EFCOG - Electrical Safety Improvement Project (ESIP) - Area 4 - Reporting Criteria/Performance Measurement

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Task 4 Objectives

- Establish a standardized approach for evaluating electrical energy events across the DOE complex.
- Develop a consistent method for determining the severity of an electrical event.
- Provide a tool to assist in the determination and classification of ORPS Group 2 Significance Category for electrical events.
- Provide a tool to monitor performance over time.

Task 4 Status

- Tool was piloted at select sites (LANL, SRS, INL, NTS, Hanford, and PNNL)
- Pilot completed August, 2006
- EFCOG ESIP to Recommend to DOE that tool is ready for complex-wide deployment
- DOE to make determination on complex-wide deployment

Electrical Incident/Accident Critiques and Reports

- What is “hazardous” electrical energy?
  - some is harmless
  - some hurts
  - some cripples
  - some can kill
- Describing electrical energy
  - voltage, current, power, energy, waveform
- Sources
  - power, equipment, dc, capacitors, batteries, rf
- What is “unexpected discovery”?
  - I never expected to find it?
  - I suspected it could be there?
  - I didn’t know for sure where it might be?
  - engineering controls failed?
- How to I take into account that I used methods to protect me, in case I encountered electricity?

Some Important Questions

- Can we prevent all shocks? NO!
  - human error
  - equipment failure
  - everyday use of electricity
- Are some shocks harmless? YES!

Problems with Reporting

- Lack of understanding of
  - the level of hazard
  - the potential for injury
  - the standards for protection
- has led to some events being
  - over reported,
  - under reported, or
  - not reported at all
- Our process for critiques and reports may not lead us to the right lessons learned and corrective actions

Goals

- We need better tools for assessing and reporting electrical accidents and incidents
- We need a consistent process for evaluating electrical incidents across the DOE complex
- We need tools to help gather the relevant electrical information during a critique

EFCOG/DOE Electrical Safety Improvement Project Task Group 4

- Develop tool(s) to be used to evaluate electrical incident severity
- Utilize quantitative methods based on national codes and standards
- Deploy complex-wide assuring consistent application

Components of Method

- The proposed solution is a two part package:
  - Electrical Severity Ranking Tool
  - Electrical Severity Index Tool

Electrical Severity Ranking Tool

- Used by an electrical Subject Matter Expert (SME) will require the gathering of the necessary electrical data
- Quantifies the electrical hazard based on national codes and standards
- Quantifies exposure to the hazard based on national codes and standards
- Quantifies injury based on short term and long term effects

Electrical Severity Index Tool

- Normalizes incidents at a site to the number of work hours performed

Purpose of the Proposed Tools

- The proposed tools are NOT intended to:
  - assess the worker's qualification
  - assess work control in place
  - assess human behavior

- The proposed tools DO
  - force the gathering of the necessary technical information
  - provide a quantitative severity ranking based on codes
  - account for some protective measures
  - provide a method of trending based on site size

Electrical Event Severity Ranking Methods

- **Electrical Severity = (Electrical Hazard Factor) * (1 + Environment + Shock Proximity + Arc Flash Proximity + Thermal Proximity) * (Injury Factor)**

- **ESI= $\frac{200{,}000[(ES_1) + (ES_2) + (ES_n)\ldots.]}{\text{(hours worked)}}$**

A Little Recent History

- The development of these proposed tools is recent.
- Driven by a need to better understand, critique, and report on incident investigation and reporting.
- Driven by the disparate nature of reporting within a single site, and from site to site.

Problems with Current System

- ORPS Process seems to result in:
  - Inconsistent reporting
  - Incomplete details when dealing with Electrical
  - Improper categorization
  - Lack of SME agreement on level of hazard
  - In addition, use of the ORPS reporting matrix varies significantly depending on the occurrence investigator, the SME(s), the DOE/NNSA facility representatives, or the managers present at the critique

A New Severity Ranking Tool

Severity Significance =
(Potential for Injury) *
(Did you cross boundaries? were you protected?) *
(Were you injured?)

The first two factors are based on national codes and standards:
(1) electrical hazard classification
(2) allowed approach boundaries and proper PPE

The tool MUST be used by an SME who understands:
- electricity
- national codes and standards for electrical work

The Potential for Injury

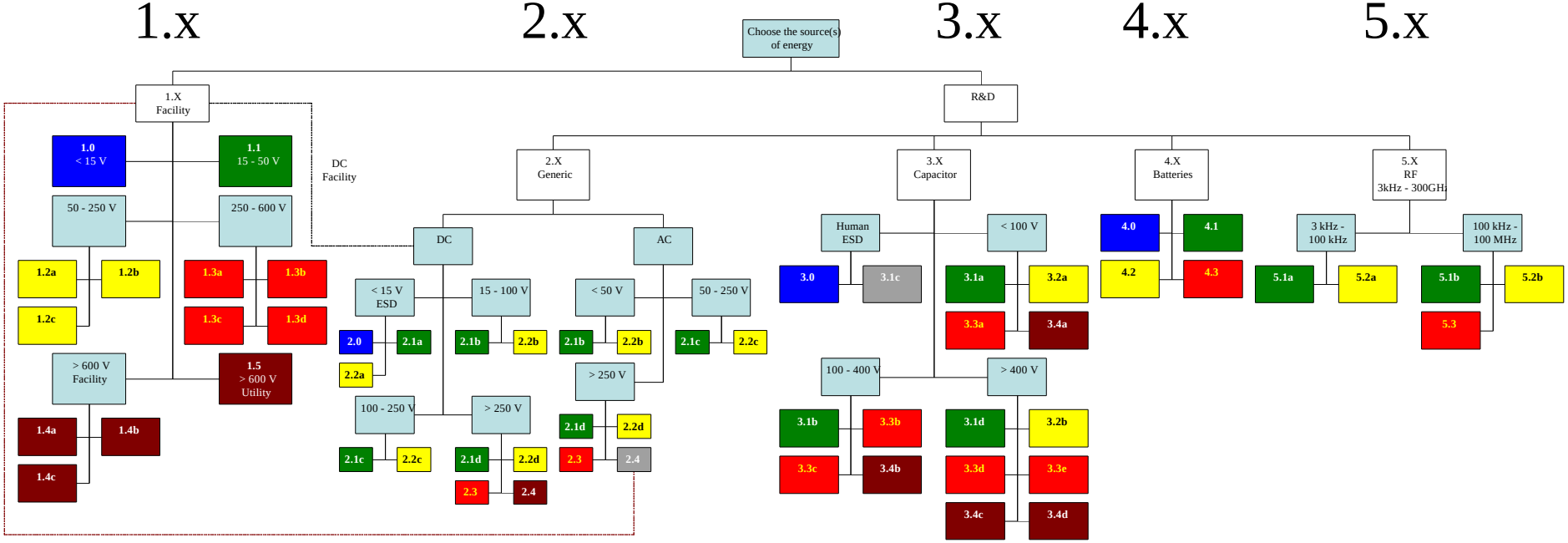
- **Electrical Hazard Factor**

blue-no hazard	0
green-low hazard	1
yellow-moderate hazard	10
orange-high hazard	50
red-very high hazard	100

The Electrical Hazard Factor is determined by the Electrical Hazard Classification Tables.

Electrical Hazard Classification Organizational Table

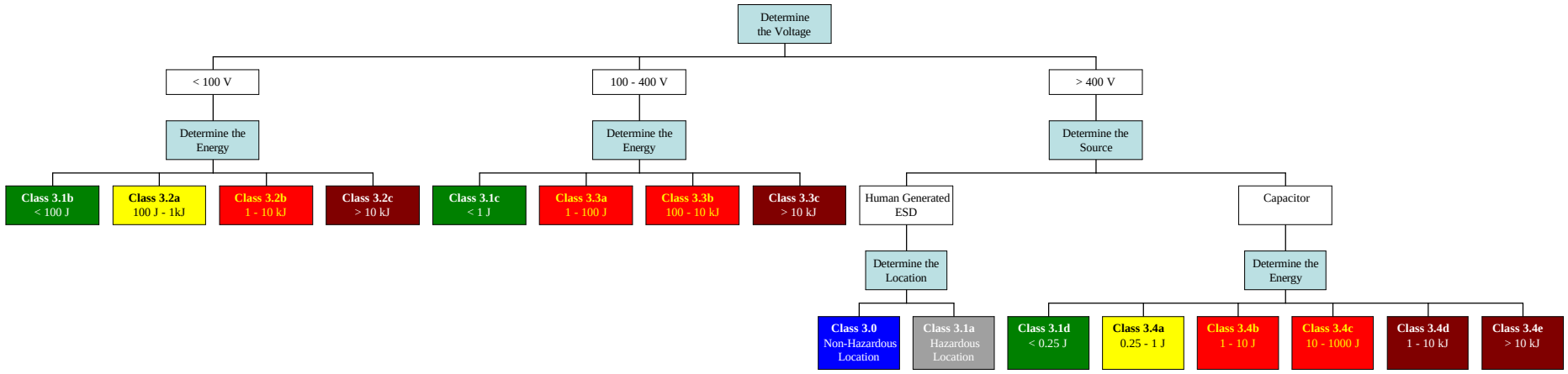
1.x 2.x 3.x 4.x 5.x



AC DC capacitor batteries RF

hazards - covers ALL electrical hazards

Classification Table 3.X: Capacitors



hazards - electrocution, high current, blast, magnetic force

Event Conditions

Environment

Dry	0
Damp	5
Wet	10

The Environment Factor is determined by the condition most commonly found in the area of the event. (Dry is indoors unless otherwise noted, Damp is outdoors, Wet is assumed when water could be or was involved.)

Event Conditions

Shock Proximity

Outside Limited Approach Boundary	0
Within Limited Approach Boundary	1
Within Restricted Approach Boundary	3
Within Prohibited Approach Boundary	10

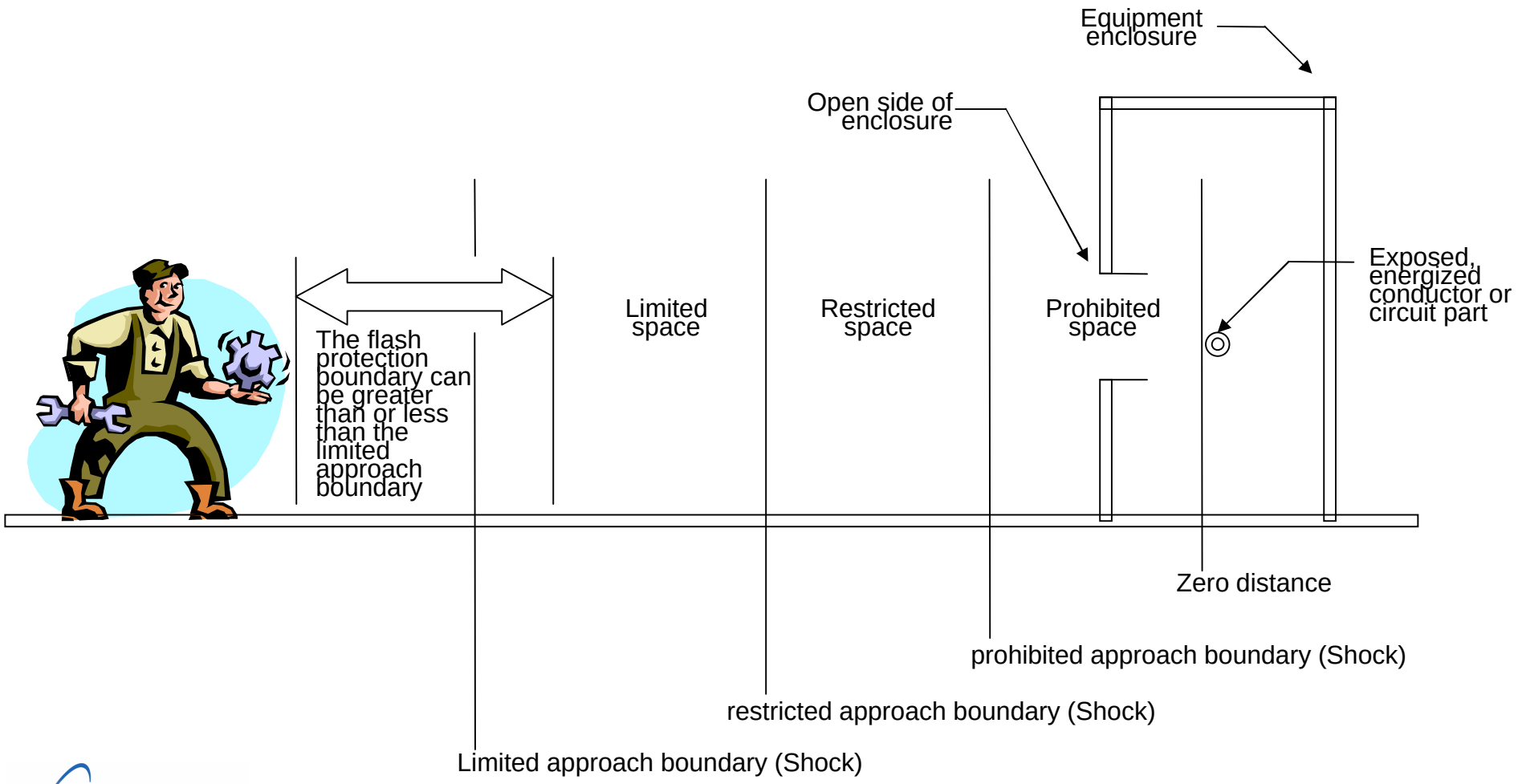
As determined by the approach boundary in Table 130.2(C) of NFPA 70E.

Arc Flash Proximity

Outside Arc Flash Boundary	0
Inside Arc Flash Boundary	10

The Arc Flash Proximity Factor is determined by a Flash Hazard Analysis found in NFPA 70E 130.3(A) (>250V).

Boundaries for Electric Hazards



Event Conditions

- **Thermal Proximity**

	Power	
	1-30kW	*>30kW*
No contact	0	0
Contact	3	10

The Thermal Proximity Factor is determined by the amount of human contact with the conductive media and the power available to the contacting media (below 50V).

- **PPE**

correct for Environmental	reduces the environmental factor to	0
correct for Shock Proximity	reduces the Shock Proximity factor to	0
correct for Arc Flash Proximity	reduces the Arc Flash Proximity to	0

Reduces the factor with the use of the correct PPE for the electrical hazard.

Injury Sustained

- **Injury Factor**

none	1
shock (no fibril), burn (1st degree)	3
arc flash/blast (2nd degree)	5
effects on heart	10
permanent disability	20
fatality	100

The injury factor is determined by the worker(s) injury.

Severity Score

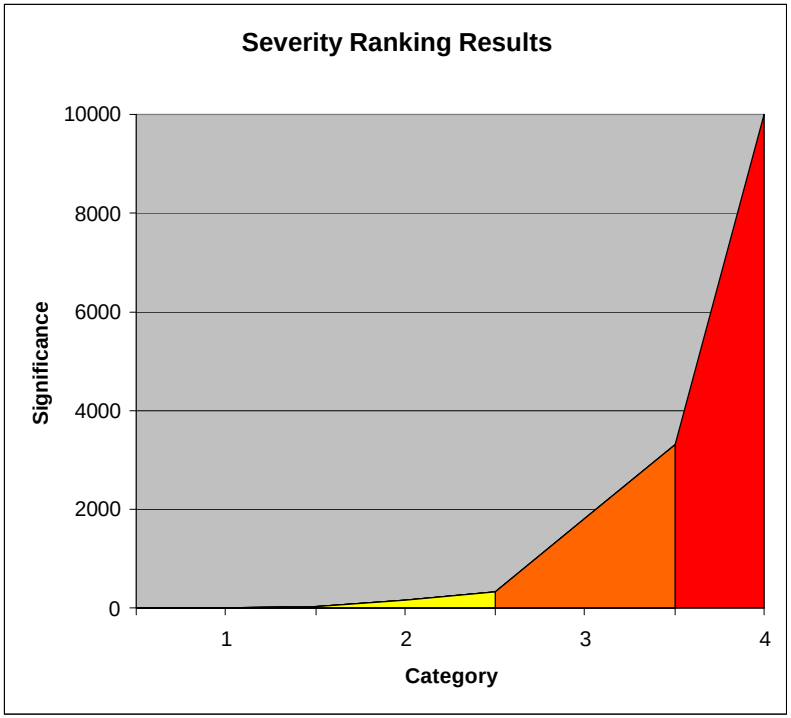
- **Severity Significance**

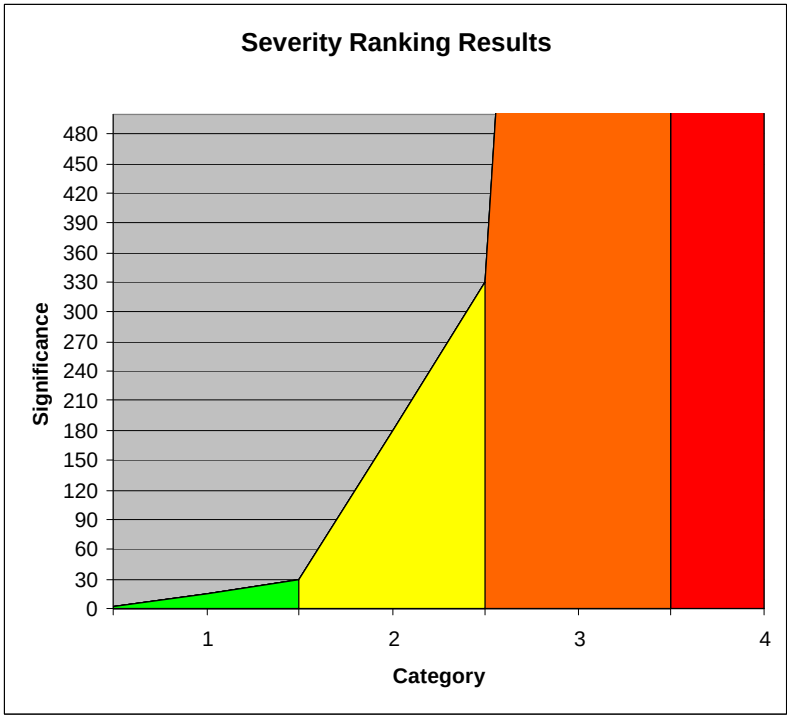
	Severity index	possible ORPS score
Extreme	• 3300	1/2
High	330 - 3300	3
Medium	30 - 330	4
Low	0 - 30	non reportable*

The severity index is used to group the events by severity. We propose that this tool be used as the basis for assigning a severity index to all electrical events in the future. This tool should be used by electrical SMEs to provide for objectively determining the level of hazard present during an electrical event.

*Requires evaluation under ORPS Group 10 criteria (management concern)

Severity Range of Values





Tool Performance

- The tools lead to improved application of the ORPS categorization process in electrical events
- The tool promoted an SME to be at all electrical critiques
- Severity Ranking Tool helps to consistently ask the right questions during a critique
- More accurate failure points determined and bin data
- Uses consensus Electrical Hazard Classification
- Uses national codes and standards for quantification
- Severity # helps to determine what events were severe and where resources should focus, may also indicate precursor to a potential fatality

Event Successes

- Four out of 34 events were previously under categorized:
  - 480 V arc flash +1
  - 480 V near miss +1
  - complex work with capacitors +1
  - 4000 V shock to student +1
- One event out of 34 was significantly over categorized - 2
  - backhoe severs 120 V line
- 18 events out of 34 were somewhat over emphasized - 1
  - some were not even electrical events
  - most were penetration/excavation events with controls in place
  - some were LOTO procedural errors

Pilot Conclusions

- Input from the six pilot sites were important for "tweaking" the tool, and adding application notes. Examples include:
  - How to account for equipment failure
  - Can outdoors be dry? (NTS)
  - How to define an electric shock
  - How to deal with everyday, simple, dry hand 120 V shocks
  - Increase weighting value for "yellow" tables

What If's

- During the testing of the tool, a type of misuse was observed.
- What if:
  - someone walked over and stuck their hand inside of the open equipment
  - someone had tried to insert a plug with both hands, and wet
  - The carpet shock ignited flammable vapors
- "What Ifs" can drive reporting to unreasonable and impractical levels.

Tool quantifies and identifies a "near miss"

- The Hazard Classification and environment identify how serious an accident "could have been"
- The Proximity Factors identify a measure of Probability, or "was it a close call?"
- Beyond that, speculation on "what ifs" move into low probabilities and become very subjective. It is best to not apply What ifs.

Future Use of the Tool

- EFCOG is establishing an “Electrical Advisory Board” composed of 15 - 25 subject matter experts. This body will help to assure consistent application of the tool, and answer questions on unusual cases.
- The proposed Center of Excellence for Electrical Safety will gather data from across the complex

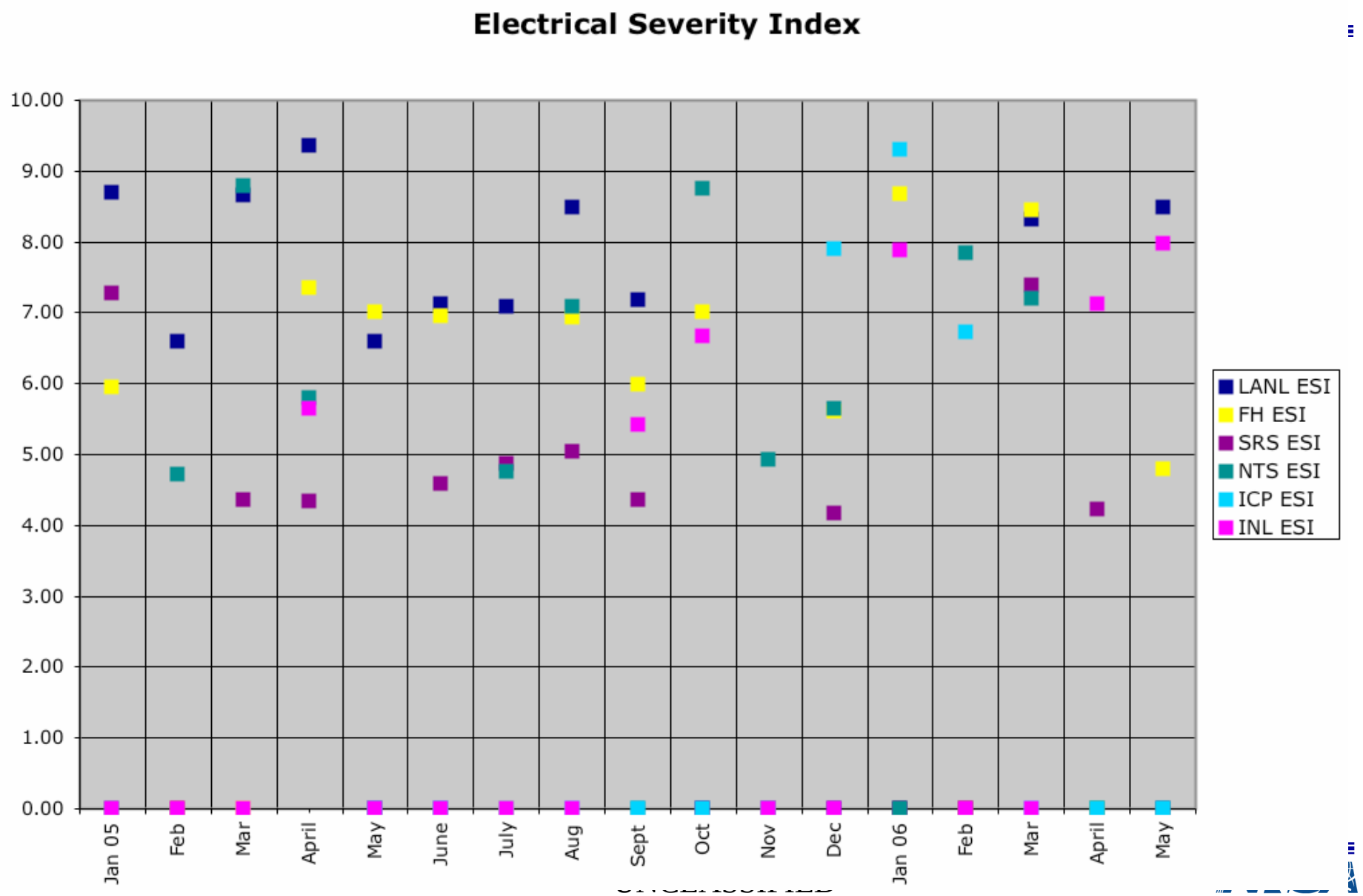
Examples

DATE	**Description of Event**	Hazard Factor	Environ't Factor	Shock Proximity	Arc Proximity	Thermal Proximity	PPE (YES or NO)	Injury	Electrical Severity	ORPS Category
1/11/2009	UPS batteries	10	0	0	0	3	NO	1	40	4
1/28/2009	Rectifier cabinet capacitor hazard	100	0	10	0	0	NO	1	1100	3
3/1/2009	120V Penetration	10	5	0	0	0	YES	1	60	4
3/4/2009	280V light switch	50	0	10	0	0	NO	3	1650	3
3/17/2009	120V Penetration	10	0	1	0	0	NO	1	20	0
4/5/2009	220V wet shock level detector	10	10	10	0	0	NO	3	630	3
4/19/2009	MCC arc flash	50	0	0	10	0	NO	5	2750	3
5/11/2009	110V student shock furnace	10	0	10	0	0	NO	3	330	4
6/30/2009	5Kv P Student shock	10	0	10	0	0	NO	3	330	4
8/7/2009	Roofing sub-contractor severs de-energized 480v conductor while removing roofing material.	50	5	10	10	0	NO	1	1300	3
8/18/2009	Defective Connector on UPS Causes a Short Circuit.	10	0	0	0	0	NO	1	10	0
9/29/2009	Trenching operation damages live 480V circuit.	50	10	0	0	0	YES	1	550	3
3/30/2010	Electric shock with no injury from contacting live wires inside control chassis.	10	0	10	0	0	NO	3	330	4
5/4/2010	Contract Worker hits 480V Circuit with Jackhammer.	50	10	10	10	0	NO	1	1550	3
10/12/2008	480 V arc flash at SLAC	50	0	0	10	0	NO	20	11000	1
1/17/2000	13.2 kV penetration at LANL	100	5	10	10	0	NO	100	260000	1
5/17/2010	Contract Worker hits 120V Circuit with Jackhammer.	10	10	0	0	0	YES	1	110	4

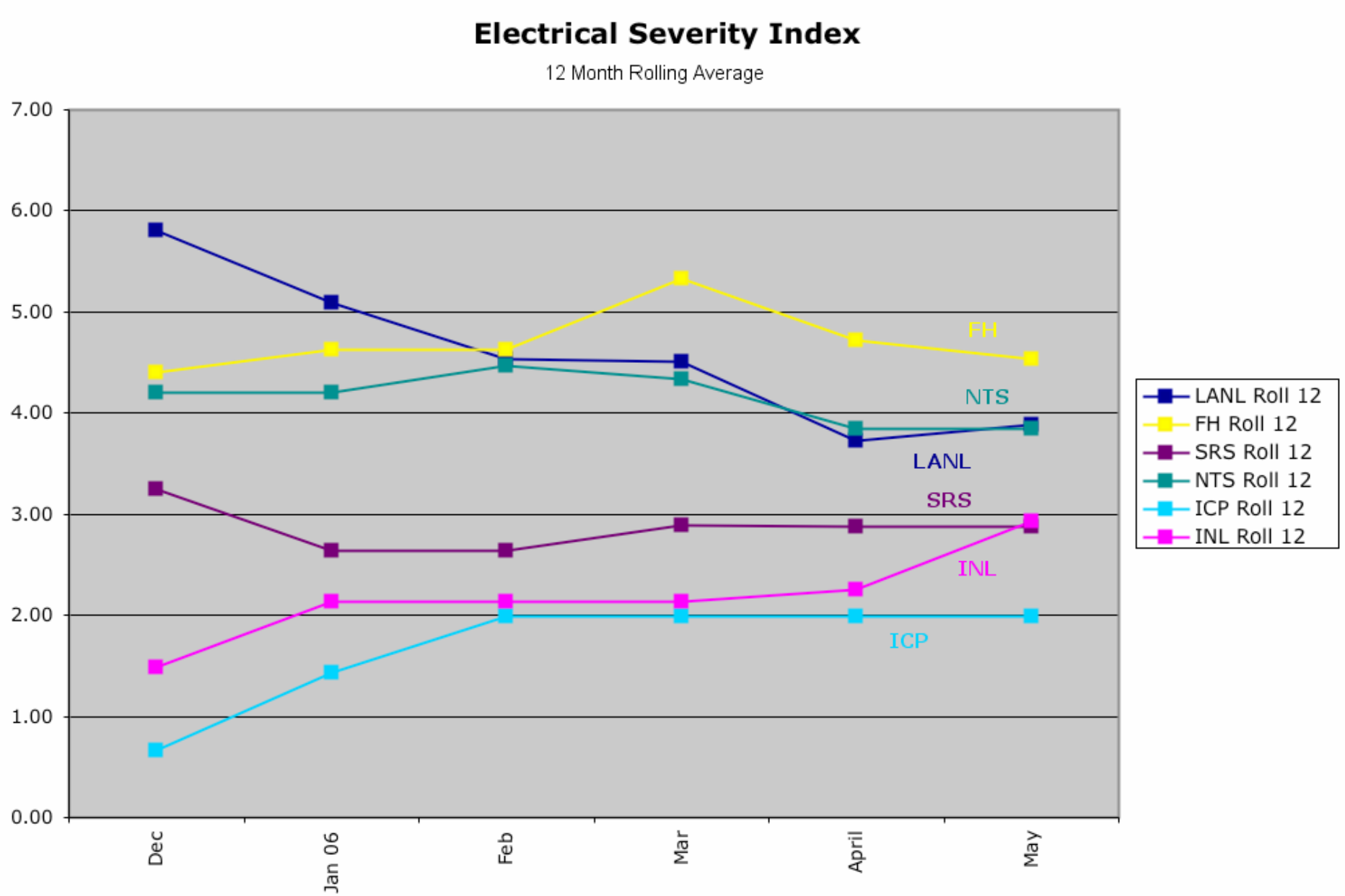
Using the data

- The most important benefit from using the Reporting Criteria tools is the actual process itself, leading to:
  - involvement of the electrical SME
  - asking the right questions
  - having information sufficient to prevent similar events
  - addressing code compliance
  - taking into account exposure and injury
- This leads to program improvement by understanding each event.
- There are many ways to display the data, a couple of examples follow:

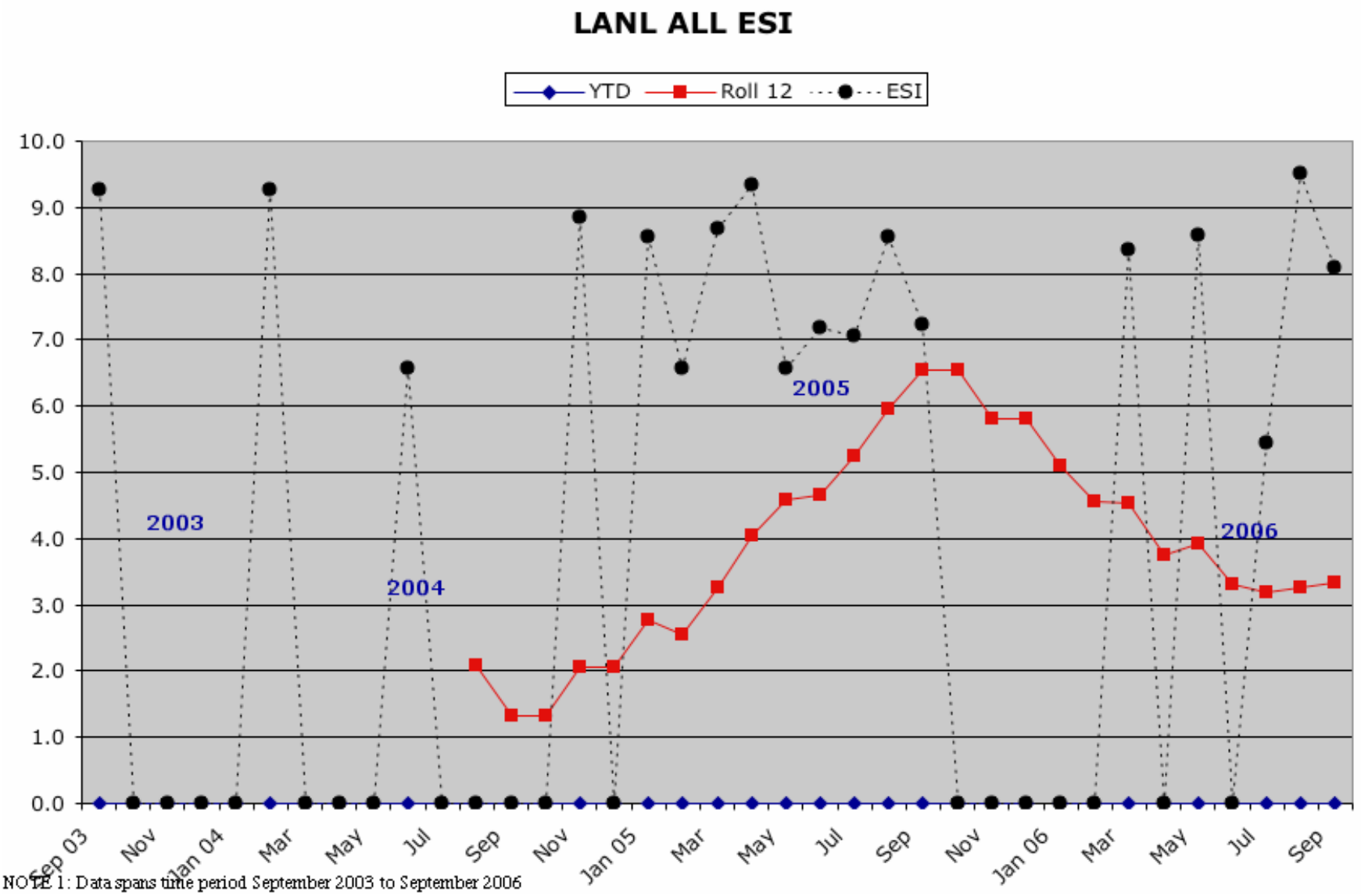
Monthly Value for Six Sites over 17 months



Rolling Twelve Average for Six Sites Over 6 months

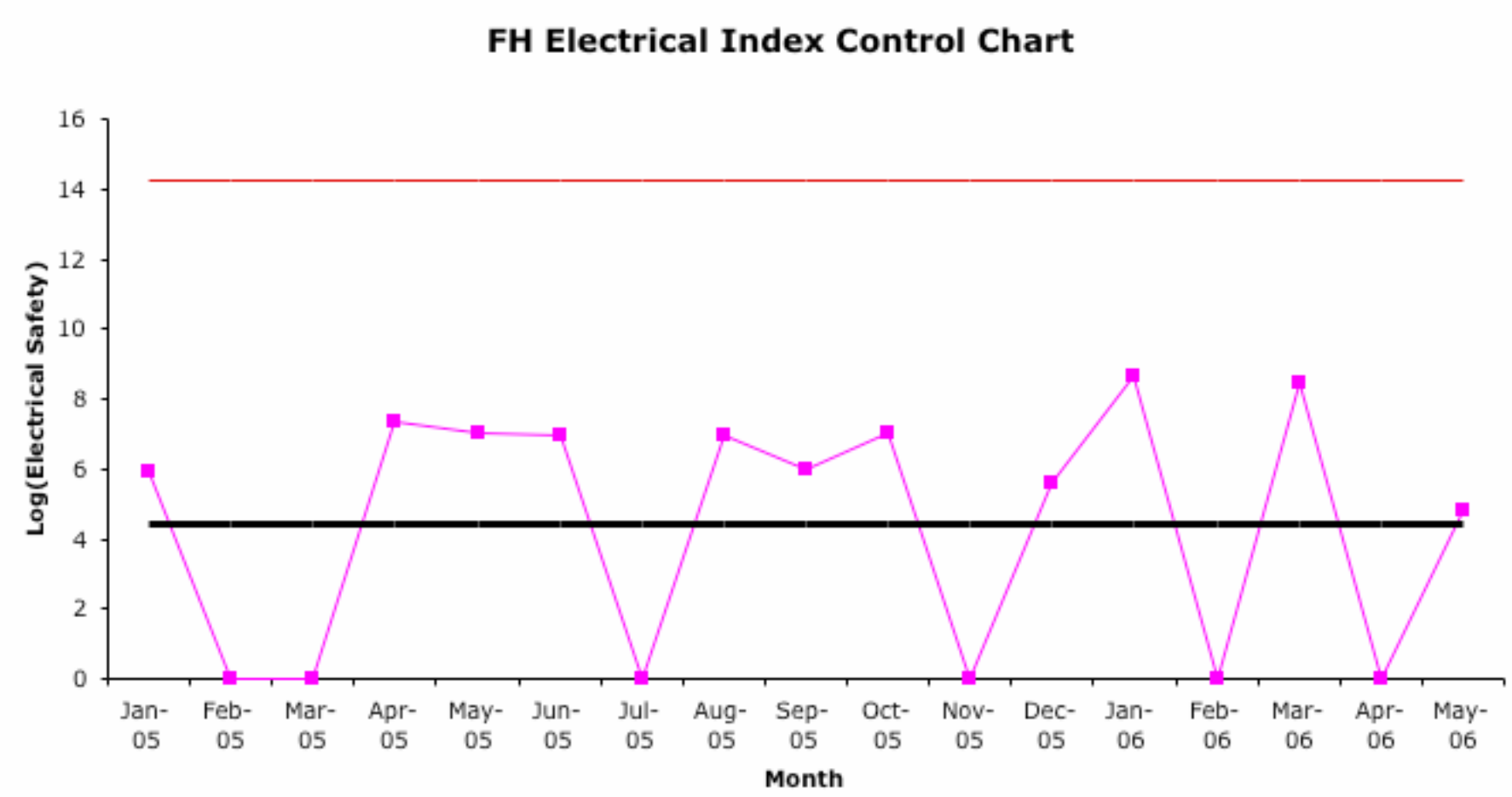


Monthly value and Rolling 12 Average for LANL over 3 Years



NOTE 1: Data spans time period September 2003 to September 2006

FH Electrical Index Control Chart



Recommendations

- Tool be used by the DOE Contractors to:
  - assist in categorizing electrical energy events in accordance with DOE mandated occurrence reporting (e.g. ORPS)
  - determine the severity of an electrical event
  - measure electrical safety performance over time