EFCOG Best Practice #240
Electrical Utility Risk Assessment

Facility: DOE Complex

Best Practice Title: Electrical Utility Risk Assessment

Point of Contact:

Don Lehman	INL	(208) 821-5947	Don.Lehman@inl.gov
Scot Winningham	ORNL	(865) 574-6190	Winninghamrs@ornl.gov
Melkie Tega	DOE-PPPL	(609) 243-3707	Melkie.Tega@science.doe.gov

Brief Description of Best Practice: This best practice is developed to define and evaluate risk for working with medium and high voltage activities in the DOE complex.

Why the best practice was used: Electrical Utility tasks involve high hazard activities where the risk is often undefined. This best practice is developed to assess the risk of high hazard activities to assist DOE contractors in implementing controls to reduce risk. These controls follow the hierarchy of control method defined in ISM and NFPA 70E. Additionally, human performance indicators and tools are utilized to address the human element of risk.

What are the benefits of the best practice: Using this best practice will allow DOE contractors to evaluate their high hazard tasks in order to reduce risk to an acceptable level. This best practice provides a common, systematic approach for all DOE contractors to evaluate their Electrical Utility Operations. Making use of this systematic approach will enable each site to implement adequate work control to assure the proper rigor, staffing, and work method controls are in place and implemented for appropriate high-risk activities.

What problems/issues were associated with the best practice: NFPA 70E requires electrical activities to go through a risk assessment process; however, Electrical Utility Operations are exempted from those requirements. Electrical Utility Operations are among the highest hazard activities performed on DOE sites. This is developed to evaluate the risk of EUO high hazard task and provide methods for implementing risk control.

How the success of the Best Practice was measured: This best practice was developed using several experienced EUO personnel from multiple DOE sites.

EFCOG Best Practice #240
Electrical Utility Risk Assessment

Description of process experience using the Best Practice: The known operating experience to date is limited to a few sites associated with the development of this product who have successfully employed some or all of the components of this Best Practice at their respective sites.

Scope and Applicability

The best practice applies to Electrical Utility Operations (EUO) at United States Department of Energy (DOE) sites. The risk assessment herein covers the scope of high hazard electrical work not covered by NFPA 70E *Electrical Safety in the Workplace*.

Note: The information provided is intended to be modified by each facility to meet their applicable mission, roles, staffing, and tasks.

Roles and Responsibilities:

Line Manager	• Review high risk work to determine if appropriate hierarchy of controls are implemented. • Review and approve energized electrical work requiring a permit.
Foreman/Supervisor	• Participate in the pre-job and/or package walkdown. • Provide oversight as needed for the assigned task.
Engineer/Planner	• Participate in the pre-job and/or package walkdown. • Prepare the work package. • Involve appropriate Subject Matter Experts (SMEs) as appropriate. • Utilize the Risk Assessment Matrix detailed in this best practice. • Provide field technical expertise, as needed. • Provide interface with Engineering and Design personnel to ensure that risks and safety hazards encountered in the field are considered.
Additional Worker	• Participate in the pre-job and/or package walkdown • Trained and prepared for emergency rescue. • Satisfies the 2-person rule. • Implement Human Performance Indicators (HPI) principles to reduce the severity of consequences of human error.
Crew Chief / Lead Worker	• Participate in the pre-job and/or package walkdown • Trained and prepared for emergency rescue. • Satisfies the 2-person rule. • Implement HPI principles to reduce the severity of consequences of human error. • Serves as the Employee in Charge.
Safety	• Participate in work package planning and walkdowns. • Assists with recognition and control of hazards. • Provide technical guidance in the work planning process.

EFCOG Best Practice #240
Electrical Utility Risk Assessment

Performing a Risk Assessment for High Hazard Electrical Utility Operation Tasks:

Identify the Scope and Hazards

1. Identify the scope of work that will be assessed for risks.
2. Perform a planning walk-down and/or table-top to identify hazards (shock, arc flash, environmental, chemical exposure, work from heights, etc.) associated with the task(s). Involve appropriate SMEs, as needed.
3. Identify possible situations that could develop into accidents during work task, considering serious/high impact, but credible, scenarios.

Categorization

1. Using Table 1, organize scenarios into one of the following three categories, according to what would be impacted by an accident: More than one may apply.
    - People
    - Equipment – including critical system operational function
    - Environment

Assign Consequences and Severity

1. Review the Consequence and Severity Definition of Scale.
2. Select the most appropriate severity using:
    - Site documented events
    - DOE documented events
    - Electrical Utility industry documented events.
3. Document the severity for the selected scenario.

Estimate Likelihood

1. Select the most appropriate likelihood using:
    - Site documented events
    - DOE documented events
    - Electrical Utility industry documented events.
2. Document the likelihood for the selected scenario.

EFCOG Best Practice #240
Electrical Utility Risk Assessment

Utilize the Risk Assessment Matrix and Implementing Controls

1. Calculate risk. Risk = Severity × Likelihood.

   Example: Environmental Release that has previously occurred at the facility

   Severity (4) × Likelihood (3) = Total Risk (12)
2. Record the risk score current work practice controls.
3. If evaluated risk is unacceptable, utilize the hierarchy of risk control method to implement additional controls to reduce risk. Examples of hierarchy of risk control methods are below:

   - **Elimination**
     - Conductors and/or circuit parts de-energized, have a visible open, and are equipotentially grounded
   - **Substitution**
     - Remote device operation
     - Reduce energy to below hazardous energy thresholds
   - **Engineering**
     - Adjusting relay protection
     - Arc flash reduction maintenance switch

____Controls below this should have redundancy in implementation –

Consider utilizing HPI tools/concepts___

   - **Awareness**
     - Signs, barricades, barriers
     - Labels
     - Attendant/Spotter
   - **Administrative**
     - 3-part communication for switching
     - Training
     - Procedures
   - **Personal Protective Equipment (PPE)**
     - Shock and arc flash PPE

EFCOG Best Practice #240
Electrical Utility Risk Assessment

Table 1: Risk Assessment Matrix

Severity	Consequence			Probability – Increasing Likelihood				
				1	2	3	4	5
	People	**Equipment**	**Environment**	Event never heard of in the industry	Event heard of in the industry	Event has occurred in similar company	Event happens several times per year	Event occurs several times per year in a specific location
1	No health effects or injury	No damage	No effect	1	2	3	4	5
2	Slight health effect of injury (first aid)	Minor damage	Minor effect	2	4	6	8	10
3	Minor health effect of injury (outpatient)	Localized damage	Contained effects	3	6	9	12	15
4	Major injury requiring surgery, hospitalization or extensive treatments	Major damage	Uncontained effects	4	8	12	16	20
5	Fatalities	Extensive damage	Extensive Geographic effects	5	10	15	20	25
Low 1 - 6			Medium 7 - 12			High 13 - 25		

Note: Each site should establish the site-specific thresholds for consequence and severity.

Human Performance

1. Utilize site HPI program to provide an avenue for worker and work evolution success.
2. See NFPA 70E (2018) and DOE HPI Handbook Vol. 1 and 2.

Oversight Matrix

1. Implement Oversight Matrix per determined level of risk.

EFCOG Best Practice #240
Electrical Utility Risk Assessment

Table 2: Oversight Matrix

Level of Risk	Additional Worker	Crew Chief / Lead Worker	Foreman / Supervisor	Safety	Engineer / Planner	Line Manager
LOW	*	*	A, B	*	*	*
MEDIUM	A, C	A, C	A, B, C	A, *	A	*
HIGH	A, C	A, C	A, D	A, C	A, C	*

A: Involved in pre-job and/or package walk down
B: Periodic/random job involvement or oversight
C: On the job for the Risk element of the task
D: Full task oversight

** May be required per site requirements*
*** Additional worker to be a qualified worker for the equipment, task, and/or potential rescue.*

References

29 CFR 1910.269
DOE HPI Handbook Volumes I & II
NFPA 70E (2018) Standard for Electrical Safety in the Workplace
IEEE ANSI C2 (2017) National Electrical Safety Code

EFCOG Best Practice #240
Electrical Utility Risk Assessment

Appendix A: Examples of Task Based Risk Assessment

Table A1: Example Task Based Risk Assessment

		Shock Exposure	Shock Analysis				Arc Flash Analysis			Risk Matrix			Risk	Oversight Matrix					
	Task	Exposed and Energized >50V	Shock Hazard <150Vac	Shock Hazard 151 - 750Vac	Shock Hazard 751 - 15kV	Shock Hazard >15kV	Arc Flash Hazard <1.2 cal/cm2	Arc Flash Hazard 1.2 to 12 cal/cm2	Arc Flash Hazard >12 cal/cm2	Severity	Likelihood	Risk Score	Risk Level	Additional Worker	Crew Chief / Lead Worker	Foreman / Supervisor	Safety	Engineer / Planner	Line Manager
1	Transformer Visual Inspection (not crossin MAD)	No						7.6		2	1	2	LOW	*	*	A, B	*	*	*
2	Applying Grounds (15kV system)	Yes			15000			4.8		3	4	12	MEDIUM	A, C	A, C	A, B, C	A, *	A	*
3	Manually racking breaker	Yes			13800				23.1	4	4	16	HIGH	A, C	A, C	A, D	A, C	A, C	*

A	Involved in pre-job and/or package walk down
B	Periodic/random job involvement or oversight
C	On the job for the Risk element of the task
D	Full task oversight
*May be required per site requirement	
**Additional worker should be a qualfied worker for the equipment and task	

Example 1:

Task: Perform visual inspections on an outdoor 15kV transformer (checking for oil leaks, oil level, cracking in concrete, welds, etc.). This is normally performed monthly by one person.

Hazards:

- Arc Flash (calculated) = 7.6 cal/cm^2
- Bees, wasps, snakes, animal feces
- Slips, trips, and falls
- Overhead energized 15kV line
- Heat/Cool stress

Likelihood of Occurrence = 1
Severity of Occurrence = 2
Calculated Risk = 2 (Low)
Additional Controls: None Required

EFCOG Best Practice #240
Electrical Utility Risk Assessment

Example 2:

Task: Establishing an equipotential ground for replacement of pole mounted 15kV transformer.

Hazards:
- Shock Hazard = 15kV
- Arc Flash (calculated) = 4.8 cal/cm^2
- Bees, wasps, snakes
- Slips, trips, and falls
- Other energized circuits in the area.
- Working from heights, hoisting and rigging
- Potential re-energization and/or induction
- High winds, other weather events

Likelihood of Occurrence = 4
Severity of Occurrence = 3
Calculated Risk = 12 (Medium)

Additional Controls:
- Fall Protection
- Electrical shock and arc flash PPE
- Live-line tools and Minimum Approach Distance (MAD)
- Switching orders

Example 3:

Task: Manually racking in and out 13.8 kV distribution breaker XYZ for scheduled maintenance.

Hazards:
- Shock Hazard = 13.8 kV
- Arc Flash (calculated) = 23.1 cal/cm^2
- Slips, trips, and falls
- Heavy loads (>100 lbs)
- Other energized cubicles in the area (look-alike equipment).
- Limited workspace, ergonomics, egress
- Pinch points
- Other maintenance work in the area
- Other voltages available in the cubicle (control voltages)

Likelihood of Occurrence = 4
Severity of Occurrence = 4
Calculated Risk = 16 (High)
Additional Controls:
- Arc Flash PPE
- Breaker lift cart
- Safety toe shoes
- Switching orders
- Signage and labels