipment” was finalized.
 - Training on the procedure was delivered to all technicians and contractors
 - Utilized a simulator
 - Focused on application of barriers, flags, and verification
 - Evaluated technicians on their understanding of and ability to apply the work procedure

Relay Isolation Procedure - Challenges

- Challenges to achieving consensus:
 - Workshop participants would do the same task differently. The team needed to reach agreement on the best approach
 - Some techniques were already being used within the organization. The team needed to explain benefit of a standardize procedure associated with consistent use of the techniques
 - Incorporating new terminology for those techniques and use of industry standard human performance tools and concepts into our day-to-day communications. Employees needed to change the way they referred to items/techniques



Human Error Prevention Tool Kit

- In November of 2011, additional awareness was raised through the NERC Industry Advisory on “Reducing Human Performance Errors by the Use of Configuration Control Practices”

- In December of 2011, BGE began effort to develop a formal physical Human Error Prevention Tool Kit to be used within System Protection & Control. Objectives for the Tool Kit included:
 - Meet NERC Industry Advisory regarding Configuration Control Practices
 - Align to ComEd, PECO and Calvert Cliffs best practices
 - Align to industry best practices
 - Incorporate existing BGE best practices
 - Improve BGE’s Human Performance Error Rate
 - Support technicians in successful application of the Relay Isolation Procedure to successfully perform event free work
 - Support technicians to develop assessment skills to identify error traps and risks before performing a task

Human Error Prevention Tool Kit - Development

- The Tool Kit development was led by a first-line Relay and Control Supervisor.
 - The development team included experienced relay technicians, BGE procedural development subject matter experts and a human performance subject matter expert
- Team leadership held a 3-full day workout session to finalize the tools, procedures and error prevention kit
 - Created a new System Protection & Control Work Procedure SPCWP#4710
 - Revised the existing Relay Isolation Procedure SPCWP#4700

Human Error Prevention Tool Kit - Development

- The team ordered kit items from various vendors and developed printed and training materials, including job performance measures
- In August 2012, all R&C technicians, instructors and contractors were trained on procedural use of the kit
- On September 1st 2012, all technicians and contractors were equipped with a toolkit and it was put into full use for all relay and control work applications



Impact

HU Events	5	Implemented Isolation Procedure	1	1	1	Implemented EFWZ Kit	1	1	1
Types of Errors	May-2011	Oct-12	Jan-2012	Apr-2012	May-2012	Aug-2012	Dec-12	Jan-13	Feb-13
Technical Error	1		1				1	1	
WP Violation				.5	1				1
Flagging/Barriers/Teamwork	4			.5					

- We are seeing less human errors resulting from poor teamwork (crew engagement and focus as a team), failing to isolate, or working on the wrong equipment.
- Data excludes human errors by contractors.
- Supporting our transition to a learning culture, during the same time-frame error tracking has become more stringent and we more events fall into criteria for reporting than have in the past.

Human Error Prevention Tool Kit – Lessons Learned

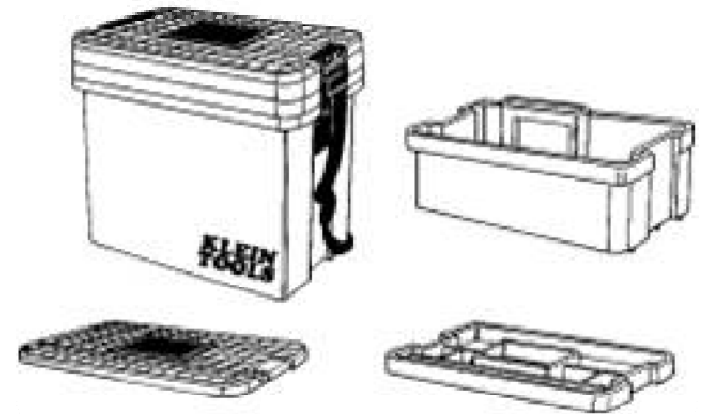
- Communicating the end goal ending the 3-day session with a finished product was extremely helpful in setting expectations
- Approached the project both top down and bottom up
 - Having relay technicians on the development team created built-in buy-in
 - Senior and mid-level leadership backed the effort 100%. Leadership challenged the team to put in place relay specific error prevention program that would help employees work event-free
- Team had a clear understanding of the objectives for the tool kit
 - NERC Lessons Learned and NERC Advisories were used as one of the guiding principals behind the initiative
- Common understanding among leadership and employees that we will continually improve, it will never be a “final” product

Human Error Prevention Tool Kit – Key Take-Away

- What the kit and procedures should do and prevent when used accordingly:
 - Designed to isolate protection with a thorough review as possible.
 - Requires all crew members to participate in job scope and pre-relay isolation discussion and performance of isolation.
 - Flagging to guide tech's to specific equipment to be manipulated throughout testing process.
 - Barriers to prevent technicians from manipulating equipment that should not be disturbed during testing.
 - Ensures all equipment was returned to service as it was found.

- What the kit does not take the place of:
 - It does not take the place of technical proficiency and experience
 - Technicians have to be capable of identifying where flagging and barriers shall be accurately placed.

ERROR PREVENTION WORK ZONE KIT



Inventory Sheet

Human Error Prevention Tool Kit



Inventory Sheet

- 2" Orange Electrical tape (3 rolls)
- 3/4" Orange Electrical Tape (3 rolls)
- Terminal Point Barriers (6 single, 6 double)
- Current Isolators (12-Orange)
- Work Sign Barrier (orange w/logo)(1 of each design-18"x48")
- Orange Masking Tape (4 each-1" rolls)
- Individual Numbered Isolation Cards (40)
- Pink Dots (2 boxes of 1000)
- Relay Test Flag (pink) (50 round)
- Magnetic Caution Sign (pink) (1)
- Wire Identification Clip (yellow) (25 each size)
- Push Button Fused Jumper (1)
- Wire Caps (yellow) (25 each size)
- Extreme Standing Pad (1)
- Safety Tape (yellow) (1 rolls)
- Velcro Straps (white 18") (8)
- Tool Box (1)
- Isolation List /Alteration Log
- Regular jumpers (yellow) (6 sets)
- Binder rings (4)
- Error Prevention LANYARD cards (1 each of Phonetic and Error Traps/Tools)
- Bags for Wire Caps (1 each)
- Logo Labels for Tool Box (1)
- Procedures #4700 and #4710 Laminated (1 each)

Barriers

Error Prevention Work Zone Kit (SPCWP4710) - Barriers

Electric Tape “Orange”



Required Use:

- Required use as an insulating barrier for Low Voltage electrical connections and test provisions.

Each Work Zone Kit will contain:

- 3 rolls each - 3/4" and 2" “Orange”

Error Prevention Work Zone Kit (SPCWP4710) - Barriers

Masking Tape “ORANGE”



Required Use:

- Required use as a barrier to identify panels and equipment that shall not be accessed during maintenance or testing activity. Not to be used as an electrical barrier.

Each Work Zone Kit will contain:

- 4 – 1” Rolls “ORANGE”

Error Prevention Work Zone Kit (SPCWP4710) - Barriers

Terminal Point Barriers “Orange”



Required Use:

- Required as a barrier for low voltage electrical connections on terminal blocks.

Each Work Zone Kit will contain:

- 6 single “Orange”
- 6 double “Orange”

Error Prevention Work Zone Kit (SPCWP4710) - Barriers

Current Isolators “ORANGE”



Required Use:

- Required use as a barrier from current transformers at test provisions.

Each Work Zone Kit will contain:

- 12 - “ORANGE”

Error Prevention Work Zone Kit (SPCWP4710) - Barriers

Work Zone Sign Barrier "ORANGE"



Recommended Use:

- Recommended use as a barrier for large areas such as panels.

Each Work Zone Kit will contain:

- 2 - 18"x48" "ORANGE" signs with plastic grommets
- Use Velcro straps to hang

Flagging

Error Prevention Work Zone Kit (SPCWP4710) - Flagging

“PINK” Dots (2 Boxes of 1000)



Required Use:

- Required use as a means to identify panels that may be accessed during maintenance or testing activities located outside of the work zone. The Pink Dots may be used in conjunction with or separate from Relay Test Card.

Each Work Zone Kit will contain:

- 2 boxes of 1000 “PINK”

Error Prevention Work Zone Kit (SPCWP4710) - Flagging

Relay Test Card with “PINK DOT” Required Use:



- Required use as a means to identify panels that may be accessed during maintenance or testing activities located outside of the work zone. The Relay Test Card may be used in conjunction with or separate from Pink Dots.

Each Work Zone Kit will contain:

- 50 – “ROUND” cards “PINK”

Error Prevention Work Zone Kit (SPCWP4710) - Flagging

Magnetic Caution Sign “PINK”



Recommended Use:

- Use as a means to identify outdoor equipment that may be accessed during maintenance or testing activities located outside of the work zone.

Each Work Zone Kit will contain:

- 1 – sign “PINK”

Specialty Tools

Error Prevention Work Zone Kit (SPCWP4710) – Specialty Tool

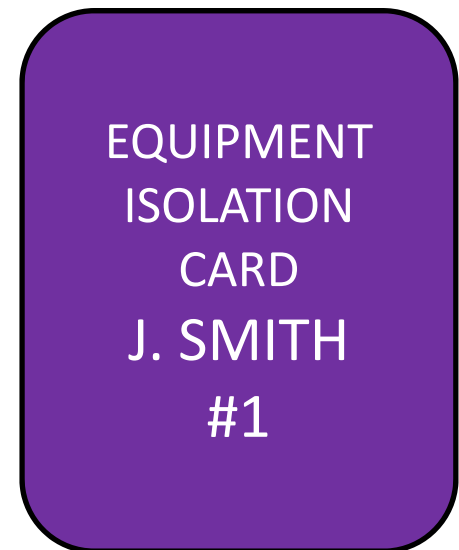
Individual Numbered Isolation Cards

Required Use:

- a. Required use as a means to identify abnormal test provisions during maintenance or testing activities only. Note that a caution tag may be placed on test provisions used to isolate failed equipment or used to isolate equipment for other organizations.
- b. Each Card used shall be recorded on the Equipment / Maintenance Alteration Log (See SPCWP4700).
- c. All cards shall be accounted for at the end of the job as recorded on the Equipment / Maintenance Alteration Log (See SPCWP4700).

Each Work Zone Kit will contain:

- 40 each



Error Prevention Work Zone Kit (SPCWP4710) – “Specialty Tool”

Push Button Fused Jumper

Required Use:

- Required use as a means to connect 2 test points when actuating a device during maintenance or testing activities.
- Required Actions
 - Identify the test points necessary to actuate the device on the print.
 - Connect the Push Button Fused Jumper to the test points.
 - Use peer verification to assure that the Push Button Fused Jumper is connected to the correct test points as shown on the print to actuate the device.
 - Depress the Push Button Fused Jumper and monitor expected results.
 - Remove Push Button Fused Jumper.

Each Work Zone Kit
will contain:

- 1 – “YELLOW”



Error Prevention Work Zone Kit (SPCWP4710) – “Specialty Tool”

Wire Identification Clip



Recommended Use:

- Use as a means to identify wires that will be lifted or tested during maintenance or testing activities.
- All clips shall be accounted for at the end of the job.

Each Work Zone Kit will contain:

- 25 – Clips “**YELLOW**”

Error Prevention Work Zone Kit (SPCWP4710) - “Specialty Tool”

Wire Caps “YELLOW”



Required Use:

- Required use as a temporary insulator to identify ring terminal connectors and wires that have been listed during testing activities.

Each Work Zone Kit will contain:

- 25 each size - .25, .281, .375
“YELLOW”

Error Prevention Work Zone Kit (SPCWP4710) - “Specialty Tool”

Jumpers “YELLOW”



Required Use:

- Required use as a means to connect 2 test points that do not actuate a device during maintenance or testing activities.
- All Yellow Jumpers shall be accounted for at the end of the job.

Each Work Zone Kit will contain:

- 6 sets “YELLOW”

Error Prevention Work Zone Kit (SPCWP4710) - “Specialty Tool”

Yellow Safety Tape



Recommended Use:

- Recommended use as a barrier to prevent other individuals from entering a critical work zone.

Each Work Zone Kit will contain:

- 2 rolls

Error Prevention Work Zone Kit (SPCWP4710) – “Specialty Tool”

Extreme Standing Pad



Recommended Use:

- Recommended use as a means to identify panels that may be accessed during maintenance or testing activities.

Each Work Zone Kit will contain:

- 1 – Pad

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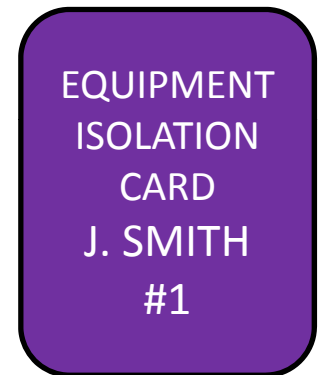
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Design Considerations

- ***From NERC Industry Advisory November 8, 2011 - Reducing Human Performance Errors by the Use of Configuration Control Practices***
 - “**Isolation Card** - A laminated plastic card placed by technicians on the physical equipment at points of isolation during maintenance or testing activities. Each technician has a personalized set of numbered isolation cards. Individual cards are placed on the physical equipment at points of isolation (e.g. test switch, control switch, or control panel) and often in a one-to-one association with entries on the MAL. After the technician has completed the work, and all items on the MAL have been restored to normal, the full set of isolation cards should have been collected. If cards are missing, the technician works to resolve the discrepancy before releasing his clearance on the equipment. By employing practices that include proper use of a MAL and Isolation Cards, entities can reduce the risk of the human performance incidents such as in Examples 1 and 3.”
- **BGE Response**
 - BGE Relay and Control technicians are required to identify and then verify each isolating test provision before isolating. After each isolation, the technician now also applies a numbered isolation card to the isolation point. The number associated with the isolation card is then recorded on the maintenance alteration log.



Design Considerations

- ***From NERC Industry Advisory November 8, 2011 - Reducing Human Performance Errors by the Use of Configuration Control Practices***
 - “**Barriers** - Colored electrical tape or rubber blankets are examples of soft barriers used to cover or protect exposed, energized components to prevent undesired electrical connections during maintenance. A device used to deter the operation of a control switch during a maintenance activity is an example of a rigid barrier. Soft barriers, such as safety tape, can be used as a visual barrier and placed across the openings of in-service equipment panels during maintenance to help prevent personnel from inadvertently entering these panels during a maintenance activity. Use of visual barriers could have been used to help prevent the technician from inadvertently entering an in-service relay panel as in Example 4.”
- **BGE Response**
 - BGE has defined the term “Barrier” as a device used to identify and deter the operation of equipment or prevent personnel from entering in-service panels during maintenance activities. Also used to cover or protect exposed energized components. **To help employees easily recognize barriers, barriers have been assigned a color code of orange.**



Design Considerations

- ***From NERC Industry Advisory November 8, 2011 - Reducing Human Performance Errors by the Use of Configuration Control Practices***
 - “**Flagging** – Signage, safety tape, or any device used to attract the attention of personnel. Flagging can be used to identify equipment that is within the technician’s zone of protection or to identify equipment that is outside the zone of protection. Flagging could have been used to help attract the attention of the technician prior to his entering the wrong relay panel, as in Example 4.”
- **BGE Response**
 - As part of their workzone kit, BGE has included several flagging tools. Flags are required as a means to identify panels that may be accessed during maintenance or testing activities located outside of the work zone. **For Flags, pink has been selected as the color code for flagging tools.**



Design Considerations

- ***From NERC Industry Advisory November 8, 2011 - Reducing Human Performance Errors by the Use of Configuration Control Practices***
 - “**Peer Review/Peer Check** - The peer check is an independent review, by qualified personnel, to validate the technicians’ equipment isolation list. The peer check should be provided by someone other than the technician performing the work or by members of a team that peer check each other’s work. Peer review may be effectively used in conjunction with other practices, such as when relay settings have been modified in the field for testing or installation purposes by downloading or documenting the setting left on the relay and having an independent reviewer compare the setting with the office record.”
- **BGE Response**
 - As per BGE’s work procedure #4700, all technicians are required to be assigned roles of participation and or peer check all relay isolation processes prior to the task. Technicians are required to deploy Human Performance Work Zone kit tools such as flagging tools and the maintenance alteration log to perform place-keeping practices. BGE has defined “place-keeping” as a method to identify only the intended relays or equipment to be operated and to keep track of the progress of the job.

Design Considerations

- ***From NERC Industry Advisory November 8, 2011 - Reducing Human Performance Errors by the Use of Configuration Control Practices***
 - “**Self Check** – Self checking is the process of pausing to review one’s own actions prior to executing error-likely tasks. It is a four-step mental process to prevent errors, particularly on critical tasks or an irreversible procedure or step. Using the acronym STAR: Stop and take the time to eliminate external distractions, focus on the task at hand with 100% undivided and focused attention. Think, verify that no critical conditions have changed, consider the impact of your immediate action and question anything that you are have uneasy feelings about or are uncertain. Act, without losing physical or visual contact with the device, remain poised and attentive to your actions. Lastly, Review, verify that you got only the specific results that you expected and wanted. By implementing self-checking skills, the technician could have avoided opening the incorrect test switch in Example 5.”
- **BGE Response**
 - “Self Check” is an existing BGE Human Performance Tool engrained in BGE culture with expectation to be used for all tasks. “STAR”

Design Considerations

- ***From NERC Industry Advisory November 8, 2011 - Reducing Human Performance Errors by the Use of Configuration Control Practices***
 - ***“Place-keeping*** – A physical marker, either temporary or permanent, that helps one keep his/her place when reviewing sequential lines or columns. Using a straight edge or consistent marking methods, one can mark sequential progress when executing long and detailed procedures. These methods are essential when interruptions or delays prevent fluid movement through a process. Consistent procedures in place-keeping allow smooth transitions and handoffs for events that involve multiple persons to interact on the same or related procedures. Detailed place-keeping also provides a historical record for procedures that occur over extended time periods.”
- **BGE Response**
 - Technicians are required to deploy Human Performance Work Zone kit tools such as flagging tools and the maintenance alteration log to perform place-keeping practices. BGE has defined place-keeping as a method to identify only the intended relays or equipment to be operated and to keep track of the progress of the job. BGE has defined thorough documentation of “as found” and “as left” data.

Job Performance Measure (Training)



Job Performance Measure Plan 1040 (Long Form)

Initial Requalification JPM

SECTION A: GENERAL

ADMIN INFORMATION

Technician's Name: _____ E#: _____ Date: _____

Instructor's Name: _____ E#: _____

PRIMARY DESCRIPTION OF JOB OR TASK

Crew will demonstrate safely isolating protective equipment using robust barriers, flagging and specialty tools.

Technician must follow all work practices and procedures.

PRECAUTIONS AND LIMITATIONS

If unexpected conditions are encountered during the isolation process, crew shall immediately stop, review the conditions and contact immediate leader if necessary.

TOOLS OR EQUIPMENT NEEDED (if any)

1. Standard PPE – Safety Glasses, Hard Hat, and sturdy work shoes
2. Hazard Level 2 FR
3. Masking and colored tape
4. Drawings
5. Relay and control maintenance alteration log
6. Human Error Prevention Tool KIT

ESTIMATED TIME-OF-PERFORMANCE

- 20 minutes walk down the job and pre-job brief
- 10 minutes to perform isolation
- 10 minutes to apply barriers and flagging
- 10 minutes using specialty tools

Mode of Demonstration: (Perform (P) Demonstrate (D) Simulate (S) Verbal/Visual Description (V,V)

Reference(s)

1. SPCWP 4700 & 4710
2. Human Error Prevention Tool Kit

SECTION B: PERFORMANCE MEASURES

Step #	PERFORMANCE STEP(S)	Tech	Instructor	Date
	<i>Crew will demonstrate safely isolating protective equipment using robust barriers, flagging and Specialty tools</i>			
1	Event-Free check used during pre-job safety brief			
2	Crew discussed scope of the work being performed			
3	Crew used a one-line to review permit and tagging requirements			
4	Crew walked down job and discussed energy source controls			
5	Crew discussed work zones and how to avoid inadvertent operations			
6	Proper roles for entire crew were identified			
7	Isolation performed using error prevention tools strictly with crew members in their proper roles			
8	Equipment Isolation / alteration log filled out			
9	Barriers and flagging placed and verified by all crew members			
10	Specialty tools used to perform identification task			
11	Specialty tools used to perform control task			
12	All equipment returned back to normal and verified by all crew members.			
13	Everything in Equipment Isolation / alteration log up to date/normal.			

