MILLSTONE NUCLEAR POWER STATION UNIT 3

design basis response to regulatory guide 1.97, revision 2

Millstone 3 Design Basis to Respond to Regulatory Guide 1.97 Rev. 2

Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident

This document presents Northeast Utilities' interpretation of what is required to meet the intent of Regulatory Guide 1.97 Revision 2 for the Millstone 3 plant. It should not be construed as the definition of the minimum set of instruments needed to safely operate this plant.

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Acronyms

AFW	-	Auxiliary Feedwater
CCW	-	Component Cooling Water
CFR	-	Code of Federal Regulations
CST	-	Condensate Storage Tank
EOP	-	Emergency Operating Procedure
ECCS	-	Emergency Core Cooling System
HHSI	-	High Head Safety Injection
ICC	-	Inadequate Core Cooling
LHSI	-	Low Head Safety Injection
LOCA	-	Loss of Coolant Accident
MSIV	-	Main Steamline Isolation Valve
NDT	-	Nil-ductility Transition
NPSH	-	Net Positive Suction Head
PAMS	-	Post Accident Monitoring System
RCS	-	Reactor Coolant System
RWST	-	Refueling Water Storage Tank
RHRS	-	Residual Heat Removal System
SW	-	Service Water
SI	-	Safety Injection
SGTR	-	Steam Generator Tube Rupture
S/G	-	Steam Generator
T_{Hot}	-	Wide Range Hot Leg Reactor Coolant Temperature
T_{Cold}	-	Wide Range Cold Leg Reactor Coolant Temperature

1.0 DISCUSSION

An analysis was conducted to develop a response to the intent of Regulatory Guide 1.97, Rev. 2. This analysis identified the appropriate variables and established appropriate design bases and qualification criteria for instrumentation employed by the control room operator during and following an accident.

This design basis establishes the key and preferred backup variables to be monitored by the control room operating staff of the Millstone 3 Nuclear Plant following the initiation of an accident. The design basis recognizes the variables essential to the control room staff up to the time other Emergency Operating Facilities are manned as well as the information essential to the control room staff in subsequently controlling the plant and proceeding to safe shutdown conditions. Also included are criteria for determining the requirements for the instruments used to monitor these variables.

The design bases for the processing and display of information (Safety Parameter Display System (SPDS) and Control Room Design Review) are not presented here, and will be sent at a later date. The detailed methodology for the handling of display will be discussed in conjunction with programs to address NUREG-0696 and NUREG-0700. Section 3 describes interface criteria which must be satisfied for the display methodology to meet the intent of Regulatory Guide 1.97 Revision 2 and this design basis.

1.1 Planned Versus Unplanned Operator Actions

The plant safety analyses and evaluations define the design basis accident event scenarios for which pre-planned operator actions are required. Accident monitoring instrumentation is necessary to permit the operator to take required actions to address these analyzed situations. However, instrumentation is also necessary for unplanned situations (i.e., to ensure that, should plant conditions evolve differently than predicted by the safety analyses, the operator has sufficient

information to monitor the course of the event). Additional instrumentation is also needed to indicate to the operator whether the integrity of the in-core fuel clad, the reactor coolant system pressure boundary, or the primary reactor containment has degraded beyond the prescribed limits defined as a result of the plant safety analyses and other evaluations. Such additional requirements are considered by this design basis.

1.2 Variable Types

Five classifications of variables have been identified. Operator manual actions identified in the operating procedures, associated with design basis accident events, are pre-planned. Those variables that provide information needed by the operator to perform these manual actions are designated Type A. The basis for selecting Type A variables is given in Section 2.2.1.

Those variables needed to assess that the plant critical safety functions are being accomplished or maintained, as identified in the plant safety analysis and other evaluations, are designated Type B.

Variables used to monitor for the gross breach or the potential gross breach of the in-core fuel clad, the reactor coolant system pressure boundary, or the primary reactor containment, are designated Type C. Type C variables used to monitor the potential breach of containment have an extended range. The extended range shall be chosen to minimize the probability of instrument saturation even if conditions exceed those predicted by the safety analysis. The response characteristics of Type C information display channels shall allow the control room operator to detect conditions indicative of gross failure of any of the three fission product barriers or the potential for gross failure of these barriers. Although variables selected to fulfill Type C functions may rapidly approach the values that indicate an actual gross failure, it is the final steady-state value reached that is important. Therefore, a high degree of accuracy and a rapid response time are not necessary for Type C information display channels.

Those variables needed to assess the operation of individual safety systems and other systems important to safety are designated Type D.

The variables that are required for use in determining the magnitude of the release and in continually assessing any releases of radioactive materials are designated Type E.

The five classifications are not mutually exclusive; that is, a given variable (or instrument) may be included in one or more types. This differentiation by variable type is intended only to guide the designer in his selection of accident monitoring variables and applicable criteria. The cross referencing of Variable to Types is given in Section 9.

1.3 Design and Qualification Criteria

Three categories of design and qualification criteria are identified. The differentiation is made in order that an importance of information hierarchy can be recognized in specifying post-accident monitoring instrumentation. Category 1 instrumentation has the highest pedigree and should be utilized for information which cannot be lost under any circumstances. Category 2 and 3 instruments are of lesser importance in determining the state of the plant and do not require the same level of operational assurance.

The primary differences between category requirements are in qualification, application of single failure criterion, power supply, and display requirements. Category 1 requires seismic and environmental qualification, the application of a single failure criterion, utilization of emergency standby power, and an immediately accessible display. Category 2 requires qualification commensurate with the required function but does not require the single failure criterion, emergency standby power, or an immediately accessible display. Category 2 requires, in effect, a rigorous performance verification for a single instrument channel. Category 3 does not require qualification, single failure criterion, emergency standby power, or an immediately accessible display.

2.0 DEFINITION OF VARIABLE TYPES

2.1 Definitions

2.1.1 Design Basis Accident Events

Those events, any one of which may occur during the lifetime of a particular plant, and those events not expected to occur but postulated because their consequences would include the potential for release of significant amounts of radioactive gaseous, liquid, or particulate material to the environment. Excluded are those events (defined as "normal" and "anticipated operational occurrences" in 10 CFR 50) expected to occur more frequently than once during the lifetime of a particular plant. The limiting accidents that were used to determine instrument functions are: 1) LOCA, 2) Steamline Break, 3) Feedwater Line Break, and 4) Steam Generator Tube Rupture.

2.1.2 Hot Standby

The state of the plant in which the reactor is subcritical such that K_{eff} is less than or equal to 0.99 and the reactor coolant system temperature is greater than or equal to $350^{o}F$.

2.1.3 Safe Shutdown (Cold Shutdown)

The state of the plant in which the reactor is subcritical such that K_{eff} is less than or equal to 0.99, the reactor coolant system temperature is less than $200^{o}F$, and the reactor coolant system pressure is less than or equal to 10 CFR 50 Appendix G limits.

2.1.4 Controlled Condition

The state of the plant that is achieved when the "subsequent action" portion of the plant emergency procedures is implemented

and the critical safety functions are being accomplished or maintained by the control room operator.

2.1.5 Critical Safety Functions

Those safety functions that are essential to prevent a direct and immediate threat to the health and safety of the public. These are the accomplishing or maintaining of:

1) reactivity control
2) reactor coolant system pressure control
3) reactor coolant inventory control
4) reactor core cooling
5) heat sink maintenance
6) primary reactor containment integrity.

2.1.6 Immediately Accessible Information

Information that is visually available to the control room operator immediately (i.e., within human response time requirements), after he has made the decision that the information is needed.

2.1.7 Primary Information

Information that is essential for the direct accomplishment of the pre-planned manual actions specified in the EOP's; it does not include those variables that are associated with contingency actions.

2.1.8 Contingency Actions

Those manual actions specified in the EOP's that address conditions beyond the Design Basis Accident Events.

2.1.9 Key Variables

Those variables which provide the most direct measure of the information required.

2.1.10 Backup Information

That information, made up of additional variables beyond those classified as key, that provides supplemental and/or confirmatory information to the operator. Backup variables do not provide an indication which is as reliable or complete as that provided by primary variables, and they should not be relied upon as the sole source of information.

2.2 Variable Functions

The accident monitoring variables and information display channels are those that are required to enable the Control Room Operating Staff to perform the functions defined by Types A, B, C, D, and E below.

2.2.1. For Type A (Note 1):

Those variables that provide the primary information required to permit the Control Room Operating Staff to:

- Take the specified pre-planned manually controlled actions, for which no automatic control is provided, that are required for safety systems to accomplish their safety function in order to recover from the Design Basis Accident Event (Note 2), and

- Reach and maintain a cold shutdown condition.

Note 1: Consistent with the definition of Type A in Regulatory Guide 1.97 Revision 2, the verification of the actuation of safety systems has been excluded from the definition of Type A. The variables which provide this verification are included in the definition of Type D.

Note 2: Variables in Type A are restricted to pre-planned actions for Design Basis Accident Events. Contingency actions and additional variables which might be utilized in these procedures will be in Types B, C, D, and E.

2.2.2 For Type B:

Those variables that provide to the Control Room Operating Staff information to assess the process of accomplishing or maintaining critical safety functions, i.e., reactivity control, reactor coolant system pressure control, reactor coolant inventory control, reactor core cooling, heat sink maintenance, and primary reactor containment integrity.

2.2.3 For Type C (Note 3):

Those variables that provide to the Control Room Operating Staff information to monitor (1) the extent to which variables, which indicate the potential for causing a gross breach of a fission product barrier, have exceeded the design basis values and (2) that the in-core fuel clad, the reactor coolant system pressure boundary or the primary reactor containment may have been subject to gross breach. These variables include those required to initiate the early phases of the emergency plan. Excluded are those associated with monitoring of radiological release from the plant which are included in Type E.

Note 3: Type C variables used to monitor the potential for breach of a fission product barrier have an extended range. The extended range is chosen to minimize the probability of instrument saturation even if conditions exceed those predicted by the safety analyses.

2.2.4 For Type D:

Those variables that provide to the Control Room Operating Staff sufficient information (Note 4) to monitor the performance of:

1) plant safety systems employed for mitigating the consequences of an accident and subsequent plant recovery to attain a cold shutdown condition. These include verification of the automatic actuation of safety systems, and

2) other systems normally employed for attaining a cold shutdown condition.

Note 4: To the extent feasible, this should be a direct measurement.

2.2.5 For Type E:

Those variables that provide the Control Room Operating Staff with information to:

1) Estimate the magnitude of release of radioactive materials through identified pathways.

3.0 CRITERIA

3.1 General Requirements

The following design and qualification criteria are applied to instrumentation for Type A, B, C, D and E variables. These are summarized in Tables 3-1 and 3-2.

3.2 Equipment Design and Qualification Criteria

The qualification requirements of the Type A, B, C, D, and E accident monitoring instrumentation are subdivided into three categories (1, 2, 3). Descriptions of the three categories are given below. Table 3-2 briefly summarizes the design and qualification requirements of the three designated categories.

3.2.1 Design and Qualification Criteria - Category 1

3.2.1.1 Selection Criteria - Category 1

The selection criteria for Category 1 variables have been subdivided according to the variable type. For Type A, those key variables used for diagnosis or providing information for necessary operator action are designated Category 1. (This does not include all Type A variables). For Type B, those key variables which are used for monitoring the process of accomplishing or maintaining critical safety functions are designated Category 1. For Type C, those key variables which are used for monitoring the potential for breach of a fission product barrier are designated Category 1.

3.2.1.2 Qualification Criteria - Category 1

The instrumentation is environmentally qualified in accordance with the Commissioners Memorandum and Order (CLI-80-21). The seismic portion of qualification is in accordance with Regulatory Guide 1.100. Instrumentation shall continue to read within the required accuracy following but not necessarily during a seismic event. At least one instrumentation channel is qualified from sensor to display. For the balance of instrumentation channels, qualification applies up to and includes the channel isolation device. (Refer to section 3.3 in regard to extended range instrumentation qualification).

3.2.1.3 Design Criteria - Category 1

(1) No single failure within either the accident-monitoring instrumentation, its auxiliary supporting features, or its power sources, concurrent with the failures that are a condition of or result from a specific accident, prevents the operator from being presented the required information. Where failure of one accident-monitoring channel results in information ambiguity (e.g., the redundant displays disagree), additional information is provided to allow the operator to deduce the actual conditions in the plant (Note 1). This is accomplished by providing additional independent channels of information of the same variable (addition of an

Note 1: If ambiguity does not result from failure of the channel, then a third redundant or diverse channel is not required.

identical channel), or by providing independent channels which monitor different variables which bear known relationships to the multiple channels (addition of a diverse channel(s)) (Note 2). Redundant or diverse channels are electrically independent and physically separated from each other, to the extent practicable with two train separation, and from equipment not classified important to safety in accordance with Regulatory Guide 1.75, "Physical Independence of Electric Systems."

Note 2: For situations such as isolation valves in series, the intent is generally to verify the isolation function. In such a situation a single indication on each valve is sufficient to satisfy the single failure criterion if those indications are from different trains (i.e. unambiguous indication of isolation).

(2) The instrumentation is energized from station emergency standby power sources, battery backed where momentary interruption is not tolerable, as provided in Regulatory Guide 1.32, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants."

(3) The out-of-service interval is based on normal Technical Specification requirements on out-of-service for the system it serves where applicable or where specified by other requirements.

(4) Servicing, testing, and calibration programs are specified to maintain the capability of the monitoring instrumentation. For those instruments where the required interval between testing is less

than the normal time interval between generating station shutdowns, a capability for testing during power operation is provided.

(5) Whenever means for removing channels from service are included in the design, the design facilitates administrative control of the access to such removal means.

(6) The design facilitates administrative control of the access to all setpoint adjustments, module calibration adjustments, and test points.

(7) The monitoring instrumentation design minimizes the development of conditions that would cause meters, annunciators, recorders, alarms, etc., to give anomalous indications potentially confusing to the operator.

(8) The instrumentation is designed to facilitate the recognition, location, replacement, repair, or adjustment of malfunctioning components or modules.

(9) To the extent practicable, monitoring instrumentation inputs are from sensors that directly measure the desired variables. An indirect measurement is made only when it can be shown by analysis to provide unambiguous information.

(11) Periodic checking, testing, calibration, and calibration verification is in accordance with the applicable portions of Regulatory Guide 1.118, "Periodic Testing of Electric Power and Protection Systems."

(11) The range selected for the instrumentation encompasses the expected operating range of the variable being monitored to the extent that saturation does not negate the required action of the instrument in accordance with the applicable portions of Regulatory Guide 1.105, "Instrument Setpoints."

3.2.1.4 Information Processing and Display Interface Criteria - Category 1

The interface criteria specified here provide requirements to be implemented in the establishment of the design basis for processing and displaying of the information. The design basis for information processing and displaying is the subject of a separate document.

(1) The operator has immediate access to the information from redundant or diverse channels in units familiar to the operator (i.e., for a temperature reading degrees not volts). Where two or more instruments are needed to cover a particular range, overlapping of instrument spans is provided.

(2) Where trend or transient information is needed, a historical record of a minimum of one instrumentation channel for each process variable is maintained. A recorded pre-event history for these channels is required for a minimum of one hour and continuous recording of these channels is required following an accident until such time as continuous recording of such information is no longer deemed necessary. This recording is available when required, but need not be immediately accessible. One hour was selected based on a representative

slow transient which is bounded by this time requirement. A one-half inch LOCA was selected since trip occurs at approximately fifty minutes after initiation. Where direct and immediate trend or transient information is essential for operator information or action, the recording is immediately accessible.

3.2.2 Design and Qualification Criteria - Category 2

3.2.2.1 Selection Criteria - Category 2

The selection criteria for Category 2 variables are subdivided according to the variable type. For Types A, B, and C, those variables which provide preferred backup information and are subject to a HELB environment when required to perform their functions, are designated Category 2. For Type D, those key variables that are used for monitoring the performance of safety systems, are designated Category 2. For Type E, those key variables to be monitored for use in determining the magnitude of the release of radioactive materials and for continuously assessing such releases, are designated Category 2.

3.2.2.2 Qualification Criteria - Category 2

Category 2 instrumentation are qualified in accordance with the Commissioners Memorandum and Order (CLI-80-21) for at least the environment (seismic and/or environmental) in which it must operate to serve its intended function.

3.2.2.3 Design Criteria - Category 2

(1) The instrumentation is energized from a highly reliable on-site power source, not necessarily the emergency standby power, which is battery backed where momentary interruption is not tolerable.

(2) The out-of-service interval is based on normal Technical Specification requirements on out-of-service for the system it serves where applicable or where specified by other requirements.

(3) Servicing, testing, and calibration programs is specified to maintain the capability of the monitoring instrumentation. For those instruments where the required interval between testing is less than the normal time interval between generating station shutdowns, a capability for testing during power operation is provided.

(4) Whenever means for removing channels from service are included in the design, the design facilitates administrative control of the access to such removal means.

(5) The design facilitates administrative control of the access to all setpoint adjustments, module calibration adjustments, and test points.

(6) The monitoring instrumentation design minimizes the development of conditions that would cause meters, annunciators, recorders, alarms, etc., to give anomalous indications potentially confusing to the operator.

(7) The instrumentation is designed to facilitate the recognition, location, replacement, repair, or adjustment of malfunctioning components or modules.

(8) To the extent practicable, monitoring instrumentation inputs are from sensors that directly measure the desired variables. An indirect measurement is made only when it can be shown by analysis to provide unambiguous information.

(9) Periodic checking, testing, calibration, and calibration verification is in accordance with the applicable portions of Regulatory Guide 1.118, "Periodic Testing of Electric Power and Protection Systems."

(10) The range selected for the instrumentation encompasses the expected operating range of the variable being monitored to the extent that saturation does not negate the required action of the instrument in accordance with the applicable portions of Regulatory Guide 1.105, "Instrument Setpoints."

3.2.2.4 Information Processing and Display, Interface Criteria - Category 2

The interface criteria specified here provide requirements to be considered in the establishment of the design basis for processing and displaying of the information. The design basis for information processing and displaying is the subject of a separate document.

The instrumentation signal is, as a minimum, processed for display on demand. Recording requirements are variable specific and are determined on a case-by-case basis.

3.2.3 Design and Qualification Criteria - Category 3

3.2.3.1 Selection Criteria - Category 3

The selection criteria for Category 3 variables are subdivided according to the variable type. For Types A, B, and C, those variables which provide preferred backup information and are not subject to a HELB environment when required to perform their functions are designated Category 3. For Types D and E, those variables which provide preferred backup information are designated Category 3.

3.2.3.2 Qualification Criteria - Category 3

The instrumentation is high quality commercial grade which is not required to provide information when exposed to a post-accident adverse environment. Only normal and abnormal environments are applicable.

3.2.3.3 Design Criteria - Category 3

(1) Servicing, testing, and calibration programs are specified to maintain the capability of the monitoring instrumentation. For those instruments where the required interval between testing is less than the normal time interval between generating station shutdowns, a capability for testing during power operation is provided.

(2) Whenever means for removing channels from service are included in the design, the design facilitates administrative control of the access to such removal means.

(3) The design facilitates administrative control of the access to all setpoint adjustments, module calibration adjustments, and test points.

(4) The monitoring instrumentation design minimizes the development of conditions that would cause meters, annunciators, recorders, alarms, etc., to give anomalous indications potentially confusing to the operator.

(5) The instrumentation is designed to facilitate the recognition, location, replacement, repair, or adjustment of malfunctioning components or modules.

(6) To the extent practicable, monitoring instrumentation inputs are from sensors that directly measure the desired variables. An indirect measurement shall be made only when it is shown by analysis to provide unambiguous information.

3.2.3.4 Information Processing and Display, Interface Criteria - Category 3

The interface criteria specified here provide requirements to be considered in the establishment of the design basis for processing and displaying of the information. The design basis for information processing and displaying is the subject of a separate document.

The instrumentation signal is, as a minimum, processed for display on demand. Recording requirements are variable specific and are determined on a case-by-case basis.

3.3 Extended Range Instrumentation Qualification Criteria

The qualification environment for extended range information display channel components is based on the design basis accident events, except the assumed maximum of the value of the monitored variable is the value equal to the specified maximum range for the variable. The monitored variable is assumed to approach this peak by extrapolating the most severe initial ramp associated with the Design Basis Accident Events. The decay for this variable is considered proportional to the decay for this variable associated with the Design Basis Accident Events. No additional qualification margin needs to be added to the extended range variable. All environmental envelopes except that pertaining to the variable measured by the information display channel are those associated with the Design Basis Accident Events. The environmental qualification requirement for extended range equipment does not account for steady-state elevated levels that may occur in other environmental parameters associated with the extended range variable. For example, a sensor measuring containment pressure must be qualified for the measured process variable range (i.e., 3 times design pressure for concrete containments), but the corresponding ambient temperature is not mechanistically linked to that pressure. Rather, the ambient temperature value is the bounding value for design basis accident events analyzed in Chapter 15 of the FSAR. The extended range requirement is to ensure that the equipment will continue to provide information if conditions degrade beyond those postulated in the safety analysis. Since extended variable ranges are nonmechanistically determined, extension of associated parameter levels is not justifiable and is therefore not required.

Table 3-1

Summary of Selection Criteria

TYPE	CATEGORY 1	CATEGORY 2	CATEGORY 3
A	KEY variables that are used for diagnosis or providing information for necessary operator action	Variables which provide PREFERRED BACKUP information and ARE subject to a HELB when required to perform their functions	Variables which provide PREFERRED BACKUP information and ARE NOT subject to a HELB when required to perform their functions
B	KEY variables that are used for monitoring the process of accomplishing or maintaining critical safety functions	Variables which provide PREFERRED BACKUP information and ARE subject to a HELB when required to perform their functions	Variables which provide PREFERRED BACKUP information and ARE NOT subject to a HELB when required to perform their functions
C	KEY variables that are used for monitoring the potential for breach of a fission product barrier	Variables which provide PREFERRED INFORMATION and ARE subject to a HELB when required to perform their functions	Variables which provide PREFERRED BACKUP information and ARE NOT subject to a HELB when required to perform their functions
D	KEY variables that are used for monitoring the performance of safety systems, which are essential to maintaining critical safety functions and which may lead the operator to take contingency actions that are not necessary and would be adverse to safety.	KEY variables (which have not been included under Category 1) which are used for monitoring the performance of plant systems	Variables which provide PREFERRED BACKUP information which are used for monitoring the performance of plant systems
E	None	KEY variables to be monitored for use in determining the magnitude of the release of radioactive materials and for continuously assessing such releases	Variables to be monitored which provide PREFERRED BACKUP information for use in determining the magnitude of the release of radioactive materials and for continuously assessing such releases

Table 3-2

Summary of Design, Qualification, and Interface Requirements

Qualification	Category 1	Category 2	Category 3
Environmental	Yes	As appropriate	No
Seismic	Yes	As appropriate	No
Design			
Single Failure	Yes	No	No
Power Supply	Emergency Standby	On-Site	As Required
Channel out of Service	Technical Specifications	Technical Specifications	No
Testability	Yes	Yes	As Required
Interface			
Minimum Indication	Immediately Accessible	Demand	Demand
Recording	Yes	As Required	As Required

SECTION 4.0

TYPE A VARIABLES

4.1 Introduction

Type A Variables are defined in Section 2.2.1. They are the variables which provide primary information required to permit the Control Room Operating Staff to:

1. Take specified pre-planned manually controlled actions, for which no automatic control is provided, that are required for safety systems to accomplish their safety function to recover from the Design Basis Accident Event (Verification of actuation of safety systems is excluded from Type A and is included as Type D);

2. Reach and maintain a cold shutdown condition

Key Type A variables are designated Category 1. These are the variables which provide the most direct measure of the information required. The KEY Type A variables are

1. RCS Pressure (Wide Range)

2. Hot Leg Reactor Coolant Temperature (Wide Range T_{hot})

3. Cold Leg Reactor Coolant Temperature (Wide Range T_{cold})

4. Wide Range Steam Generator Level

5. Narrow Range Steam Generator Level

6. Pressurizer Level

7. Primary Reactor Containment Pressure

8. Steamline Pressure

9. Refueling Water Storage Tank (RWST) Level

11. Containment High Range Internal Radiation Monitor

11. Core Exit Temperature

12. Auxiliary Feedwater Flow

13. Containment Water Level (Wide Range)

14. Fuel Drop Monitors (Containment Radiation)

15. RCS Pressure (Extended Range)

16. Containment Hydrogen Concentration

Preferred backup Type A Variables are designated Category 2. Only RCS Subcooling is designated as Type A, Category 2. It is recognized that the degree of subcooling can be obtained from System Pressure and Temperature using Type A Category 1 variables and a Steam Table. However, it is also recognized that the operator will most likely use his subcooling monitor (required by the NRC's post-TMI Action Plan). Therefore, RCS Subcooling is considered a backup Type A which in turn requires Category 2 qualification.

No Type A Variables have been designated Category 3.

TABLE 4-1

SUMMARY OF TYPE A VARIABLES

RCS Pressure	A1
Wide Range T_{hot}	A1
Wide Range T_{cold}	A1
Wide Range S/G Level	A1
Narrow Range S/G Level	A1
Pressurizer Level	A1
Primary Reactor Containment Pressure	A1
Steamline Pressure	A1
Refueling Water Storage Tank (RWST) Level	A1
Containment High Range Internal Radiation Monitor	A1
Core Exit Temperature	A1
Auxiliary Feedwater Flow	A1
Containment Hydrogen Concentration	A1
RCS Subcooling	A2
Containment Water Level (Wide Range)	A1
Fuel Drop Monitors (Containment Radiation)	A1
RCS Pressure (Extended Range)	A1

SECTION 5.0

TYPE B VARIABLES

5.1 Introduction

Type B variables are defined in Section 2.2.2. They are the variables that provide to the Control Room Operating Staff information to assess the process of accomplishing or maintaining critical safety functions, i.e.

1. Reactivity Control

2. Reactor Coolant System Pressure Control

3. Reactor Coolant Inventory Control

4. Reactor Core Cooling

5. Heat Sink Maintenance

6. Primary Reactor Containment Integrity

Variables which provide the most direct indication (i.e. KEY variable) to assess each of the 6 critical safety functions are designated Category 1. Preferred backup variables have been designated Category 2 (if subject to high energy line break (HELB) environment when required) or Category 3 (if not subject to HELB when required). These are listed in Table 5.1.

Table 5.1

Summary of Type B Variables

Reactivity Control	Key:	Neutron Flux	B1
	Preferred	a. Wide Range T_{Hot}	B2
	Backup:	b. Wide Range T_{Cold}	B2
		c. Control Rod Position	B3
Reactor Coolant System Pressure Control	Key:	RCS Pressure (WR)	B1
	Preferred	a. Containment Pressure	B2
	Backup:	b. Wide Range S/G Level	B2
Reactor Coolant Inventory Control	Key:	Pressurizer Level	B1
	Preferred	a. Containment Water Level (Wide Range)	B2
	Backup:	b. Wide Range S/G Level	B2
Reactor Core Cooling	Key:	Core Exit Temperature	B1
	Preferred	a. Wide Range T_{Hot}	B2
	Backup:	b. Wide Range T_{Cold}	B2
		c. RCS Pressure (WR)	B2
		d. RCS Subcooling	B2
Heat Sink Maintenance	Key:	a. Narrow Range S/G Level	B1
		b. Wide Range S/G Level	B1
		c. Steamline Pressure	B1
		d. Core Exit Temperature	B1
	Preferred	a. Main Steamline Isolation and Bypass Valve Status	B2
	Backup:		
Primary Reactor Containment Integrity	Key:	a. Containment Pressure	B1
		b. Containment Hydrogen	B1
	Preferred	None	
	Backup:		

SECTION 6
Type C Variables

6.1 INTRODUCTION

Type C variables are defined in Section 2.2.3. Basically, they are the variables that provide to the Control Room Operating Staff information to monitor the potential for breach or actual gross breach of:

1. In-core fuel clad;
2. Reactor Coolant System Boundary; or
3. Primary Reactor Containment Boundary.

(Variables associated with monitoring of radiological release from the plant are included in Type E).

Those Type C key variables which provide the most direct measure of the POTENTIAL for breach of one of the 3 fission product boundaries are designated Category 1. Backup information indicating potential for breach is designated Category 2. Variables which indicate actual breach have been designated as preferred backup information and have been designated to Category 2 or Category 3 depending on Qualification Requirements.

Table 6-1 summarizes the selection of Type C variables.

TABLE 6-1 - Type C

	POTENTIAL FOR BREACH	ACTUAL BREACH
IN-CORE FUEL CLAD	Key: Core Exit Temperature (C1)	Preferred Backup: RCS Sampling (C3)
RCS BOUNDARY	Key: RCS Pressure (C1) (Extended Range)	Preferred Backup: RCS Pressure (Wide Range) (C2) Containment Pressure (C2) Containment Water Level Wide Range (C2) Containment Structure Radiation Internal (C2) Fuel Drop Radiation Monitors (Containment Radiation) (C2) Hydrogen Recombiner Cubicle Ventilation (C2) Radiation
CONTAINMENT BOUNDARY	Key: Containment Pressure (C1) (Extended Range) Hydrogen Concentration (C1)	Preferred Backup: Ventilation Vent (Extended Range) (C2) Supplementary Leak Collection and Release System (C2)

TABLE 6-1 - Type C (Continued)

POTENTIAL FOR BREACH	ACTUAL BREACH
	Containment Recirculation Cooler Service Water Outlet (C2)
	Containment Isolation Valve Status (C2)
	Containment Pressure (C2)

SECTION 7.1

TYPE D VARIABLES

7.1 INTRODUCTION

Type D variables are defined in Section 2.2.4. Basically, they are those variables that provide sufficient information to the Control Room Operating Staff to monitor the performance of:

1. Plant safety systems employed for mitigating the consequences of an accident and subsequent plant recovery to attain a cold shutdown condition, including verification of the automatic actuation of safety systems; and

2. Other systems normally employed for attaining a cold shutdown condition.

All Type D KEY variables are designated Category 2. No Type D variables requiring Category 1 qualification were identified.

Preferred backup information is designated Type D Category 3.

The following systems have been identified as requiring Type D information to be monitored:

1. Pressurizer Level and Pressure Control (assess status of RCS following return to normal pressure and level control under certain post-accident conditions)

2. Chemical and Volume Control System (CVCS) (employed for attaining a safe shutdown under certain post-accident conditions)

3. Secondary Pressure and Level Control (employed for restoring/maintaining a secondary heat sink under post-accident conditions)

4. Emergency Core Cooling System (ECCS)

5. Auxiliary Feedwater

6. Containment Systems

7. Component Cooling Water

8. Service Water

9. Residual Heat Removal (employed for attaining a cold shutdown condition under certain post-accident conditions)

10. Heating, Ventilation, Air Conditioning

11. Electric power to vital safety systems

12. Verification of Automatic Actuation of Safety Systems

Table 7-1 lists the key variables identified for each system listed above, and specifies the seismic and environmental qualification for each variable.

For purposes of specifying seismic qualification for Type D Category 2 variables, it is assumed that a seismic event and a break in Category I piping will not occur concurrently. As a result, the limiting event is an unisolated (single failure of a MSIV) break in ASME Class 2 main steam piping. Instrumentation associated with the safety systems which are required to mitigate and monitor this event should be seismically qualified instrumentation. Similarly, the environmental qualification for Type D Category 2 variables depends on whether the instrumentation is subject to a HELB when required to provide information.

TABLE 7-1

Type D Key Variables

System Designation	Key Variable Instrumentation	Seismic	Enviromental
1. Pressurizer Level and Pressure Control	PORV Status	Yes	HELB
	Safety Valve Status	Yes	HELB
	Heater Breaker Position	No	Ambient
	Pressurizer Level	Yes	HELB
	RCS Pressure (WR)	Yes	HELB
2. CVCS	Charging Flow	No	Ambient
	Letdown Flow	No	Ambient
	VCT Level	No	Ambient
	Seal Injection Flow	No	Ambient
	Valve Status	Yes (Isolation valves only)	Ambient
3. Secondary Pressure and Level Control	S/G PORV Status	Yes	HELB*
	Main Steamline Isolation and Bypass Valve Status	Yes	HELB*
	S/G Safety Valve Status	Yes	HELB*
	Steamline Pressure	Yes	HELB*
	MFW Control and Bypass Valve Status	Yes	HELB*
	MFW Isolation Valve Status	Yes	HELB*
	MFW Flow	No	Ambient
	Auxiliary Flow	Yes	HELB*
	S/G Level (WR) and (NR)	Yes	HELB
	S/G Blowdown Isolation Valve Status	Yes	Ambient

TABLE 7-1 (Continued)
Type D Key Variables

System Designation	Key Variable Instrumentation	Seismic	Enviromental
4. ECCS	RWST Level	Yes	Ambient
	Total HHSI Flow	Yes	HELB**
	Total LHSI Flow	No	HELB**
	Containment Water Level (Wide Range)	No	HELB
	Valve Status	Yes	HELB**
	Accumulator Tank Pressure	Yes	HELB
	Accumulator Isolation Valve Status	Yes	HELB
	Accumulator Nitrogen Vent Isolation Valve Status	Yes	HELB
5. Auxiliary Feed	Auxiliary Feedwater Flow	Yes	HELB*
	Valve Status	Yes	HELB
	DWST Level	Yes	Ambient
6. Containment	Containment Temperature	No	HELB
	Containment Water Level (WR)	No	HELB
	Spray System Valve Status	No	HELB**
	Containment Pressure	No	HELB
	Containment Spray Flow	No	HELB**
7. CCW	Header Temperature	Yes	Ambient
	Valve Status	Yes	Ambient
	Flow to ESF Components	Yes	HELB

TABLE 7-1 (Continued)

System Designation	Key Variable Instrumentation	Seismic	Enviromental
8. Service Water	Valve Status	Yes	HELB
	Flow to RSS Heat-exchanger	Yes	Ambient
9. RHR	Heat Exchanger Discharge Temperature	No	HELB**
	Flow	No	HELB**
	Valve Status	No	HELB**
	RCS Pressure (WR)	Yes	HELB
10. HVAC	Damper Positions	Yes	HELB**
11. Electric Power	Emergency Bus(s) Voltage	Yes	Ambient
12. Verification of Automatic Actuation of Safety Systems	Reactor Trip Breaker Position	Yes	Ambient
	AFW Pump Status	Yes	Ambient
	SI Pump Status	Yes	Ambient
	Service Water Pump Status	Yes	Ambient
	CCW Pump Status	Yes	Ambient
	SI Valve Alignment	Yes	HELB
	Containment Spray System Pump Status	Yes	HELB

*These systems must be qualified to the worst case environment in which they must function (including HELB's inside and outside containment).

**These systems may see radiation from components in the recirculation path.

Section 8.0

Type E Variables

8.1 Introduction

Type E variables are defined in Section 2.2.5. They are those variables that provide the Control Room operating staff with information to:

1) Estimate the magnitude of release of radioactive materials through identified pathways.

Key Type E variables shall be qualified to Category 2 requirements. Preferred backup Type E variables shall be qualified to Category 3 requirements. Table 8-1 summarizes the selection of Type E variables.

TABLE 8.1

SUMMARY OF TYPE E VARIABLES

Containment Structure High Range Internal Radiation Monitor	E2
Ventilation Vent (Extended Range) Monitor	E2
Supplementary Leak Collection and Release System Extended Range Monitor	E2
Hydrogen Recombiner Cubicle Ventilation Monitor	E2
Condenser Air Ejector Monitor	E3
Turbine-Driven Auxiliary Feedwater Pump Turbine Discharge Monitor	E2
Main Steam Relief Line Monitor	E2
Containment Recirculation Cooler Service Water Outlet Monitor	E2
Flow Rate Out Ventilation Vent	E2
Flow Rate to Unit 1 Stack	E2
Site Environmental Radiation Level	E3
Fuel Drop Monitors (Containment Radiation)	E2

SECTION 9.0

SUMMARY

The variables in this document have been defined by Northeast Utilities as Types A, B, C, D, or E and Category 1, 2, or 3 in response to the intent of Regulatory Guide 1.97 based upon the design bases and qualification criteria set forth in this document.

Table 9-1 summarizes the variables by type and category.

Table 9-1

Summary of Variables and Categories

Variable	Type and Category				
	Type A	Type B	Type C	Type D	Type E
RCS Pressure (Wide Range)	1	1,2	2	2	
Wide Range T hot	1	2			
Wide Range T cold	1	2			
Wide Range S/G Level	1	1,2			
Narrow Range S/G Level	1	1		2	
Pressurizer Level	1	1		2	
Containment Pressure	1	1,2	2	2	
Steam[illegible]e Pressure	1	1		2	
RWST Level	1			2	
Containment Water Level (Wide Range)	1	2	2	2	
Auxiliary Feedwater Flow	1			2	
Containment Structure High Range Internal Radiation Level	1		2		2
Core Exit Temperature	1	1	1		
Fuel Drop Monitors (Containment Radiation)	1		2		2
RCS Subcooling	2	2			
Neutron Flux		1			
Containment Isolation Valve Status			2		
Control Rod Position Ind.		3			
Containment Hydrogen Concentration	1	1	1		

Table 9-1 (Continued)

Summary of Variables and Categories

(Excluding Selection of D-3)

Variable	Type and Category				
	Type A	Type B	Type C	Type D	Type E
Containment Pressure (Extended Range)			1		
RCS Pressure (Extended Range)	1		1		
RCS Sampling			3		
PORV Valve Status				2	
Primary Safety Valve Status				2	
Pressurizer Heater Breaker Position				2	
Charging System Flow				2	
Letdown Flow				2	
VCT Level				2	
CVCS Valve Status				2	
RCP Seal Injection Flow				2	
S/G Atmospheric PORV Status				2	
Main Steam Line Isol/Bypass Valve		2		2	
S/G Safety Valve Status				2	
Main Feedwater Control Valve				2	
Main F/W Control Bypass Valve				2	
Main F/W Isolation Valve				2	
Main Feedwater Flow				2	
S/G Blowdown Isolation Valve Status				2	

Table 9-1 (Continued)

Summary of Variables and Categories

(Excluding Selection of D-3)

Variable	Type and Category				
	Type A	Type B	Type C	Type D	Type E
Total HHSI Flow				2	
Total LHSI Flow				2	
ECCS Valve Status				2	
Aux F/W Valve Status				2	
DWST Level				2	
Containment Spray System Valve Status				2	
Containment Spray System Pump Status				2	
CCW Header Temperature				2	
CCW Valve Status				2	
CCW Flow to ESF Components				2	
Service Water System Valve Status				2	
Service Water Flow to RSS Heat-exchanger				2	
RHR Heat-exchanger Discharge Temp				2	
RHR Flow				2	
RHR Valve Status				2	
HVAC Damper Positions				2	
AC, DC, Emergency Voltage				2	
Reactor Trip Breaker Position				2	

Table 9-1 (Continued)

Summary of Variables and Categories

(Excluding Selection of D-3)

Variable	Type and Category				
	Type A	Type B	Type C	Type D	Type E
Auxiliary F/W Pump Status				2	
SI Pump Status				2	
SI Valve Alignment				2	
Service Water Pump Status				2	
CCW Pump Status				2	
Accumulator Tank Pressure				2	
Accumulator Isolation Valve Status				2	
Accumulator Nitrogen Vent Isolation Valve Status				2	
Flow Out Ventilation Vent					2
Flow Rate to Unit 1 Stack					2
Supplementary Leak Collection (Extended Range)			2		2
Containment Recirculation Cooler			2		2
Ventilation Vent (Extended Range)			2		2
Turbine Driven Auxiliary Feedwater Pump Discharge					2

Table 9-1 (Continued)

Summary of Variables and Categories

(Excluding Selection of D-3)

Variable	Type and Category				
	Type A	Type B	Type C	Type D	Type E
Main Steam Relief Line					2
Condenser Air Ejector					3
Hydrogen Recombiner Cubicle Ventilation			2		2
Site Environmental Radiation Level					3