# User Specifications for Operational and Switching Procedures, a Working Group Report

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*Abstract:*

In general, power software lacks lockout/tagout procedures and transfer/switching procedures - both critical shortcomings. In 2008 this Working Group was created to develop methodology for software programs addressing operational procedures, switching procedures including lockout/tagout, and transfer procedures. The "User Guideline Specification" provides this methodology. Software itself will be developed by software vendors.

Related was a goal to present a clear, simple, mathematical and graphical language to promote rigorous analysis and virtual verification of the applicable software; a unified suite for an operational, mathematical and graphical language. Referenced papers provide a sound basis for work toward achieving this goal, a task which the WG commends to future authors and Working Groups.

Although it is outside the defined scope, the WG notes that these basic concepts apply to other energy systems. The WG encourages interested parties to develop similar approaches for other energy systems.

*Key Words:*
*Lockout/tagout; operating conditions; power system application software; safe work practices; switching procedures.*

*Introduction:*

The many software programs in use for power systems provide a powerful set of tools for analyses such as load flow, short circuit, voltage regulation, arc flash, and others. Typically these programs share a common data base with interacting programs. The troubling omission has been a program to address requirements encompassed by switching programs, particularly lockout/tagout (LOTO) programs for safety and transfer/switching procedures for system integrity and service continuity. Fundamentally, two obstacles inhibited development of switching software; one was lack of a comprehensive mathematical basis or set of algorithms by which such a program could be created, the second was absence of a practical way to incorporate mechanical and non-electrical devices.

For more than a decade a series of papers developing the theoretical foundation have been presented at IAS/ICPS meetings; a simple software program was presented to demonstrate the practicality of developing comprehensive programs; and this Working Group was created in 2008 to derive a way to provide the missing software. This WG report provides guideline specifications for obtaining the desired software.

Software as specified will be a tool to assist the User's Engineer in making decisions regarding operational procedures, including lockout/tagout procedures for safety and switching/transfer procedures involving system integrity and service continuity. The Engineer is reminded that this software will complement other procedures, but will not eliminate the need for practices such as identifying (visually) and marking all cables and switches on a one-line diagram (to identify any sneak path of power), marking all temporary grounding cables on the one-line and labeling the cables, (to collect and visually verify that all grounding cables are removed before a switch is operated to power a system), and verifying system safety by visually checking before any switching is done.

The User is responsible for all decisions regarding application and use of this software; the User's Engineer is in the best position to know what is required.

This "User Guideline Specification" is a generic outline for editing by the User. Sections in *italics* are information for the User's Specifying Engineer, not part of the specifications for the Software Vendor. The intent is to help the User describe clearly and completely the software requirements for the User's application, or in essence, to focus on the User's needs rather than on a Vendor's preferences. It does not, however, require a Vendor to conform to a particular set of specific features and/or interfaces; Vendors can propose features provided by their own software product that best suit the specifications.

This report completes the assigned task.

# USER GUIDELINE SPECIFICATION FOR OPERATIONAL AND SWITCHING PROCEDURES

### General

The purpose of this document is to obtain a software program that is fully integrated with User's existing software programs, such that it will assist the User in developing and documenting operational and switching procedures.

*Include only applicable sections. Portions of these specifications offer choices in square [ ] brackets. Select an appropriate option in each case; delete options that are not essential. Edit the final document to eliminate any conflicts between sections and to ensure that it is complete, accurate, and understandable.*

Validity of data provided in this specification is shown for the respective items.

*Define the validity of each part of the data provided in the specification, such as drawings, equipment data, software programs, calculations, etc. Consider using data tabulation that includes a validity statement with each part of the tabulation. Consider using one of the following statements for each section:*

[Information is accurate and complete as provided]*; or*

[Information is basically accurate and complete as provided but will require field verification in the following areas]*, then list the areas; or*
*Insert appropriate statement.*

### References

The following publications form a part of this specification.

*Select the applicable references.*

1. IEEE Standards:
    1.1. P3007.1: Recommended Practice for the Operation and Management of Industrial and Commercial Power Systems
    1.2. P3007.2: Recommended Practice for the Maintenance of Industrial and Commercial Power Systems
    1.3. P3007.3: Recommended Practice for Electrical Safety in Industrial and Commercial Power Systems
2. NFPA 70E: Electrical Safety in the Workplace
3. European Standard EN50110 (-1, -2): Operation of Electrical Installations, CENELEC
4. *Add other references as needed.*

### Input Data

The following data are a part of these specifications, either by reference or by inclusion as appendices.

1. Drawings and calculations
    1.1. Normal and Switching one-line diagrams
        1.1.1. Drawing List: *List drawings by number and title in an Appendix or refer to a file*
        1.1.2. Source: *Specify where and how to obtain drawings if they are not included as part of the specifications*
        1.1.3. Validity: *Specify validity as described in the 'General' section.*
    1.2. Calculations
        1.2.1. Programs: *Identify all existing related programs such as load flow, short circuit, arc flash, voltage regulation, stability, etc. Provide vendor's name and identify versions.*
        1.2.2. Source: *Specify how to obtain programs if they are not included as part of the specifications*
        1.2.3. Validity: *Specify validity as described in the 'General' section.*
2. Equipment data and operating characteristics
*List under each item*
    2.1. Sources of energy: *Identify by reference to drawings, tabulations, or other documentation*
        2.1.1 Utilities
        2.1.2 Local generation
        2.1.3 DC sources, batteries
        2.1.4 Retained excitation, e.g.: capacitors, transformers, residual charges on cables
        2.1.5 UPS
        2.1.6 Emergency or temporary sources
        2.1.7 Non-electrical stored energy sources, e.g.: hydraulic accumulators, surge tanks, mechanical springs, gravity
        2.1.8 Validity: *Specify validity as described in the 'General' section.*
    2.2 Loads: *Identify by reference to drawings, tabulations, or other documentation*
        2.2.1 Motors
        2.2.2 Lighting
        2.2.3 Communications
        2.2.4 *Other*
        2.2.5 Validity: *Specify validity as described in 'General' section.*

2.3    Switching equipment and protective devices *Identify by reference to drawings, tabulations, or other documentation*

    2.3.1    Switchgear

    2.3.2    Circuit breakers

    2.3.3    Transfer switches

    2.3.4    Motor Control Centers

    2.3.5    Protective devices

    2.3.6    *Other*

    2.3.7    Validity: *Specify validity as described in the 'General' section.*

2.4    Mechanical and non-electrical devices that are considered a part of the system

    2.4.1    Key interlocks

    2.4.2    Grounding cables or connections

    2.4.3    *Other*

    2.4.4    Descriptions and locations are [shown on the one-line] *or* [tabulated in Appendix xx]

    2.4.5    Validity: *Specify validity as described in the 'General' section.*

2.5    Present Operational and Switching Information

    2.5.1    See Appendix yy. *Append present operational and switching procedures and sequences*

    2.5.2    Validity: *Specify validity as described in the 'General' section.*

2.6    Present LOTO Procedures and Sequences:

    2.6.1    See Appendix zz. *Append present LOTO procedures*

    2.6.2    Validity: *Specify validity as described in the 'General' section.*

2.7    Critical Loads:

    2.7.1    *Identify and prioritize critical loads, both for standard operating procedures and for special switching procedures*

    2.7.2    *Describe production and process constraints that impact system operation and switching*

    2.7.3    Validity: *Specify validity as described in the 'General' section.*

**NOTE: the following sections describe some, but not necessarily all, major required 'deliverables'.**

*Program Requirements*

1.    Scope of work:

    1.1.    The Operations & Switching (O&S) program shall be capable of analyzing and developing procedures for the power system in its entirety as presented in the referenced documents. It shall also be capable of performing the same functions for selected portions of the system such as one bus or a group of busses.

    1.2.    The procedures shall include detailed instructions for specific operational, switching, and LOTO procedures, including both de-energizing and restoring power circuits.

2.    Changes:

    2.1.    Retain the underlying programs and data without change so this information can be recalled readily as the permanent record.

    2.2.    Provide means to enter data for the O&S program.

        2.2.1.    Modified relay settings

        2.2.2.    Mechanical and non-electrical devices

        2.2.3.    Modified transformer tap changes

        2.2.4.    Modified operating limits or bounds

        2.2.5.    Modified alarm settings

        2.2.6.    Storage of the different one-line changes (i.e. scenarios)

        2.2.7.    *Other data as appropriate. Show any additional special requirements here.*

        2.2.8.    Provide means to modify circuit breaker settings on a temporary basis.

3.    Existing programs:

    3.1.    This O&S program shall be fully integrated with all existing programs.

    3.2.    Existing programs shall run O&S data concurrently with the O&S program and shall store these outputs without changing or affecting any existing records or files.

4.    Alarms, alerts:

    4.1.    Show alarms for operating conditions that are out of established bounds.

    4.2.    Show alarms that are out of bounds established for O&S procedures.

4.3.　　Use highlights, flashing signals, color codes, or methods used in the underlying programs, and use these same methods for silencing or canceling alarms.

5.　Documentation:

5.1.　　Retain and identify internal records of all selected O&S procedures, including trial runs.

5.2.　　Tabulate or capture by other means all alarms and alerts.

5.3.　　Prevent automatic deletion of records.

6.　Check lists:

6.1.　　Provide a check list for switching functions suitable for keyboard entry.

6.2.　　Provide a duplicate hard copy suitable for manual entry.

*Output*

1. Provide a sequence of operating or switching procedures:

1.1.　　For switching from one condition or status to another

1.2.　　For switching back to the previous status

1.3.　　With means to check off each switching or operational step.

2. Present the effect of each step of the procedures as determined by the underlying programs, with clear indication of any questionable or out of bounds conditions.

3. Provide a method to display the O&S program output as each switching operation occurs.

4. Provide a record of switching events as they occur in sequence.

5. Preferred formats are .pdf and Microsoft Word.

*Supplementary support*

1. Define the software training that will be required when the program is commissioned.

2. Define the recommended field support.

3. State how long the program will be valid and supported.

4. Define ownership of the program and documentation.

*Terms and Conditions*

*Include User's "Terms and Conditions" as required.*

*Appendix A*

**Note**: The following papers are listed as additional, optional, reading for the Software Vendor. Essential items have been included in the specifications. Appendix A is not a part of the specifications.

### INDEX OF PAPERS ON ELECTRICAL SAFETY

S1.　G. D. Gregory, J. H. Kusca, G. Parise, M. K. Sanders, C. M. Wellman "How Do the NEC and IEC 60364 Help Provide Electrical Safety?" 2000 IEEE/IAS PCIC Conference San Antonio TX; 2000 IEEE-IAS Annual Meeting Roma October 8-12

S2.　G. Parise G. Donato G. Lucarelli C. Turella An Electrical Consulting Board to Improve Safety in the Electrical Field 2001 IEEE-IAS I&CPS Technical Conference New Orleans May 12-19.

S3.　G. Parise, S. Annibaldi, L. Martirano " Toward Alignement of Safety Levels Concerning Electrical Installations In EU" IEEE- Industry Application Magazine vol.7, n. 3 May-June 2001

S4.　G. Parise, W. Moylan P. E. Sutherland Electrical safety for employee workplaces in Europe and in USA IEEE Transactions on ,Volume: 41 , Issue: 4 , July-August 2005 Pages:1091-1098

S5.　K. G. Mastrullo, Ray Jones, Bruce McClung, P. S. Hamer, G.Parise Globalization Of Electrical Codes And Standards 2002 IEEE/IAS PCIC Conference New Orleans

S6.　G. Parise, S. Pasqualini, The Electrical System "Chessboard" As An Useful Tool For Comparison Between N.American And European Power Systems 2004 IEEE-IAS I&CPS Tech. Conf. Clearwater FL USA, May 3-5.

S7.　G.Parise, R.E. Nabours, B. McClung "Relevance of competence in risk reduction for electrical safety" Transactions IEEE/IAS volume 44 n.6 November December 2008 page 1892-1895

### INDEX OF PAPERS ON OPERATIONAL PROCEDURES

O1.　G. Parise, E. Hesla: "Basic Concepts and Auto-Check for Clearing Procedures" May 2-6 1999 IEEE-IAS ICPS Technical Conference, Sparks NV USA

O2. G.Parise, E. Hesla: "Electrical Status Space for Clearing Procedures in Electrical Installations", IEEE Safety Workshop, April 2000, New Delhi India,

O3. G. Parise, E. Hesla: "Clearing Procedures in Electrical Installations: The Electrical Status Space", IEEE Transactions on Industry Applications vol. 38 May/June 2002 pag. 797-802

O4. G. Parise, E. Hesla: "A New Analytical Language for Clearing Procedures in Electrical Installations", IEEE-IAS Annual Meeting October 2004, Seattle WA USA

O5. G. Parise, E. Hesla: "A Programmable Language for Clearing Procedures", IEEE-IAS ICPS Technical Conference May 2005, Saratoga Springs NY USA

O6. G. Parise, E. Hesla: "The Sources Sets for Operational Procedures", IEEE-IAS ICPS Technical Conference May 2006, Dearborn MI USA

O7. G. Parise, E. Hesla R. Rifaat: "Comprehensive Design of Electrical Installations by Integrating System Configuration and Operational Safety Aspects" IEEE-IAS Annual Meeting October 2006, Tampa FL USA

O8. G.Parise, E.Hesla "Transitions Maps for Integrity in Operational Procedures of Electrical Installations" 2007 IEEE-IAS ICPS Technical Conference, May 6-9, 2007 Edmonton, Alberta (Canada)

O9. Comprehensive Design of Electrical Installations Integrating System Configuration and Operational Safety Aspects 2007 IEEE-IAS ICPS Technical Conference, May 6-9, 2007 Edmonton, Alberta (Canada) (Tutorial)

O10. G. Parise, E.Hesla, R. Rifaat "Architecture impact on integrity of electrical installations: cut&tie rule, ring configuration, floating node" Industry Applications, IEEE Transactions on, Volume 45, Issue 5, Sept.-Oct. 2009 Page(s):1903 - 1909

O11. G. Parise, "Four color theorem explained by electrical operational procedures?" 2008 IEEE/I&CPS Technical Conf., Clearwater Beach, Florida, USA, May 4-8, 2008

O12. G.Parise, A.Gabelli, E.Berenato, D.Brambilla,L.Signorelli "Architecture Of Electrical Installations: The Node Double Two" IEEE-IAS Annual Meeting October 5-9, 2008, Edmonton, Alberta (Canada)

O13. G. Parise "Transitions theory for intersections/nodes and generalized euclidean kinematics in operation of electrical installations" IEEE-IAS Annual Meeting October 4-8, 2009, Houston (USA)

O14. G. Parise, E.Hesla, R. Rifaat "Genetic Code of Electrical Operational Procedures: Lockout Systems, Simulators and Training" Transactions IEEE/IAS volume 46 n.2 March April 2010