NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Sudden Pressure Relays and Other Devices that Respond to Non-Electrical Quantities

SPCS Input for Standard Development in Response to FERC Order No. 758

System Protection and Control Subcommittee

December 2013

RELIABILITY | ACCOUNTABILITY




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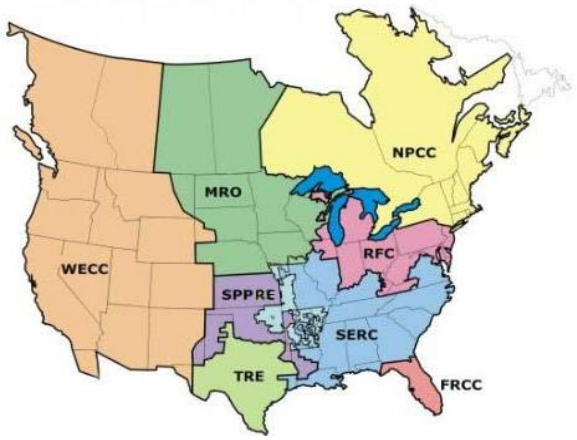
NERC's Mission

The North American Electric Reliability Corporation (NERC) is an international regulatory authority established to enhance the reliability of the Bulk-Power System in North America. NERC develops and enforces Reliability Standards; assesses adequacy annually via a ten-year forecast and winter and summer forecasts; monitors the Bulk-Power System; and educates, trains, and certifies industry personnel. NERC is the electric reliability organization for North America, subject to oversight by the U.S. Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada.[1]

NERC assesses and reports on the reliability and adequacy of the North American Bulk-Power System, which is divided into eight Regional areas, as shown on the map and table below. The users, owners, and operators of the Bulk-Power System within these areas account for virtually all the electricity supplied in the U.S., Canada, and a portion of Baja California Norte, México.



Note: The highlighted area between SPP RE and SERC denotes overlapping Regional area boundaries. For example, some load serving entities participate in one Region and their associated transmission owner/operators in another.

NERC Regional Entities

FRCC Florida Reliability Coordinating Council	**SERC** SERC Reliability Corporation
MRO Midwest Reliability Organization	**SPP RE** Southwest Power Pool Regional Entity
NPCC Northeast Power Coordinating Council	**TRE** Texas Reliability Entity
RFC ReliabilityFirst Corporation	**WECC** Western Electricity Coordinating Council

[1] As of June 18, 2007, the U.S. Federal Energy Regulatory Commission (FERC) granted NERC the legal authority to enforce Reliability Standards with all U.S. users, owners, and operators of the bulk power system, and made compliance with those standards mandatory and enforceable. In Canada, NERC presently has memorandums of understanding in place with provincial authorities in Ontario, New Brunswick, Nova Scotia, Québec, and Saskatchewan, and with the Canadian National Energy Board. NERC standards are mandatory and enforceable in Ontario and New Brunswick as a matter of provincial law. NERC has an agreement with Manitoba Hydro making reliability standards mandatory for that entity, and Manitoba has recently adopted legislation setting out a framework for standards to become mandatory for users, owners, and operators in the province. In addition, NERC has been designated as the "electric reliability organization" under Alberta's Transportation Regulation, and certain reliability standards have been approved in that jurisdiction; others are pending. NERC and NPCC have been recognized as standards-setting bodies by the Régie de l'énergie of Québec, and Québec has the framework in place for reliability standards to become mandatory. NERC's reliability standards are also mandatory in Nova Scotia and British Columbia. NERC is working with the other governmental authorities in Canada to achieve equivalent recognition.

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This technical document was approved by the NERC Planning Committee on December 11, 2013.

Executive Summary

In Order No. 758, FERC directed NERC to identify ". . . devices that are designed to sense or take action against any abnormal system condition that will affect reliable operation [of the Bulk-Power System]." In response to this directive, the Standards Committee requested the SPCS develop a technical report to support development of modifications to NERC Reliability Standard PRC-005, Protection System Maintenance and Testing. This report to the NERC Planning Committee (PC) addresses issues raised in the order regarding devices that respond to non-electrical quantities in general, and specifically sudden pressure relays. Upon PC approval, this report will be forwarded to the NERC Standards Committee to support a standard drafting team that will modify the existing standard or develop a new standard.

In developing this report, the SPCS evaluated all devices on the IEEE list of device numbers to identify which devices that respond to non-electrical quantities may impact reliable operation of the Bulk-Power System. As a result of this analysis, the SPCS concludes the only devices responding to non-electrical quantities that should be included in the applicability of PRC-005 are sudden pressure relays utilized in a tripping function. When applied in a tripping function, these devices initiate actions to clear faults to support reliable operation of the Bulk-Power System. The other devices evaluated respond to abnormal equipment conditions and take action to protect equipment from mechanical or thermal damage, or premature loss of life, rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Based on its conclusion, the SPCS assessed existing industry practices for maintenance and testing of sudden pressure relays and conducted an informal industry survey to develop recommendations for maintenance and testing requirements to be included in PRC-005. To validate its approach, the SPCS contacted the following entities for their feedback: the IEEE Power System Relaying Committee, the NATF System Protection Practices Group, and the EPRI Generator Owner/Operator Technical Focus Group. All three of these organizations indicated the results of the SPCS survey are consistent with their respective experiences.

Considering its analysis and conclusion, the SPCS recommends the following guidance for future development of NERC Reliability Standard PRC-005, Protection System Maintenance, to address the concerns stated in FERC Order No. 758.

Modify PRC-005 to explicitly address maintenance and testing of the actuator device of the sudden pressure relay when applied as a protective device that trips a facility described in the applicability section of the Reliability Standard.

- Develop minimum maintenance activities for sudden pressure relays similar to Table 1-1: Protective Relay. Based on the survey results, the SPCS recommends the maximum interval for time-based maintenance programs be 6 years.
- Modify Table 1-5: Control Circuitry Associated With Protective Functions to explicitly include the sudden pressure control circuitry.

Introduction

Overview

In Order No. 758, FERC directed NERC to identify ". . . devices that are designed to sense or take action against any abnormal system condition that will affect reliable operation [of the Bulk-Power System]." In response to this directive, the Standards Committee requested the SPCS develop a technical report to support development of modifications to NERC Reliability Standard PRC-005, Protection System Maintenance and Testing. This report to the NERC Planning Committee (PC) addresses issues raised in the order regarding devices that respond to non-electrical quantities in general, and specifically sudden pressure relays.[2] Upon PC approval, this report will be forwarded to the NERC Standards Committee to support a standard drafting team that will modify the existing standard or develop a new standard.

Background

FERC Order No. 758 is associated with an interpretation of NERC Reliability Standard PRC-005-1, Protection System Maintenance and Testing. The interpretation addressed a series of questions submitted by the Regional Entities Compliance Monitoring Processes Working Group. The questions sought interpretation of whether specific components must be included in a maintenance and testing program. Specifically, the questions pertained to battery chargers, auxiliary relays and sensing devices, reclosing relays, dc circuitry, and communications systems.

In the order, FERC approved the interpretation as it pertains to the text of the existing standard and relevant defined terms in the NERC glossary. However, FERC identified concerns with certain devices that may impact reliability of the Bulk-Power System and directed that NERC address these concerns as specified in the order. The concerns specified in the order pertain to reclosing relays and to sudden pressure relays and other devices that respond to non-electrical quantities. Concerns related to maintenance and testing of reclosing relays are addressed in a separate, joint report of the NERC System Analysis and Modeling Subcommittee (SAMS) and the SPCS. This report focuses on the directive in the order pertaining to sudden pressure relays and other devices that respond to non-electrical quantities.

In the Notice of Proposed Rulemaking (NOPR) associated with this interpretation, FERC noted a concern that the proposed interpretation may not include all components that serve in some protective capacity. FERC further noted its concerns included the exclusion of auxiliary and non-electrical sensing relays. FERC proposed to direct NERC to develop a modification to Reliability Standard PRC-005-1 to include any component or device that is designed to detect defective lines or apparatuses or other power system conditions of an abnormal or dangerous nature, including devices designed to sense or take action against any abnormal system condition that will affect reliable operation, and to initiate appropriate control circuit actions.

In its comments on the NOPR, NERC noted that the revised definition of protection system and changes to PRC-005-1, in progress at that time, address FERC's concerns pertaining to auxiliary relays.[3] NERC also acknowledged FERC concerns related to protective relays that do not respond to electrical quantities and agreed that sudden pressure relays which trip for fault conditions should be maintained in accordance with NERC Reliability Standard requirements. However, NERC noted concern that the scope of the proposed directive was so broad that any device that is installed on the Bulk-Power System to monitor conditions in any fashion may be included. NERC further noted that, in fact, many of these devices are advisory in nature and should not be reflected within NERC standards if they do not serve a necessary reliability purpose.

NERC therefore proposed to develop, either independently or in association with other technical organizations such as IEEE, one or more technical documents which:

i. describe the devices and functions (to include sudden pressure relays which trip for fault conditions) that should address FERC's concern; and

ii. propose minimum maintenance activities for such devices and maximum maintenance intervals, including the technical basis for each.

[2] Order No. 758 used the term sudden pressure relays, which the SPCS has interpreted to refer to the general class of relays responding to pressure, including sudden pressure, rapid pressure rise, and Buchholz relays.

[3] The changes referenced by NERC are included in PRC-005-2, adopted by the NERC Board of Trustees on November 7, 2012 and filed with a petition to FERC on February 26, 2013.

NERC stated that these technical documents will address those protective relays that are necessary for the reliable operation of the Bulk-Power System and will allow for differentiation between protective relays that detect faults from other devices that monitor the health of the individual equipment and are advisory in nature (e.g., oil temperature). Following development of the above-referenced document(s), NERC will propose a new or revised standard (e.g., PRC-005) using the NERC Reliability Standards development process to include maintenance of such devices, including establishment of minimum maintenance activities and maximum maintenance intervals.

In Order No. 758, FERC accepted the NERC proposal, and directed NERC to file, within sixty days of publication of the Final Rule, a schedule for informational purposes regarding the development of the technical documents referenced above, including the identification of devices that are designed to sense or take action against any abnormal system condition that will affect reliable operation. The SPCS has previously provided information regarding the schedule and steps planned to develop the proposed documents and this information was included in an informational filing on April 12, 2012 (see Appendix A). In accordance with the filed schedule, this report is submitted for approval to the Planning Committee to support standard development beginning in the first quarter of 2014.

Chapter 1 – Devices that Respond to Non-Electrical Quantities

Considerations for Inclusion in PRC-005

The SPCS considered the risk to reliable operation of the Bulk-Power System when developing a basis for identifying devices that should be included in the maintenance and testing standard. The following criteria were evaluated:

- Action taken: The SPCS considered the criticality of the effect of the action taken on system reliability, noting that tripping equipment is typically initiated when such action is necessary for reliability, although differentiation is necessary between tripping equipment to support reliable operation of the Bulk-Power System versus tripping to minimize the impact of abnormal operating conditions on a specific element. The SPCS also noted that initiating an alarm implies there is time for operator intervention to alleviate an adverse impact, and that initiating a control action implies immediate isolation of equipment (i.e., tripping) is not necessary.
- The risk associated with misoperation for an inadvertent operation or a failure to operate: The SPCS concluded that evaluating the impact on system reliability must consider the impact of both a failure of the device to operate when its operation is required (a dependability-related failure) and an inadvertent operation (a security-related failure).
- The risk of inadvertent operation during a disturbance: The SPCS considered the risk of a device inadvertently operating in response to a system disturbance and causing or contributing to a cascading event. Devices that respond to quantities directly associated with an abnormal condition are typically more secure than devices that monitor quantities indirectly associated with the abnormal condition. Furthermore, devices that respond to quantities associated with an abnormal equipment condition are typically unaffected by conditions experienced during system disturbances, and thus, are much less prone to inadvertent operation during a disturbance than relays that respond to electrical quantities.

Basis for Evaluation

The SPCS considered the above alternatives and identified the attributes important to assessing the potential for a device to affect reliability of the Bulk-Power System. After consideration of the attributes identified, the SPCS determined the best approach for performing an assessment was to group all device types into one of three categories to differentiate the risk to reliable operation of the Bulk-Power System. The three categories are listed in order of decreasing potential for risk to Bulk-Power System reliability. Of these, the first category is deemed to present a risk to Bulk-Power System reliability that is sufficient to include maintenance and testing of the device in PRC-005.

(1) Devices that initiate actions to clear faults or mitigate abnormal system conditions to support reliable operation of the Bulk-Power System,

(2) Devices that initiate action for abnormal equipment conditions for purposes other than supporting reliable operation of the Bulk-Power System, and

(3) Devices that monitor the health of the individual equipment and provide information that is advisory in nature.

Analysis of Individual Devices

The SPCS used the list of IEEE device numbers as a starting point for its assessment to assure that all possible devices responding to non-electrical quantities were considered. A list of all IEEE device numbers, including a description of each device is included in Appendix B.

To address the concern identified in Order No. 758, the SPCS used a two-step process to identify devices that initiate actions to clear faults or mitigate abnormal system conditions to support reliable operation of the Bulk-Power System.

In the first step, the SPCS identified devices already addressed as a result of the revised definition of Protection System or that are clearly not protective devices, such as primary equipment and control devices. The initial categorization of devices

from this first step is documented in Appendix C. The SPCS used the following criteria to eliminate such devices and develop a short list of devices requiring detailed analysis.

- Protective relay already addressed in PRC-005-2: Maintenance and testing requirements are already established for these devices and no further consideration is required.
- Auxiliary relay already addressed in PRC-005-2: Maintenance and testing requirements are already established for these devices and no further consideration is required.
- Autoreclosing and synchronism check relays: Maintenance and testing considerations for these devices are proposed in a separate report to address the directive in paragraph 27 of Order No. 758[4]; these devices do not require further consideration in this report.
- Primary equipment: Devices such as governors, valves, motors, and circuit breakers are primary equipment, rather than protective devices, and do not require further consideration.
- Control device: Devices such as position switches, contactors, and field application relays that are used for starting, stopping, or otherwise controlling operation of equipment, respond to manual input or signals directly associated with operation of the equipment. These devices may be separate from, or an integral part of, the controlled equipment. Control systems are excluded from maintenance and testing requirements in PRC-005.

In the second step, the SPCS evaluated each device on the short list to group them into one of the three categories. The short list of devices and the SPCS evaluation of each device are included in Appendix D. The list includes a description of each device, whether the device trips a power system element and, if so, the potential risk to the Bulk-Power System based on the preceding criteria. Classification of devices on the short list is presented in Table 1. Some devices appear in more than one category; e.g., some devices may be used to alarm or to isolate equipment, depending on the application and the practices that entities have developed specific to their circumstances.

As a result of the analysis, the SPCS concludes that sudden pressure relays that are utilized in a trip application should be included in the Protection System Maintenance and Testing standard. Recommendations for minimum maintenance activities and maximum intervals are discussed in the next section of this report.

[4] The SPCS recommended modifications to PRC-005 to explicitly address maintenance and testing of autoreclosing relays applied as an integral part of a SPS, and autoreclosing relays at or in proximity to certain generating plants. See *Considerations for Maintenance and Testing of Autoreclosing Schemes*, NERC System Analysis and Modeling Subcommittee and System Protection and Control Subcommittee, November 2012.

Table 1: Classification of Devices		
Initiate Actions to Clear Faults or Mitigate Abnormal System Conditions to Support Reliable Operation of the Bulk-Power System	**Initiate Action for Abnormal Equipment Conditions for Purposes other than Supporting Reliable Operation of the Bulk-Power System**	**Monitor the Health of Individual Equipment and Provide Information that is Advisory in Nature**
Sudden Pressure (63) (when utilized in a trip application)	• Overspeed Device (12) • Underspeed Device (14) • Apparatus Thermal Device (26) • Flame Detector (28) • Bearing Protective Device (38) • Mechanical Condition Monitor (39) • Atmospheric Condition Monitor (45) • Machine or Transformer Thermal Relay (49) • Density Switch or Sensor (61) • Pressure Switch (63) (other than sudden pressure relays utilized in trip application • Level Switch (71)	• Apparatus Thermal Device (26) • Bearing Protective Device (38) • Mechanical Condition Monitor (39) • Atmospheric Condition Monitor (45) • Machine or Transformer Thermal Relay (49) • Density Switch or Sensor (61) • Pressure Switch (63) (other than sudden pressure relays utilized in trip application • Level Switch (71)

Chapter 2 – Sudden Pressure Relays

Maintenance Intervals and Activities

In order to determine present industry practices related to sudden pressure relay maintenance, the SPCS conducted a survey of Transmission Owners and Generator Owners in all eight Regions requesting information related to their maintenance practices. The SPCS received responses from 75 Transmission Owners and 109 Generator Owners. Note that, for the purpose of the survey, sudden pressure relays included the following: the "sudden pressure relay" (SPR) originally manufactured by Westinghouse, the "rapid pressure rise relay" (RPR) manufactured by Qualitrol, and a variety of Buchholz relays. A copy of the survey is included in Appendix C.

Table 2 provides a summary of the results of the responses:

Table 2: Sudden Pressure Relay Maintenance Practices – Survey Results

	Transmission Owner	Generator Owner
Number of responding owners that trip with Sudden Pressure Relays:	67	84
Percentage of responding owners who trip that have a Maintenance Program:	75%	78%
Percentage of maintenance programs that include testing the pressure actuator:	81%	77%
Average Maintenance interval reported:	5.9 years	4.9 years

Additionally, in order to validate the information noted above, the SPCS contacted the following entities for their feedback: the IEEE Power System Relaying Committee, the IEEE Transformer Committee, the Doble Transformer Committee, the NATF System Protection Practices Group, and the EPRI Generator Owner/Operator Technical Focus Group. All of these organizations indicated the results of the SPCS survey are consistent with their respective experiences.

Pressure Actuator Testing

The pressure actuator can take several forms; however, the basic function is to detect a sudden pressure increase within the transformer that is outside of the normal pressure changes that would occur due to expansion and contraction of the oil as a result of external temperature changes or heating due to loading. These devices can be installed at various locations on the transformer and, depending on location, may require the equipment to be removed from service prior to testing the device.

The SPCS also assessed the maintenance activities included in Table 1-1 of PRC-005-2 and concluded that the activities necessary for sudden pressure relay maintenance and testing are analogous to activities performed during maintenance and testing of electromechanical protective relays identified in Table 1-1: Protective Relay.

Sudden Pressure Control Circuitry

The only control circuitry associated with the sudden pressure relays is the circuit which trips the breaker or other interrupting device. As noted in the Supplementary Reference and FAQ document associated with PRC-005-2, maintenance and testing of this circuitry is already included in the requirements of the revised standard. The SPCS believes activities and intervals for maintenance and testing of sudden pressure control circuitry should be explicitly stated in the associated Table 1-5: Control Circuitry Associated With Protective Functions.

Chapter 3 – Recommendations

Based on its analysis, the SPCS has determined the only device that responds to non-electrical quantities that should be included in PRC-005 is a sudden pressure relay that trips the equipment it is monitoring. Therefore, the SPCS recommends the following guidance for future development of NERC Reliability Standard PRC-005, Protection System Maintenance, to address the concerns stated in FERC Order No. 758.

Modify PRC-005 to explicitly address maintenance and testing of the actuator device of the sudden pressure relay when applied as a protective device that trips a facility described in the applicability section of the Reliability Standard.

- Develop minimum maintenance activities for sudden pressure relays similar to Table 1-1: Protective Relay. Based on the survey results, the SPCS recommends the maximum interval for time-based maintenance programs be 6 years.
- Modify Table 1-5: "Control Circuitry Associated With Protective Functions" to explicitly include the sudden pressure control circuitry.

Appendix A – Attachment to NERC Informational Filing in Response to FERC Order No. 758 – April 12, 2012

ATTACHMENT A

NERC System Protection and Control Subcommittee Tentative Schedule for Activities Related to Paragraph 15 of FERC Order No. 758

February 2012 – May 2012	Develop a list of devices to be addressed in a subsequent revision of PRC-005 (use the IEEE device list as a reference of possible devices to be considered)
	Document devices considered and recommendations for which items are/are not to be included
May 2012 – May 2013	Work with IEEE Power System Relaying Committee and IEEE Transformer Committee regarding minimum maintenance activities and maximum intervals for those devices recommended for inclusion in PRC-005
	Review manufacturer's literature and recommended maintenance practices
	Conduct a survey, possibly through the Transmission Forum, of maintenance practices for identified devices
May 2013 – September 2013	Develop a report to NERC Planning Committee
September 2013 – December 2013	NERC Planning Committee review and approval
First Quarter 2014	Submit technical document(s) to NERC Standards Committee

Prepared by the NERC System Protection and Control Subcommittee

March 15, 2011

Appendix B – IEEE Device Numbers and Functions

The devices in switching equipment are referred to by numbers, according to the functions they perform. These numbers are based on a system which has been adopted as standard for automatic switchgear by IEEE. This system is used on connection diagrams, in instruction books, and in specifications.

1 – Master element
An initiating device, such as a control switch, voltage relay, float switch etc., that serves either directly, or through such permissive devices as protective and time-delay relays, to place an equipment in or out of operation.

2 – Time-delay starting or closing relay
A device that functions to give a desired amount of time delay before or after any point of operation in a switching sequence or protective relay system, except as specifically provided by device functions 48, 62 and 79 described later.

3 – Checking or interlocking relay
A device that operates in response to the position of a number of other devices, (or to a number of predetermined conditions), in an equipment to allow an operating sequence to proceed, to stop, or to provide a check of the position of these devices or of these conditions for any purpose.

4 – Master contactor
A device, generally controlled by device No. 1 or equivalent, and the required permissive and protective devices, that serve to make and break the necessary control circuits to place an equipment into operation under the desired conditions and to take it out of operation under other or abnormal conditions.

5 – Stopping device
A control device used primarily to shut down an equipment and hold it out of operation. [This device may be manually or electrically actuated, but excludes the function of electrical lockout (see device function 86) on abnormal conditions.]

6 – Starting circuit breaker
A device whose principal function is to connect a machine to its source of starting voltage.

7 – Rate-of-rise relay
A relay that functions on an excessive rate of rise of current.

8 – Control power disconnecting device
A disconnecting device, such as a knife switch, circuit breaker, or pull-out fuse block, used for the purpose of respectively connecting and disconnecting the source of control power to and from the control bus or equipment.

9 – Reversing device
A device is used for the purpose of reversing a machine field or for performing any other reversing functions.

10 – Unit sequence switch
A switch used to change the sequence in which units may be placed in and out of service in multiple-unit equipment.

11 – Multifunction device
A device that performs three or more comparatively important functions that could only be designated by combining several of these device function numbers. All of the functions performed by device 11 shall be defined in the drawing legend or device function list.

12 – Over speed device
A device, usually a direct connected speed switch, that functions on machine over speed.

13 – Synchronous-speed device
A device s such as a centrifugal speed switch, a slip frequency relay, a voltage relay, an undercurrent relay, or any other type of device that operates at approximately the synchronous speed of a machine.

14 – Underspeed device
A device that functions when the speed of a machine falls below a pre-determined value.

15 – Speed or frequency matching device
A device that functions to match and hold the speed or the frequency of a machine or of a system equal to, or approximately equal to, that of another machine, source, or system.

16 – Reserved for future application

17 – Shunting or discharge switch
A switch that serves to open or to close a shunting circuit around any piece of apparatus (except a resistor), such as a machine field, a machine armature, a capacitor, or a reactor.

Note: This excludes devices that perform such shunting operations as may be necessary in the process of starting a machine by devices 6 or 42, or their equivalent, and also excludes device 73 function that serves for the switching of resistors.

18 – Accelerating or decelerating device
A deice used to close or to cause the closing of circuits that are used to increase or decrease the speed of a machine.

19 – Starting-to-running transition
A contactor that operates to initiate or cause the automatic transfer of a machine from the starting to the running power connection.

20 – Electrically operated valve
An electrically operated, controlled, or monitored valve used in a fluid, air, gas, or vacuum line.

Note: The function of the valve may be indicated by the use of suffixes.

21 – Distance relay
A relay that functions when the circuit admittance, impedance, or reactance increases or decreases beyond a predetermined value.

22 – Equalizer circuit breaker
A breaker that serves to control or to make and break the equalizer or the current balancing connections for a machine field, or for regulating equipment, in a multiple unit installation.

23 – Temperature control device
A device that functions to raise or to lower the temperature of a machine or other apparatus, or of any medium, when its temperature falls below or rises above a predetermined value.

Note: An example is a thermostat that switches on a space heater in a switchgear assembly when the temperature falls to a desired value as distinguished from a device that is used to provide automatic temperature regulation between close limits and would be designated as 90T.

24 – Volts per hertz relay
A relay that functions when the ratio of voltage to frequency exceeds a preset value. The relay may have an instantaneous or a time characteristic.

25 – Synchronizing or synchronism check
A device that operates when two ac circuits are within the desired limits of frequency, phase angle, or voltage to permit or to cause the paralleling of these two circuits.

26 – Apparatus thermal device
Functions when the temperature of the protected apparatus (other than the load-carrying windings of machines and transformers as covered by device function number 49) or of a liquid or other medium exceeds a predetermined value; or when the temperature of the protected apparatus or of any medium decreases below a predetermined value.

27 – Under voltage relay
A relay that operates when its input voltage is less than a predetermined value.

28 – Flame detector
A device that monitors the presence of the pilot or main flame in such apparatus as a gas turbine or a steam boiler.

29 – Isolating contactor
A device used expressly for disconnecting one circuit from another for the purposes of emergency operation, maintenance, or test.

30 – Annunciator relay
A non-automatically reset device that gives a number of separate visual indications upon the functioning of protective devices and that may also be arranged to perform a lock-out function.

31 – Separate excitation device
A device that connects a circuit, such as the shunt field of a synchronous converter, to a source of separate excitation during the starting sequence; or one which energizes the excitation and ignition circuits of a power rectifier.

32 – Directional power relay
A relay that operates on a predetermined value of power flow in a given direction or upon reverse power flow such as that resulting from the motoring of a generator upon loss of its prime mover.

33 – Position switch
A switch that makes or breaks contact when the main device or piece of apparatus that has no device function number reaches a given position.

34 – Master sequence device
A device such as a motor operated multi contact switch, or the equivalent, or a programming device, such as a computer, that establishes or determines the operating sequence of the major devices in an equipment during starting and stopping or during other sequential switching operations.

35 – Brush-operating or slip-ring short circuiting
A device used for raising, lowering or shifting the brushes of a machine; short-circuiting its slip rings; or engaging or disengaging the contacts of a mechanical rectifier.

36 – Polarity or polarizing voltage device
A device that operates, or permits the operation of, another device on a predetermined polarity only or that verifies the presence of a polarizing voltage in an equipment.

37 – Undercurrent or under power relay
A device that functions when the current or power flow decreases below a predetermined value.

38 – Bearing protective device
A device that functions on excessive bearing temperature or on other abnormal mechanical conditions associated with the bearing, such as undue wear, which may eventually result in excessive bearing temperature or failure.

39- Mechanical condition monitor
A device that functions upon the occurrence of an abnormal mechanical condition (except that associated with bearings as covered under device function 38), such as excessive vibration, eccentricity, expansion, shock, tilting, or seal failure.

40 – Field relay
A relay that functions on a given or abnormally low value or failure of machine field current, or on an excessive value of the reactive component of armature current in an ac machine indicating abnormally low field excitation.

41 – Field circuit breaker
A device that functions to apply or remove the field excitation of a machine.

42 – Running circuit breaker
A device whose principal function is to connect a machine to its source of running or
operating voltage. This function may also be used for a device, such as a contactor, that is used in series with a circuit breaker or other fault protecting means, primarily for frequent opening and closing of the circuit.

43 – Manual transfer or selector device
A manually operated device that transfers the control circuits in order to modify the plan of operation of the switching equipment or of some of the devices.

44 – Unit sequence starting relay
A relay that functions to start the next available unit in multiple unit equipment upon the failure or nonavailability of the normally preceding unit.

45 – Atmospheric condition monitor
A device that functions upon the occurrence of an abnormal atmospheric condition, such as damaging fumes, explosive mixtures, smoke, or fire.

46 – Reverse-phase or phase-balance
A current relay is a relay that functions when the polyphase currents are of reverse phase sequence or when the polyphase currents are unbalanced or contain negative phase-sequence components above a given amount.

47 – Phase-sequence or phase-balance
A voltage relay that functions upon a predetermined value of polyphase voltage in the desired phase sequence, or when the polyphase voltages are unbalanced, or when the negative phase-sequence voltage exceeds a given amount.

48 – Incomplete sequence relay
A relay that generally returns the equipment to the normal, or off, position and locks it out if the normal starting, operating, or stopping sequence is not properly completed within a predetermined time. If the device is used for alarm purposes only, it should preferably be designated as 48A (alarm).

49 – Machine or transformer thermal
A relay that functions when the temperature of a machine armature winding or other load-carrying winding or element of a machine or power transformer exceeds a predetermined value.

50 – Instantaneous over current relay
A relay that functions instantaneously on an excessive value of current.

51 – Ac time over current relay
A relay with either a definite or inverse time characteristic that functions when the ac input current exceeds a predetermined value, and in which the input current and operating time are independently related or inversely related through a substantial portion of the performance range.

52 – Ac circuit breaker
A device that is used to close and interrupt an ac power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

53 – Exciter or dc generator relay
A relay that forces the dc machine field excitation to build up during starting or that functions when the machine voltage has built up to a given value.

54 – Turning gear engaging device
An electrically operated, controlled, or monitored device that functions to cause the turning gear to engage (or disengage) the machine shaft.

55 – Power factor relay
A relay that operates when the power factor in an ac circuit rises above or falls below a predetermined value.

56 – Field application relay
A relay that automatically controls the application of the field excitation to an ac motor at some predetermined point in the slip cycle.

57 – Short-circuiting or grounding device
A primary circuit switching device that functions to short circuit or ground a circuit in response to automatic or manual means.

58 – Rectification failure relay
A device that functions if a power rectifier fails to conduct or block properly.

59 – Over voltage relay
A relay that operates when its input voltage is higher than a predetermined value.

60 – Voltage or current balance relay
A relay that operates on a given difference in voltage, or current input or output, of two circuits.

61 – Density switch or sensor
A device that operates on a given value, or a given rate of change, of gas density.

62 – Time-delay stopping or opening relay
A time-delay relay that serves in conjunction with the device that initiates the shutdown, stopping, or opening operation in an automatic sequence or protective relay system.

63 – Pressure switch
A switch that operates on given values, or on a given rate of change, of pressure.

64 – Ground detector relay
A relay that operates upon failure of machine or other apparatus insulation to ground, or on flashover of a dc machine to ground.

Note: This function is assigned only to a relay which detects the flow of current from the frame of a machine or enclosing case or structure of a piece of apparatus to ground, or detects a ground on a normally ungrounded winding or circuit. It is not applied to a device connected in the secondary neutral of a current transformer, or in the secondary neutral of current transformers, connected in the power circuit of a normally grounded system.

65 – Governor
The assembly of fluid, electrical, or mechanical control equipment used for regulating the flow of water, steam, or other media to the prime mover for such purposes as starting, holding speed or load, or stopping.

66 – Notching or jogging device
A device that functions to allow only a specified number of operations of a given device or equipment, or a specified number of successive operations within a given time of each other. It is also a device that functions to energize a circuit

periodically or for fractions of specified time intervals, or that is used to permit intermittent acceleration or jogging of a machine at low speeds for mechanical positioning.

67 – Ac directional over current relay
A relay that functions on a desired value of ac over current flowing in a predetermined direction.

68 – Blocking relay
A relay that initiates a pilot signal for blocking of tripping on external faults in a transmission line or in other apparatus under predetermined conditions, or that cooperates with other devices to block tripping or to block reclosing on an out-of-step condition or on power swings.

69 – Permissive control device
Generally, a two-position device that in one position permits the closing of a circuit
breaker, or the placing of an equipment into operation, and in the other position prevents the circuit breaker or the equipment from being operated.

70 – Rheostat
A variable resistance device used in an electric circuit which is electrically operated or has other electrical accessories, such as auxiliary, position, or limit switches.

71 – Level switch
A switch that operates on given values, or on a given rate of change, of level.

72 – Dc circuit breaker
A circuit breaker used to close and interrupt a dc power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

73 – Load-resistor contactor
A contactor used to shunt or insert a step of load limiting, shifting, or indicating resistance in a power circuit, or to switch a space heater in circuit, or to switch a light, or regenerative load resistor of a power rectifier or other machine in and out of circuit.

74 – Alarm relay
A relay other than an annunciator, as covered under device function 30, that is used to operate, or that operates in connection with, a visual or audible alarm.

75 – Position changing mechanism
A mechanism that is used for moving a main device from one position to another in an equipment; for example, shifting a removable circuit breaker unit to and from the connected, disconnected, and test positions.

76 – Dc over current relay
A relay that functions when the current in a dc circuit exceeds a given value.

77 – Telemetering device
A transmitter used to generate and transmit to a remote location an electrical signal representing a measured quantity, or a receiver used to receive the electrical signal from a remote transmitter and convert the signal to represent the original measured quantity.

78 – Phase-angle measuring or out-of step
A relay that functions at a predetermined phase angle between two voltages, or between two currents, or between voltage and current.

79 – Ac reclosing relay
A relay that controls the automatic reclosing and locking out of an ac circuit interrupter.

80 – Flow switch
A switch that operates on given values, or on a given rate of change, of flow.

81 – Frequency relay
A relay that responds to the frequency of an electrical quantity, operating when the frequency or rate of change of frequency exceeds or is less than a predetermined value.

82 – Dc load-measuring reclosing relay
A relay that controls the automatic closing and reclosing of a dc circuit interrupter, generally in response to load circuit conditions.

83 – Automatic selective control or transfer relay
A relay that operates to select automatically between certain sources or conditions in equipment or that performs a transfer operation automatically.

84 – Operating mechanism
The complete electrical mechanism or servomechanism, including the operating motor, solenoids, position switches, etc., for a tap changer, induction regulator, or any similar piece of apparatus that otherwise has no device function number.

85 – Carrier or pilot-wire receiver relay
A relay that is operated or restrained by a signal used in connection with carrier-current or dc pilot-wire fault directional relaying.

86 – Lockout relay
An electrically operated hand or electrically reset auxiliary relay that is operated upon the occurrence of abnormal conditions to maintain associated equipment or devices out of service until it is reset.

87 – Differential protective relay
A protective relay that functions on a percentage, or phase angle, or other quantitative difference between two currents or some other electrical quantities.

88 – Auxiliary motor or motor generator
A device used for operating auxiliary equipment, such as pumps, blowers, exciters, rotating magnetic amplifiers, etc.

89 – Line switch
Used as a disconnecting, load interrupter, or isolating switch in an ac or dc power circuit. (This device function number is normally not necessary unless the switch is electrically operated or has electrical accessories, such as an auxiliary switch, a magnetic lock, etc.)

90 – Regulating device
Functions to regulate a quantity or quantities, such as voltage, current, power, speed, frequency, temperature, and load, at a certain value or between certain (generally close) limits for machines, tie lines, or other apparatus.

91 – Voltage directional relay
A relay that operates when the voltage across an open circuit breaker or contactor exceeds a given value in a given direction.

92 – Voltage and power directional relay
A relay that permits or causes the connection of two circuits when the voltage difference between them exceeds a given value in a predetermined direction and causes these two circuits to be disconnected from each other when the power flowing between them exceeds a given value in the opposite direction.

93 – Field-changing contactor
Functions to increase or decrease, in one step, the value of field excitation on a machine.

94 – Tripping or trip-free relay

Functions to trip a circuit breaker, contactor, or equipment, or to permit immediate tripping by other devices; or to prevent immediate reclosing of a circuit interrupter if it should open automatically, even though its closing circuit is maintained closed.

95, 96, 97, 98, 99 –

Used only for specific applications on individual installations where none of the assigned numbered functions from 1 to 94 is suitable.

Appendix C – Initial Screening of Devices

Table C-1: Initial Screening of Devices			
Device Number	**Function**	**Categorization per Step 1 – Analysis of Individual Devices**	**Further Analysis**
1	Master Element	Control device	No
2	Time-Delay Starting or Closing Relay	Typically a control device When used in a protection system, an auxiliary relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
3	Checking or Interlocking Relay	Control device	No
4	Master Contactor	Control device	No
5	Stopping Device	Control device	No
6	Starting Circuit Breaker	Primary equipment	No
7	Rate-of-rise Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility (generally an integral part of a more complex protective relay)	No
8	Control Power Disconnecting Device	Control device	No
9	Reversing Device	Control device	No
10	Unit Sequence Switch	Control device	No
11	Multifunction Device	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
12	Overspeed Device	Identified for further analysis – see Appendix D	Yes
13	Synchronous-Speed Device	Control device	No
14	Underspeed Device	Identified for further analysis – see Appendix D	Yes
15	Speed or Frequency Matching Device	Control device	No
16	(Reserved For Future Application)	Not applicable	—
17	Shunting or Discharge-Switch	Control device	No
18	Accelerating or Decelerating Device	Control device	No

Table C-1: Initial Screening of Devices			
Device Number	**Function**	**Categorization per Step 1 – Analysis of Individual Devices**	**Further Analysis**
19	Starting-to-Running Transition Contactor	Control device	No
20	Electrically Operated Valve	Primary equipment	No
21	Distance Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
22	Equalizer Circuit Breaker	Control device	No
23	Temperature Control Device	Control device	No
24	Volts-per-Hertz Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
25	Synchronizing or Synchronism Check	Subject of separate report by SAMS and SPCS	No
26	Apparatus Thermal Device	Identified for further analysis – see Appendix D	Yes
27	Undervoltage Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
28	Flame Detector	Identified for further analysis – see Appendix D	Yes
29	Isolating Contactor	Control device	No
30	Annunciator Relay	Generally provides information that is advisory in nature When used in a protection system, an auxiliary relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
31	Separate Excitation Device	Control device	No
32	Directional Power Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
33	Position Switch	Control device	No
34	Master Sequence Device	Control device	No
35	Brush-Operating or Slip-Ring Short-Circuiting Device	Control device	No
36	Polarity or Polarizing Voltage Device	Control device	No
37	Undercurrent or Underpower Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
38	Bearing Protective Device	Identified for further analysis – see Appendix D	Yes

Table C-1: Initial Screening of Devices			
Device Number	**Function**	**Categorization per Step 1 – Analysis of Individual Devices**	**Further Analysis**
39	Mechanical Condition Monitor	Identified for further analysis – see Appendix D	Yes
40	Field Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
41	Field Circuit Breaker	Primary equipment	No
42	Running Circuit Breaker	Primary Equipment	No
43	Manual Transfer or Selector Device	Control device	No
44	Unit Sequence Starting Relay	Control device	No
45	Atmospheric Condition Monitor	Identified for further analysis – see Appendix D	Yes
46	Reverse-Phase or Phase-Balance Current Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
47	Phase-Sequence or Phase Balance Voltage Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
48	Incomplete Sequence Relay	Control device	No
49	Machine or Transformer Thermal Relay	Identified for further analysis – see Appendix D	Yes
50	Instantaneous Overcurrent	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
51	AC Time Overcurrent Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
52	AC Circuit Breaker	Primary Equipment	No
53	Exciter or DC Generator Relay	Control device	No
54	Turning Gear Engaging Device	Control device	No
55	Power-Factor Relay	Control device	No
56	Field Application Relay	Control device	No
57	Short-Circuiting or Grounding Device	Primary equipment	No
58	Rectification Failure Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No

Table C-1: Initial Screening of Devices			
Device Number	**Function**	**Categorization per Step 1 – Analysis of Individual Devices**	**Further Analysis**
59	Overvoltage Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
60	Voltage or Current Balance Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
61	Density Switch or Sensor	Identified for further analysis – see Appendix D	Yes
62	Time-delay Stopping or Opening Relay	Auxiliary relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
63	Pressure Switch	Identified for further analysis – see Appendix D	Yes
64	Ground Detector Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
65	Governor	Control device	No
66	Notching or Jogging Device	Control device	No
67	AC Directional Overcurrent Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
68	Blocking Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
69	Permissive Control Device	Control device	No
70	Rheostat	Control device	No
71	Level Switch	Identified for further analysis – see Appendix D	Yes
72	DC Circuit Breaker	Primary equipment	No
73	Load-Resistor Contactor	Control device	No
74	Alarm Relay	Provides information that is advisory in nature	No
75	Position-Changing Mechanism	Control device	No
76	DC Overcurrent Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
77	Telemetering Device	Control device	No
78	Phase-Angle Measuring or Out-Of-Step Protective Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
79	AC Reclosing Relay	Subject of separate report by SAMS and SPCS	No
80	Flow Switch	Control device	No

Table C-1: Initial Screening of Devices			
Device Number	**Function**	**Categorization per Step 1 – Analysis of Individual Devices**	**Further Analysis**
81	Frequency Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
82	DC Load-Measuring Reclosing Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
83	Automatic Selective Control or Transfer Relay	Control device	No
84	Operating Mechanism	Control device	No
85	Carrier or Pilot-Wire Receiver Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
86	Lockout Relay	Auxiliary relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
87	Differential Protective Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
88	Auxiliary Motor or Motor Generator	Primary equipment	No
89	Line Switch	Primary equipment	No
90	Regulating Device	Control device	No
91	Voltage Directional Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
92	Voltage And Power Directional Relay	Protective relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
93	Field-Changing Contactor	Control device	No
94	Tripping or Trip-Free Relay	Auxiliary relay addressed by the protection system definition and subject to PRC-005 if applied on an applicable facility	No
95	(Reserved For Special Application)	Not applicable	—
96	(Reserved For Special Application)	Not applicable	—
97	(Reserved For Special Application)	Not applicable	—
98	(Reserved For Special Application)	Not applicable	—
99	(Reserved For Special Application)	Not applicable	—

Appendix D – Detailed Assessment of Devices

The SPCS reviewed a list of all IEEE/ANSI device numbers and discussed each device type. After eliminating devices already addressed by the revised definition of Protection System and devices that are clearly not protective devices, such as primary equipment and control devices, detailed analysis was performed for the following list of devices:

- Overspeed Device (12)
- Underspeed Device (14)
- Apparatus Thermal Device (26)
- Flame Detector (28)
- Bearing Protective Device (38)
- Mechanical Condition Monitor (39)
- Atmospheric Condition Monitor (45)
- Machine or Transformer Thermal Relay (49)
- Density Switch or Sensor (61)
- Pressure Switch (63)
- Level Switch (71)

For each device, a summary of the evaluation and conclusion is presented. As a result of this analysis, the SPCS concludes that the only devices responding to non-electrical quantities that should be included in the applicability of PRC-005 are sudden pressure relays utilized in a tripping function. When applied in a tripping function, these devices initiate actions to clear faults to support reliable operation of the Bulk-Power System. The other devices evaluated respond to abnormal equipment conditions and take action to protect equipment from mechanical or thermal damage or premature loss of life, rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System. Thus, these devices are not recommended for inclusion in PRC-005. The SPCS recognizes that devices that respond to abnormal equipment conditions perform an important function. However, these devices do not directly support NERC's mission to ensure the reliability of the Bulk-Power System.

Overspeed (12): Usually a direct-connected speed switch that functions on machine over speed.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to the equipment operating at an excessive speed. This device is set to operate after an electrical device responding to frequency, which is set at a lower threshold.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm, unnecessary control action, or unnecessarily removing the equipment from service. In some cases, the device is applied to primary equipment, while in other cases, it may be applied to ancillary equipment such as a fan or motor. The impact of removing BES equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Overspeed protection responds to an abnormal operating condition rather than a fault and, for generator applications, typically is not expected to operate when the generator is connected to the system, thereby limiting the potential impact to the Bulk-Power System. A failure to operate could result in damage to the generator prime mover depending on what other protection or controls operate to remove the unit from service, but would not result in removal of other elements from service.

Risk of inadvertent operation during a disturbance: The overspeed device directly measures the speed of the machine. Therefore, an overspeed device should only operate during a fault or abnormal system condition if an actual overspeed condition occurs (e.g., due to a loss of synchronism) or if an independent failure of the device occurs. There is no

operating experience in which misoperation of an overspeed device in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from mechanical damage rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Underspeed (14): A device that functions when the speed of a machine falls below a pre-determined value.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to the equipment operating at insufficient speed. This device is set to operate after an electrical device responding to frequency, which is set at a higher threshold.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm, unnecessary control action, or unnecessarily removing the equipment from service. In some cases, the device is applied to primary equipment, while in other cases, it may be applied to ancillary equipment such as a fan or motor. The impact of removing BES equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Underspeed protection responds to an abnormal operating condition rather than a fault. A failure to operate could result in damage to the generator prime mover depending on what other protection or controls operate to remove the unit from service, but would not result in removal of other elements from service.

Risk of inadvertent operation during a disturbance: The underspeed device directly measures the speed of the machine. Therefore, an underspeed device should only operate during a fault or abnormal system condition if an actual underspeed condition occurs (e.g., due to a loss of synchronism) or if an independent failure of the device occurs. There is no operating experience in which misoperation of an underspeed device in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from mechanical damage rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Apparatus thermal device (26): Functions when the temperature of the protected apparatus (other than the load-carrying windings of machines and transformers as covered by device function number 49) or of a liquid or other medium (e.g., transformer top oil temperature, which may be the most prevalent) exceeds a predetermined value; or when the temperature of the protected apparatus or of any medium decreases below a predetermined value.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to the equipment operating at an elevated temperature that may result in increased loss of life.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm or trip the equipment could lead to loss of life or equipment damage resulting from operation at elevated temperature.

Risk of inadvertent operation during a disturbance: The apparatus thermal device directly measures the temperature of the of the protected apparatus or medium. Therefore, an apparatus thermal device should only operate during a fault or abnormal system condition if the actual temperature is outside its operating limits or if an independent failure of the device occurs. There is no operating experience in which misoperation of an apparatus thermal device in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from excessive loss of life rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Flame detector (28): A device that monitors the presence of the pilot or main flame in such apparatus as a gas turbine or a steam boiler.

Action taken: This device initiates a control action to remove the fuel source from a gas turbine or steam turbine boiler in response to a loss of combustion.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: The flame detector responds to an abnormal operating condition rather than a fault. A failure to operate could result in an uncontrolled delivery of fuel that is not consumed, but would not result in removal of other elements from service.

Risk of inadvertent operation during a disturbance: The flame detector indirectly measures the presence of a flame; however, this is done by monitoring heat or radiation from the flame, which are both independent of power system conditions. Therefore, a flame detector should only operate during a fault or abnormal system condition for an actual loss of flame (e.g., flameout in a combustion turbine) or if an independent failure of the device occurs. There is no operating experience in which misoperation of a flame detector in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from mechanical damage rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Bearing protective device (38): Functions on excessive bearing temperature or on other abnormal mechanical conditions associated with the bearing, such as undue wear, which may eventually result in excessive bearing temperature or failure.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to an abnormal condition such as the bearing operating at an elevated temperature. The device typically alarms at one level. When tripping is provided, such as for a hydraulic unit thrust bearing, it trips at a second level.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm or trip the equipment could lead to loss of life or excessive wear, and may eventually lead to failure of the bearing.

Risk of inadvertent operation during a disturbance: The bearing protective device indirectly measures the temperature or other physical condition of the bearing; however, this is done by monitoring mechanical quantities in proximity to the bearing which are independent of power system conditions. Therefore, a bearing protective device should only operate during a fault or abnormal system condition for an actual bearing problem or if an independent failure of the device occurs. There is no operating experience in which misoperation of a bearing protective device in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from excessive loss of life or eventual failure rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Mechanical condition monitor (39): A device that functions upon the occurrence of an abnormal mechanical condition (except that associated with bearings as covered under device function 38), such as excessive vibration, eccentricity, expansion, shock, tilting, or seal failure.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to an abnormal mechanical condition of the equipment. The device typically alarms at one level, and either provides a second alarm or trips at a second level.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm or trip the equipment could lead to loss of life or equipment damage.

Risk of inadvertent operation during a disturbance: The mechanical condition monitor indirectly measures the physical condition of the protected device; however, this is done by monitoring mechanical quantities in proximity to the device which are independent of power system conditions. Therefore, a mechanical condition monitor should only operate during a fault or abnormal system condition for an actual mechanical problem or if an independent failure of the device occurs. There is no operating experience in which misoperation of a mechanical condition in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from excessive loss of life or eventual failure rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Atmospheric condition monitor (45): A device that functions upon the occurrence of an abnormal atmospheric condition, such as damaging fumes, explosive mixtures, smoke, or fire.

Action taken: This device provides an alarm or shuts down a process and prevents restarting until normal atmospheric conditions are restored.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily shutting down a process. When shutting down a process results in removing equipment from service, the impact would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm or trip the equipment could lead to an unsafe operating condition and the potential for equipment damage.

Risk of inadvertent operation during a disturbance: The atmospheric condition monitor directly or indirectly measures atmospheric conditions; however, even indirect measurement is accomplished by monitoring atmospheric conditions local to the equipment. Therefore, an atmospheric condition monitor should only operate during a fault or abnormal system condition if the power system event affected atmospheric conditions, or if an independent failure of the monitor occurs. There is no operating experience in which misoperation of an atmospheric condition monitor in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from excessive loss of life rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Machine or transformer thermal relay (49): A relay that functions when the temperature of a machine armature winding or other load-carrying winding or element of a machine or power transformer exceeds a predetermined value.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to the equipment operating at an elevated temperature that may result in increased loss of life.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm or trip the equipment could lead to loss of life resulting from operation at elevated temperature.

Risk of inadvertent operation during a disturbance: The machine or transformer thermal relay indirectly measures the temperature of the of the winding; however, this is accomplished by measuring the temperature of the medium in which the winding is contained. Therefore, a thermal relay should only operate during a fault or abnormal system condition if the calculated temperature is outside its operating limits or if an independent failure of the relay occurs. There is no operating experience in which misoperation of a thermal relay in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from excessive loss of life rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Density switch or sensor (61)[5]: A device that operates on a given value, or a given rate of change, of gas density.

Action taken: This device activates a visual indicator and/or switch to provide an alarm in response to a change in gas density within the equipment it is monitoring. In some cases, activation of a switch associated with this device, trips, or blocks tripping of, the affected equipment.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm, trip, or lockout the equipment could lead to loss of life resulting from operation at low gas density levels.

Risk of inadvertent operation during a disturbance: The density switch or sensor may directly or indirectly measure gas density; however, even indirect measurement is accomplished by measuring both pressure and temperature of the gas. Therefore, a density switch or sensor should only operate during a fault or abnormal system condition if the gas density is outside its operating limits or if an independent failure of the switch or sensor occurs. There is no operating experience in which misoperation of a density switch or sensor in response to a system disturbance has contributed to a cascading event.

[5] Gas density is affected by changes in pressure and temperature. Gas density monitors are modified pressure measuring instruments with electrical accessories. Gas density monitors typically combine both measuring and switching functions in one single instrument. Because gas density is strongly affected by changes in pressure, the switching functions provided with a gas density monitor are often labeled "63" rather than "61".

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from excessive loss of life rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Pressure switch (63): A switch that operates on given values, or on a given rate of change, of pressure.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to changes in pressure within a device such as a circuit breaker or transformer.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm or trip the equipment could lead to unavailability of the equipment, loss of life resulting from operation at low pressure, or extended exposure to fault current.

Risk of inadvertent operation during a disturbance: The pressure switch directly measures pressure of the monitored medium. A pressure switch should only operate during a fault or abnormal system condition if a pressure exceeds the level necessary to operate the device. In some applications, such as transformer sudden pressure relays used to detect faults internal to a transformer, the pressure switch may operate due to a pressure change associated with through-fault current caused by an external fault. There is no operating experience in which misoperation of a pressure switch in response to a system disturbance has contributed to a cascading event; however, inadvertent operation for an external fault could result in tripping additional system elements.

Conclusion: This device responds to an abnormal equipment condition, such as low gas or air pressure, as well as rapid pressure rises associated with faults in oil-filled equipment (e.g., transformers and shunt reactors). Where this device is applied to respond to abnormal equipment conditions, it takes action to protect the equipment from excessive loss of life or to indicate unavailability of service, rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System. Where the device is installed to respond to rapid pressure rise in facilities described in the applicability section of Reliability Standard PRC-005, and configured to take action to initiate fault clearing to support reliable operation of the Bulk-Power System, it should be included as a device to be maintained and tested.

Level switch (71): A switch that operates on given values, or on a given rate of change, of level.

Action taken: This device provides an alarm, and in some cases trips the affected equipment, in response to changes in level within the equipment it is monitoring.

Impact of inadvertent operation: Inadvertent operation would result in a nuisance alarm or unnecessarily removing the equipment from service. The impact of removing the equipment from service would be the same as for a TPL-002-0b Category B contingency, "Loss of an Element without a Fault," for which the system is designed and operated to withstand.

Impact of failure to operate: Failure to alarm, or trip the equipment could lead to loss of life resulting from operation at undesirable levels.

Risk of inadvertent operation during a disturbance: The level switch directly measures liquid level in a device. Therefore, a level switch should only operate during a fault or abnormal system condition if the level is outside its operating limits or if an independent failure of the switch occurs. There is no operating experience in which misoperation of a level switch in response to a system disturbance has contributed to a cascading event.

Conclusion: This device responds to an abnormal equipment condition and takes action to protect the equipment from excessive loss of life rather than for the purpose of initiating fault clearing or mitigating an abnormal system condition to support reliable operation of the Bulk-Power System.

Appendix E – SPCS Sudden Pressure Relay Survey

NERC System Protection and Control Subcommittee (SPCS)

Questionnaire on Maintenance Practices for Fault Pressure Relays
(Sudden Pressure, Rapid Pressure Rise, Buchholz, etc)

Purpose: The SPCS is seeking industry input concerning present industry practices related to the maintenance and testing of Fault Pressure Relays (relays which operate on pressure changes caused by faults) applied on Transmission equipment. This survey pertains specifically to three types of relays:

- Sudden Pressure Relay (SPR)- these devices are mounted on the outside of the transformer and operate on an increase in gas pressure.
- Rapid Pressure Rise Relay (RPR)- these devices are mounted on the outside of the transformer and operate on an increase in oil pressure.
- Buchholz relays- these devices are mounted on some oil-filled power transformers and reactors, equipped with an external overhead oil reservoir called a conservator and detect when oil flows rapidly into the conservator.

Company Name: _____

Survey response from: Transmission _____ Generation _____ Both _____

Note: If practices are different for Transmission and Generation, please provide separate responses

1. Does your company utilize Fault Pressure Relays in the 'trip' application?
   SPR Yes_____ No _____
   RPR Yes_____ No _____
   Buchholz Yes_____ No _____

2. Does your company have a 'maintenance' program in place for these devices?
   SPR Yes _____ No _____
   RPR Yes _____ No _____
   Buchholz Yes_____ No _____
3. Does your company's 'maintenance' program include verifying the trip circuit associated with the Fault Pressure Relay?
   Yes____ No ____ N/A _____ If Yes, what is the prescribed or expected interval. _____

4. Does your company's 'maintenance' program include verifying the operation of the 'pressure actuation' portion of the Sudden Pressure Relay?
   SPR Yes_____ No _____ If Yes, prescribed or expected interval? _____
   RPR Yes_____ No _____ If Yes, prescribed or expected interval? _____
   Buchholz Yes_____ No _____ If Yes, prescribed or expected interval? _____

   If Yes, does your company simulate an 'operate' and a 'non-operate' condition with some form of pressure test? Yes_____ No ____

5. Are there any other activities that are included in the maintenance of Sudden Pressure Relays?
   Yes____ No _____ If so, please describe:

6. Does your company use another type of Fault Pressure Relay not listed above? Yes ____ No _____
   If so, please describe:

Appendix F – System Protection and Control Subcommittee

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