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FINAL REPORT - PART II

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THE IDENTIFICATION OF THE IMPACTS OF
MAINTENANCE & TESTING UPON
THE SAFETY OF LWR POWER PLANTS
FINAL REPORT - PART II

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APPENDIX A

OVERVIEW OF LITERATURE RELATING TO RADIATION EXPOSURE AND OPERATING EXPERIENCE

APPENDIX A

OVERVIEW OF LITERATURE RELATING TO RADIATION EXPOSURE AND OPERATING EXPERIENCE

Radionuclides associated with crud are the major sources of occupational exposure. In particular, ^{60}Co is believed to be the nuclide causing more exposure than any other single nuclide.

In PWR's, work on the steam generator caused the highest proportion of exposure. An average of 27 percent of the total annual exposure (300-400 man-rem) was attributed to steam generator work. The range was 6.1 percent to 88 percent. Inservice inspection caused an average of only 5.6 percent of the total annual exposure with a range of 0.6 percent to 8.3 percent.

In BWR's, the highest proportion of annual exposure was from work on recirculation pumps and the clean-up system. The average proportion of annual exposure from this source was 7.8 percent, with a range of 0.6 percent to 29 percent. Annual exposures were found to increase with plant age. The increases are believed to be due to the accumulation of crud nuclides.

The distribution of cumulative doses (man-rem) among the major work functions of the workers at power reactor facilities showed that routine maintenance continues to be the major contributor of occupational exposure. Radioactive maintenance and repair jobs have significant impacts on plant availability. The exposure by work function for an average LWR is displayed on Table 1.

In the area of maintenance, occupational exposure from steam generator repair efforts had been significant. The repair of downcomer welds in a major refueling, maintenance, and ECCS backfitting outage at an older nuclear plant resulted in a total exposure of about 3500 man-rem

Table 1. Exposure by Work Function for an Average LWR

Work Function	Exposure (%)
Reactor Operations & Surveillance	10.8
Routine Maintenance*	52.6
Inservice Inspection	3.0
Special Maintenance*	19.0
Waste Processing	6.9
Refueling	7.7

* Maintenance (routine and special) accounts for about 72 percent of the exposure

for about 1500 people. About 1800 man-rem were received by boilermakers. Repairs on failed generator tube sheet cladding resulted in a total dose of 225 man-rem for 225 personnel involved.

Most steam generator repairs involved the tube testing and plugging operations. Radiation levels near the tube sheets are usually around 15 R/hr. Sludgelancing (10 man-rem), tube pulling (85 man-rem), eddy current testing (39 man-rem), and plugging of 31 tubes (9 man-rem) were the most significant tasks. Repair jobs are usually complicated by difficulties of working in a confined space, high radiation, and time-pressure condition.

A large repair effort involving the installation of a thermal sleeve took eight months. This resulted in a total whole-body radiation exposure of 1140 man-rem for 700 men. Sparger replacement in a BWR required men to enter the reactor vessel and its high radiation field to perform various operations, e.g., grinding, welding, etc. Total exposure from this operation was 266 man-rem to 285 men.

As can be seen in steam generator repair efforts, radiation levels on components away from the reactor vessel can be quite high. An NRC study found that in 1973 the average annual personnel radiation

exposure in nuclear power plants in the U.S., excluding the exposure received by contractor personnel, was 261 man-rems. Of that total, about 71 percent was received by station maintenance personnel. Hence, routine operating, maintenance, and repair jobs make significant contributions to overall personnel exposures.

During a refueling outage, a "hot" maintenance effort involving the reactor vessel head resulted in a total exposure of about 120 man-rems. Head removal and reinstallation, and internal removal, cleaning, and reinsertion contributed about 90 man-rems of that figure. Careful planning could result in a 20 to 25 percent reduction in the total exposure figure.

Some typical steam generator testing and repair experiences are:

- (1) Two maintenance men received exposures of 1.6 and 1.3 rems while reinstalling manhole covers at Pt. Beach 1 in January, 1975. The general area had radiation levels of 50-100 mrem/hr with a 5 R/hr reading under the open manhole.
- (2) Robinson 2-1972: 35 tubes were plugged, 3 were removed, 148 men received 145 man-rems.
- (3) Beznau 1-1971, 1972: 6 men plugged 840 tubes, 12.9 man-rems.
- (4) Beznau 1-1974: 3 to 4 man-mrem per inspected tube using advanced remote controlled equipment.
- (5) Yankee Rowe-1975: weld diaphragm in place and replace manway on one steam generator, 4.4 man-rems.

The performance of certain special tests and activities can influence the radiation levels at shut-down. However, personnel conducting such tests in a reactor facility experience considerable occupational exposure. This usually comes from inservice inspections where there are tests involving the removal of insulation, testing the component, and replacement of insulation. Such an operation resulted in 41-68 man-rems in a PWR and 3.3-81 man-rems for a BWR.

In a BWR, exposure from routine off-gas sampling for the gaseous radwaste system was isolated at approximately 10 mr to one man for each gas sample. Ultrasonic testing during steam generator repairs could result

in a total exposure of 88 man-rem. Special investigations to determine the adequacy of snubber supports for piping resulted in exposures from 7-14 man-rem.

Occupational exposure, due to maintenance and testing operations in a reactor facility, depends on many factors. Besides the operating history, there are, for example, shielding layout, component, installation, and shutdown contact dose rates. These originate mainly from deposited corrosion product activities and thus are consequences of materials selection and water chemistry. Exposure of maintenance personnel to activated corrosion products is the single most important reason a typical LWR presently has about 500 man-rem of exposure each year. Crud formation and buildup prevention efforts are important if the industry expects to reduce occupational exposures. Equally important, is the requirement to develop better methods to decontaminate piping and components.

Biological effects and plant availability concerns are among the many reasons for wanting to keep occupational exposures as low as reasonably achievable.

Occupational exposure can be reduced in a nuclear power plant by design. For design purposes, the annual occupational whole body exposure would not exceed one rem/year. This limit will be difficult to achieve for some reactor types, but the potential difficulty of meeting the design target emphasizes the need for considerable design effort to reduce occupational radiation exposures.

Occupational radiation exposures are dependent on the sources of radiation, levels produced by the sources, and the access requirements to the location at which the radiation level applies. The ways to reduce these contributing factors are:

(1) Reduction of sources:

Since the greatest potential sources of radiation exposures are the activated corrosion products (crud) deposited on reactor coolant circuit surfaces, and carried over with the steam and deposited

principally along the steam lines and turbine, considerable effort has been devoted to understanding the mechanism of crud production, deposition, and removal.

The significant parameters affecting deposited crud activity are the input rates of inactive cobalt and iron in the feedwater to the primary coolant. The input of cobalt and iron to the primary coolant from corrosion of the predominantly carbon steel primary circuit can be made lower by eliminating high cobalt materials such as stellite from the primary circuit and strict chemical control of the coolant. The use of a reactor coolant clean-up plant incorporating ion exchange resin beds with a capacity of 0.4 percent of the primary circuit coolant flow, assists in reducing the circuit concentration of inactive crud before deposition (and activation) in the core and in active crud release from the core.

Other methods of reducing the source of active corrosion products include avoidance of likely activity traps such as blank ended lines and rough inner surfaces of welds. The introduction of full flow magnetic filtration both in the feed train and in the reactor coolant clean-up plant are being considered at present.

(2) Reduction of radiation levels:

During early design stages, careful attention is paid to plant layout to take advantage of existing walls, missile barriers, etc. to segregate active from inactive components. Further shielding can be interposed between excess points and sources of activity, but shield design must not unduly increase access times or time spent to remove and reassemble shielding. On the design, missile barriers between main coolant pumps limit radiation to that from the pump circuit to which access may be required while additional shielding between the pump water and bowl allows work on the motor to be carried out in greatly reduced radiation fields.

(3) Reduction in access requirements:

For reduction in access requirements, components are selected on proven reliability so that less maintenance is required. Components are designed so that maintenance is speedy with quick release mechanisms which enable quick on-site maintenance or allow components to be removed to low radiation areas. An example is the easily removable coded lagging to reduce time for weld inspection.

Adequate room for inspection and maintenance must be ensured to reduce access times. Permanent stairways for required known access can produce significant savings in exposure of personnel. Further, providing built-in simple ladders in areas where access may not be expected but might be required, will be cost-effective.

Provision of remote reviewing facilities for inspection and the development of remote and/or automatic equipment for maintenance and inspection of welds has led to the development of automatic ultrasonic scanning heads which may be clamped in position and left during the scanning period. The scanning time may be used to position other scanning heads or the operator may withdraw to a lower radiation level area. Remote positioning of automatic devices should be planned during the reactor design phase so that adequate space is available.

Generally, occupational radiation exposures during maintenance and testing operations can be minimized by the following considerations:

- (a) Radiation control - Provisions to reduce the source intensity by draining, flushing, chemical cleaning, purging, and degassing.
- (b) Space requirements for the use of temporary shielding.
- (c) Contamination control - Provisions for auxiliary ventilation and portable breathing air equipment and provisions for removal of component to another area for maintenance.
- (d) Accessibility - Provision of easy access and space for tool laydown.
- (e) Isolation - Provision of flanges to facilitate quick removal of components from the system.
- (f) Standardization - Standardized equipment design and design practices to enhance maintainability; provision for the use of standard tools in maintenance operation.

The following alternatives in arriving at maintenance decisions should be considered

- (a) adjust in place;
- (b) perform contact maintenance;
- (c) replace instead of repair;
- (d) remove, decontaminate, and repair
- (e) decontaminate in place and repair;
- (f) remote replacement; and
- (g) remote repair.

Finally, the following maintenance aspects should be concentrated on:

- (a) Establish procedures for assembly and disassembly of components and issue step-by-step instructions with supporting illustrations to the maintenance crew.
- (b) Use performance history, contractor experience, and supplier data to minimize maintenance time.

For inservice inspection, the following guidelines should be considered to reduce occupational exposure:

- (1) Provide adequate access to equipment, piping, and valves.
- (2) Standardize inspection procedures, inspection tools, and certification of personnel.
- (3) Use cartridge or mirror type insulation to minimize preparation and restoration time of surface areas.
- (4) Devise improvements in eddy current examination techniques for steam generator and other radioactive heat exchangers including techniques for remote tube plugging operations.
- (5) Provide for the use of remote inspection equipment in areas where the radiation level would preclude manual inspection. (Periscope, cameras, close circuit TV, remote probes, etc).

In conclusion, the above design and operational guidelines are presented to minimize in-plant radiation exposure to As Low As Reasonably Achievable (ALARA). If implemented, these guidelines will substantially reduce in-plant radiation exposure. The implementation must be based on the stage of plant design and hardware selection, as well as economics and feasibility of implementation of any specific design consideration.

Review of operation experience has shown that tube failures in steam generators in nuclear power plants are expensive occurrences. A 1974 survey of failures in steam generators at water-cooled nuclear power reactors by Atomic Energy of Canada limited shows tube failure at 25 of the 59 reactors. In most water-cooled-reactor stations with steam generators, tube leaks are likely to occur after a few years of operating time. Leaks are most often likely to occur after a few years of operating time. Leaks are most often located

just above the tube sheet. Significant failures also occur at the first support place and in the U-bend. Failures at the tube sheet are most often found in the sludge zone. Most failures are caused by corrosion. Hence, there is a need for periodic tube inspections.

Most failures are plugged with explosively welded plugs. Explosive plugging is generally more reliable and gives a lower man-rem dose to repair crews. Radiation fields commonly range from five to fifteen R/hr inside the reactor head, which are high enough to warrant decontamination before inspection and/or repairs and are certainly high enough to warrant the introduction of automated inspection techniques. Remote eddy-current scanning and explosively welded plugs are now accepted inspection and repair procedures because of their saving in man-rem doses and their high reliability.

The integrity and operability of valves in nuclear power plants have been a continuing operational concern. Maintenance of valves constitutes one of the largest elements of the maintenance work load in most plants.

The apparent rates of valve malfunction, based on the number of power reactors in operation during the time periods covered, were as follows: The 1964 to 1971 survey yielded an average rate of 2.5 malfunctions per year, and the 1971 to 1972 survey indicated approximately 2.8 malfunctions per plant per year. The shorter, but most recent, survey of 1972 disclosed an average rate of 8.1 malfunctions per plant per year. It appears that the incidence of valve malfunctions is actually increasing.

Because a major portion of the occupational radiation dose is received during maintenance, inservice inspection, refueling, and nonroutine operations; these activities warrant special attention during design. Designs should be reviewed to ensure that provisions have been included to achieve ALARA exposures in these situations.

Although the design and operating procedures are such as to limit the dose-rate in normal working areas to the practical minimum, the same criteria cannot necessarily be applied to the maintenance of a plant. There are two main aspects to consider when assessing the radiological conditions associated with plant maintenance, namely;

- (1) Radiation dose control, and
- (2) Contamination control.

The range of dose rates encountered varies between a few millirems/hr, up to tens of rems per hour. It can involve either whole body exposure, extremity dose, or a combination of both. The presence of surface contamination can produce high surface dose-rates and may give rise to an airborne hazard if the work causes resuspension.

This gives rise to the need for additional work on exposures related to M&T, especially the review of facility health physics records, for the determination of optimum manpower usage and system/component designs to achieve minimum doses.

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APPENDIX B
DETAILS OF LWR-MTC3 CLASSIFICATION SYSTEM

1.0 INTRODUCTION

The purpose of this manual is to provide a comprehensive listing of commercial nuclear power plant systems, subsystems, and components which are relevant to the analysis of the licensee event reports (LER's). A brief description of the function of each subsystem is given as a reference to LER analysts to assist in determining the impact of the occurrence of a given event. Also, special codes and abbreviations are used for systems, components, and failure modes involved to facilitate the process of LER analysis and quantification. The code system developed here is for the MTC-3 classification system. Comparison is made with other codes which have previously been used in safety analysis studies. This manual is not expected to fulfill the classification needs of every possible combination of events. It is, however, easily adaptable to changes and additions as are deemed necessary.

The manual does not provide a systems' summary for every light water reactor design; however, it does include all safety related systems from all of the commercial designs constructed thusfar. Furthermore, it includes all systems, components, and failure modes which appear in the LER event descriptions. It should, therefore, be recognized that no facility will contain each and every system described in this manual.

Transfer of information from LER's is not a direct process because of inaccuracies and voids in data content. The manual is still in a developmental state and some system descriptions might not be totally accurate, however, for data evaluation work, it has proven to be an invaluable tool. Therefore, it is necessary for an LER analyst to have some prior familiarity with nuclear power plant systems when using this manual, especially in determining the location of the impact of an event.

2.0 USER'S INSTRUCTIONS

The manual has been divided into two distinct groups; one for Boiling Water Reactor (BWR) systems and one for Pressurized Water Reactor (PWR) systems. Each group has then been subdivided into 12 general systems which are letter coded, for ease in encoding and decoding events. Both groups contain the same general system scheme.

Subsystems are then listed in alphabetical order according to the general system code. Information contained for each subsystem includes the subsystem name and its abbreviation. A brief description is given for each subsystem, including the number of redundant trains in the case of Engineered Safety Feature (ESF) systems and the purpose(s) and function(s) of the subsystem. An M&T two letter code is given, again for convenience. The first

letter is labeled according to the system involved. For example, the system code for the Auxiliary Electrical Power System (AEPS) is A; therefore, all the AEPS subsystems in the GENCLASS code will begin with the letter "A." The second letter in the subsystem label is arbitrarily selected in alphabetical order of subsystem listing under each system category. The WASH-1400 code; which is taken from Appendix II of the Reactor Safety Study, is also given so that analysis of actual classified data can be compared with the quantitative probabilistic results of WASH-1400.

Furthermore, an NRC code; which is AEC originated, is listed. This is the present code used for system delineation by NRC. The present NRC system classification is too broad in nature to be useful for data acquisition. For example, all the subsystems of the Emergency Core Coolant Injection Systems are NRC coded as (SF) and there is no distinction among the different subsystems involved.

Following the system listing, a component code, an M&T code, and a failure mode code are given. The purpose of these two sections is to aid in the development and identification of similar component(s) and failure mode(s) involved in event occurrences and in the classification of those events. The component code includes mechanical and electrical components and is listed in alphabetical order.

The M&T code is used to identify the improper action taken by M&T personnel that caused an event occurrence. This code

provides the answer to a question; such as, "What did the technician do to cause the event to happen?". The failure mode code specifies the mode of failure of the component(s) affected by the event. Both of these codes are alphabetized according to the key word of the failure mode phrase. For example, if the M&T mode is "Lack of Experience," then "Experience" is the key word.

BWR SYSTEM CODE

Code	System	Abbreviation
A	Auxiliary Electrical Power Systems	AEPS
B	Reactor Protection Systems	RPS
C	Emergency Core Coolant Injection Systems	ECCIS
D	Emergency Cooling Recirculation Systems	ECRS
E	Main Reactor Cooling Systems	MRCS
F	Containment Spray and Recirculation Systems	CSRS
G	Other Containment Systems	CS
H	Reactor Power Control Systems	RPCS
I	Auxiliary Systems for Normal Operation	ASNO
J	Radioactive Waste Processing Systems	WPS
K	Secondary Non-Nuclear Systems	SNS
L	Instrumentation and Monitoring Systems	IMS
O	Other Systems	O
U	Unknown	U
X	None/Event	X

BWR SUBSYSTEMS

Subsystem of A: Auxiliary Electrical Power System (AEPS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH- 1400 CODE	NRC CODE
Off-site AC power system	EPS-OFF	Two offsite AC power sources used to supply the emergency power needs for the ESF systems, and safe shutdown. (The preferred source)	AA	Q	EA
On-site AC power system	EPS-AC	Two or more independent DG sets which are required upon loss of off-site power sources.	AB	Q,X	EB
On-site DC power system	EPS-DC	Four 125V batteries and accessories. Each battery is aligned to serve a 125V DC bus, to provide power to several ESF systems upon the loss of AC power. In addition, the four batteries are paired by connecting two in series to provide two sources of 250V DC power.	AC	Q	EC
Auxiliary equipment for AEPS/EPs	EPS-EQP	This includes transformers, cables, buses, protective devices, etc., for the 23kv and 4.16 kv systems.	AD	Q	EG

Subsystem of B: Reactor Protection System (RPS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Reactor protection control rod system	RPCRS	This system is made up of the control rod drive mechanisms, the control rods, and the hydraulic control modulus. These components provide for the rapid insertion of the control rods when a trip condition exists.	BA	3	RB
Reactor protection logic system	RPLS	It senses improper operating conditions and removes power from the control rod drives thus initiating a reactor trip. It consists of two independent trip systems.	BB	3	IA

Subsystem of C: Emergency Core Coolant Injection System (ECCIS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Residual heat removal system Low pressure coolant injection function	RHR-LPCIS	It's function is to provide a large volume of low pressure water in the event of a large LOCA to restore and maintain the water level in the reactor vessel. Or for a small LOCA, when the HPCIS fails, when used with the CSIS and the ADS. It consists of three loops. Source of water is condensate storage tank.	CB	B	SF
Core spray injection system	CSS	It operates alone or in combination with LPCIS to deliver emergency coolant following a large LOCA. The two systems, operating in conjunction with ADS, are also used to inject emergency coolant into the reactor core following small LOCA if the HPCIS fails to reflood the core within two minutes. It consists of two independent subsystems. Source of water is the suppression pool.	CC	A	SF
Core spray injection system - Instrument and control system	CSS-ICS	The electrical logic system of the CSIS. It receives initiation signals from various reactor and drywell sensors, and determines the requirements for CSIS operation. It consists of two separate logic trains.	CD	A	SF
High pressure core spray injection system	HPCIS	It's function is to depressurize the nuclear boiler system and to provide	CG	F	SF

Subsystem of C: Emergency Core Coolant Injection System (ECCIS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
		makeup water in the event of small LOCA. In addition, it prevents fuel cladding damage by spraying water over the fuel assemblies. The system can operate independent of normal auxiliary AC power, plant service air, or the emergency cooling water system. It receives water from the condensate storage tank first, and then from the suppression pool. It consists of one loop.			
High pressure core spray injection system - instrument and control system	HPCIS-ICS	The electrical logic system of the HPCIS. Its' sensors monitor reactor vessel, drywell, and main steam line conditions.	CH	F	SF
Reactor core isolation cooling system	RCICS	It is a standby core cooling system used when the reactor is isolated from the turbine. Additionally it may be considered as a back-up to the HPCIS in the case of a small LOCA. Water supply sources (in order) are; the condensate storage tank, steam condensed in RHR heat exchangers, and the suppression pool. It also provides make-up water to the reactor vessel, if required during the initial phase of any shutdown.	CI	L	CE

Subsystem of C: Emergency Core Coolant Injection System (ECCIS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Automatic depressurization system	ADS	It is designed to actively function in the event the HPCIS and RCICS fail to reflood the reactor after a small LOCA, by venting the reactor pressure vessel steam into the suppression pool, thus reducing pressure so that the LPCIS or CSIS can inject coolant into the reactor vessel.	CJ	2	SF
Automatic depressurization system - Instrumentation and control system	ADS-ICS	The electric logic system of the ADS. It checks the availability of the RHR-LPCIS and the CSIS, and if the HPCIS and RCICS fail to depressurize the reactor core within the allotted time, it commands the ADS relief valves to open, dumping the reactor steam into the wetwell.	CK	2	SF
Low pressure core spray	LPCS	The function is to prevent fuel cladding damage in the event of LOCA. It goes into operation when CSIS and RHR-LPCIS prove inadequate to maintain vessel water level. It consists of one loop, which operates in conjunction with one RHR-loop. Source of water is suppression pool and/or condensate storage tank.	CL	B	SF
Residual heat removal system Suppression pool cooling function	RHR-SPC	It ensures that the temperature in the suppression pool immediately after blow down, and when the vessel pressure is greater than 135 psig. doesn't exceed	CM		SF

Subsystem of C: Emergency Core Coolant Injection System (ECCIS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG	WASH	NRC
			CODE	1400 CODE	CODE
		a predetermined limit (generally 170°F). Suppression pool water is pumped from the pool through either or both of two completely independent loops, including pump and heat exchanger, and returned to the pool. Cooling water is supplied by ESWS. The heat removed by the heat exchanger is transferred to the RHR system service water. SPC is manually initiated.			
Residual heat removal system Steam condensing function (Hot standby)	RHR-SC	During nuclear boiler system isolation and in conjunction with the operation of the RCICS and steam blow down to the suppression pool, steam at reduced pressure and temperature is directed from the main steam lines to the RHR heat exchanger. Condensate at a temperature not exceeding 140°F is directed to the nuclear power system. SC is manually initiated. Source of cooling water is SWS. It consists of one loop.	CN		CF
Residual heat removal system Shutdown cooling function	RHR-SHC	It removes residual heat from the nuclear boiler system after shutdown in preparation for refueling or plant servicing. It is manually initiated when vessel pressure is reduced to 135 psig after shutdown. It has the capability of reducing reactor vessel to a temperature of 125°F, including draining	CO		CF

Subsystem of C: Emergency Core Coolant Injection System (ECCIS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
		and flushing within 20 hours after the CRD are inserted. Reactor water is taken from one of the reactor water recirculation loops, pumped through the heat exchanger, and returned to the vessel by way of the feedwater lines. It consists of two loops.			
Standby liquid control system	SBLCS	It is a redundant control system capable of shutting the reactor down from rated power operation to the cold condition in the postulated situation that the control rods cannot be inserted. The liquid control chemical is boron in the form of a sodium pentaborate solution. The operation of this system is manually initiated from the control room. It is a single system with one redundant pump and injection valve.	CR		SF
Other				CS	

Subsystem of D: Emergency Core Coolant Recirculation Systems (ECCRS)

Subsystem	Abbreviation	Description and Function	NSRG	WASH	NRC
			CODE	1400 CODE	CODE
Low pressure core recirculation system	LPCRS	It provides a source of low pressure water to the reactor core after core reflood. Makes use of the same system as LPCIS, except all water comes from the suppression pool. It consists of two loops.	DA	M	SF
Emergency service water system	ESWS	ESWS is a standby system for SWS. It also acts as a source of cooling water for the LPCRS and CSRS pumps, and provides the only source of cooling water to the diesel generators. It is a single system.	DC	M	SF
Core spray recirculation system	CSRS	Same function as LPCRS. Uses the same system as CSIS, and consists of two independent subsystems.	DE	M	SF
Emergency equipment cooling system	EECS	It services certain equipment required for normal and emergency shutdown of the plant. The system provides cooling water for the RHR system pump motor and pump seal cooler and the HPCIS pump motors and pump seal coolers. Also EECS provides ventilation cooling for HPCIS, LPCIS, RHR, and RCICS equipment upon loss of normal ventilation such as may occur upon loss of external AC power.	DF		SF
High pressure service water system	HPSWS	Following a LOCA, heat stored in the reactor coolant system and subsequent	DG	D	SF

Subsystem of D: Emergency Core Coolant Recirculation Systems (ECCRS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG	WASH	NRC
			CODE	1400 CODE	CODE
		heat picked up by emergency coolant are deposited in the primary containment wet well. The HPSWS in conjunction with LPCRS, is used to transfer the long term accumulation of heat in the wet well to an external heat sink. The HPSWS can also be used alone as a last resort to inject (river) water directly into the reactor vessel, thereby flooding the reactor and containment. It consists of two separate subsystems.			
Torus		The torus is a passive wet well, located below the RV, which is used as a water source and dump for many ESF systems. Also, known as the suppression chamber.	DH		SF

Subsystem of E: Main Reactor Cooling System (MRCS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Main steam line system	MSLS	The system of pipes, pumps, valves, pipe supports, controls, and other components from the pressure vessel up to the mainsteam isolation valves inside the primary containment. (Including Heat Exchangers.)	EA	1	CC
Reactor feed water system	RFWS	<p>It's function is to control feed water supplied to the vessel. RFWS is similar to that in a conventional thermal plant. with the possible following exceptions.</p> <ol style="list-style-type: none"> 1. A main feed water control valve is required for each circulating loop to ensure correct flow. 2. Condenser hot well storage capacity must be provided to accommodate system surges due to the design of turbine load reduction and amount of steam by-pass capacity to the condenser, without relying upon the reserve condensate storage. 3. Storage is required for operational purposes such as feed water make-up, when the water treatment plant is being regenerated or out of service. <p>It consists of one subsystem for each coolant loop.</p>	EB	6	CH
Other reactor vessel internals	RVI	Includes the reactor pressure vessel, jet pumps, steam separators and dryers, and the core support structure.	EC		RA

Subsystem of E: Main Reactor Cooling System (MRCS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG	WASH	NRC
			CODE	1400 CODE	CODE
Other	RCS	Includes all other aspects of the reactor cooling system, or unidentifiable subsystems.	ED		

Subsystem of F: Containment Spray and Recirculation System (CSRS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Vapor suppression system	VSS	<p>It's function is to limit the resulting power pressure transients in the dry well in the event of a break in the RCS where large quantities of steam would be dumped into the dry well region of the reactor containment.</p> <p>Steam from a LOCA could, if unchecked, pressurize the dry well to levels dangerous to the structural integrity of the containment.</p> <p>The VSS function is successful, therefore, when the LOCA steam is successfully ducted into and condensed by the wet well (suppression pool) water, thus, maintaining the containment pressure below the maximum tolerance pressure.</p>	FA	9	SF
Residual heat removal containment spray system	RHR-CSIS	<p>It condenses and removes any steam heat that bypasses the dry well, and prevents over pressurization of the containment.</p> <p>The suppression pool is used as the water supply in the same manner as in the suppression pool cooling mode, except the water passes through the containment spray headers before returning to the pool.</p>	FB		SB

Subsystem of G: Other Containment Systems (CS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Containment leakage: Containment isolation system	CL CIS	It's function is to automatically seal the containment following an accident by closing isolation valves in all lines penetrating the containment, including MSIV's, not required by safety systems. ESF logic systems initiate signals which are used to close the isolating valves. Containment leakage includes airlocks, manways, equipment hatches, and the containment building itself.	GA	S	SD
Secondary containment system (other than SBGTS)	SC	It's function is, within certain bounds, to limit the ground level release of radioactive materials that may be released beyond the confines of the primary containment (PC); also SCS is designed to provide a means of controlled elevated release of the reactor building atmosphere. SCS is designed as a back-up to the PC for small PC break areas only; a gross breach of that barrier would render the SCS ineffective. Operation of the SCS must be considered in concert with the status of PC integrity.	GC		SA
Standby gas treatment system	SBGTS	It includes containment air purification cleanup control systems.	GD	V	SC

Subsystem of G: Other Containment Systems (CS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG	WASH	NRC
			CODE	1400 CODE	CODE
Containment atmosphere dilution system	CADS	It has two principal functions to perform in the event of a LOCA. To limit the ground level release of contaminants by providing a negative pressure within the reactor building; And to filter and release any air within the secondary containment at an elevated release point. Normal operation events are usually concerned with pressure and temperature differentials outside of limits.	GE	Y	SA
Containment purge and exhaust system	CPES	Includes systems used for nitrogen supply (combustible control) and RB ventilation.	GH		SE
Primary containment	PC	The reactor building concrete dome which provides for the reactor building environment and limits the level of radioactivity release to the environment both during normal and emergency operations.	GI		
Other	CS		GI		

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Subsystem of H: Reactor Power Control System (RPCS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Chemical power control systems	CPS	Consists of SBLCS when used for reactor control only.	HA		PC
Reactor water recirculation system	RWRS	Includes pumps, valves and piping used in providing and controlling core flow. It's function is to control reactor power by varying recirculation flow parameters (pressure, flow rate).	HB	2	CB
Control rod systems	CRS	Includes the system of control rods, drive mechanisms, and supports necessary for proper control rod movement. It is not a scram function, but rather shim control.	HC		RB
Other	RPCS	Reactor power control auxiliaries, including logic systems and computers used for automatic control.	HD		

Subsystem of I: Auxiliary Systems for Normal Operation (ASNO)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Fuel and containment pools cooling and cleanup system	FCPCCS	It accumulates the spent fuel cooling heat load as well as dry well heat transferred to the upper containment pool. Pumping loops circulate pool water through a heat exchanger and filters and returns the flow by discharging it through diffusers mounted in the fuel storage pool and in the containment pool.	IA	#	FC
Reactor water cleanup system	RWCUS	It's purpose is to maintain high reactor water quality by removing fission products, corrosion products and other soluble and insoluble impurities. In addition, the system provides a means for water removal from the primary system during periods of increasing water volume. The system can be operated during start-up, shutdown, and refueling operation, as well as during plant operation.	IB		CG
Closed cooling water system for reactor service	CCWS	It uses water piped from the site service water source to provide a heat sink for selected nuclear system equipment. Its purpose is to provide a second barrier between the primary systems containing radioactive products and the service water system that is the final heat sink	IC	E	WA

Subsystem of I; Auxiliary Systems For Normal Operation (ASNO) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
		and, therefore, eliminates the possibility of radioactive discharge into plant effluents that could result from heat exchanger leaks. Some of the components supplied by CCWS are component cooling heat exchangers, containment ventilation coolers, diesel generator coolers, control room air conditioning system condensers and containment spray pump diesel engine coolers.			
Reactor coolant chemistry systems	RCCS	Includes systems used for RCS chemistry control, other than RWCUS. (i.e. systems for H2/O2 conc. control, etc.)	ID		PC
Service water system	SWS	The final heat sink for all plant heat loads except the main condenser. Typically there are four SW pumps and four SW booster pumps (new designs differ). All pumps are needed for normal operation, but only one service pump and two booster pumps are required for emergency shutdown. The water is usually of low quality; typically site source water. It consists of one loop.	IE		WA
Fuel storage/handling facilities	FSF	Includes facilities used for the storage and handling of new and spent fuel.	IF		FA FB FD
Other			IG		

Subsystem of J: Radioactive Waste Processing Systems (WPS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Waste processing system - liquid handling	WPS-LH	<p>It's design allows for operational flexibility and also provides for segregation of drains to allow separate handling of potentially irradiated and non-irradiated effluents</p> <p>The various process wastes are collected by suitable connections of drains, piping and tanks or sumps in the various station buildings and piped to the collection tanks in the radwaste building.</p> <p>Oil is removed from sump and equipment drains by means of oil separators. Normally the high purity waste is filtered, demineralized, monitored and returned to condensate storage for further use. The low-purity and chemical wastes are batch treated by chemical neutralization processes and then concentrated by evaporation for packaging for off-site shipment. Water boiled off in the concentrator is processed through a demineralizer, monitored and returned to condensate storage.</p>	JA	N	MA
Waste processing system-gas handling	WPS-GH	<p><u>Types of radioactive gases:</u></p> <ol style="list-style-type: none"> 1. Activation gases: elements which become radioactive from exposure to radiation (N-12, O-16, O-19, F-18), 2. Fission gases: gases released by fuel defects such as the radioisotopes of Kr, Xe. 	JB	8,N	MB

Subsystem of J: Radioactive Waste Processing Systems (WPS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
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Release paths;

1. Steam jet ejector off gases.
2. Turbine steam seal system off gases.
3. Mechanical vacuum pump exhaust.
4. Leaks from radioactive systems or components where leakage enters ventilation pathways.

This system, by batch processing and/or continuous monitoring before release, assures that any planned permissible releases, of gases from paths listed above, are "as low as reasonably achievable".

Waste processing system - Spent resin/solid handling	WPS-SH	<u>Potential radioactive solid wastes:</u> <ol style="list-style-type: none"> 1. Filter and resin sludges. 2. Concentrated wastes from liquid waste treatment concentrators. 3. Air filters from off gas and ventilation systems. 4. Solid laboratory wastes. 5. Containment clothing, tools, and small pieces of equipment which cannot be economically decontaminated. 6. Miscellaneous paper, rags, etc., from containment areas. 7. Used reactor equipment such as spent control rod blades, fuel channels and in-core ion chambers. 	JC	N	MD
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The function of this system is to process

Subsystem of J: Radioactive Waste Processing Systems (WPS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
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spent resins, produced from sources shown above, by flushing to the spent resin tank for storage before drumming. No resin in the NSSS is produced by chemical regeneration; hence there is no need for spent regeneration chemical processing. Flush water for spent resin flushing is supplied from the reactor make-up water tank. When decanted from the spent resin tank, the liquid is recycled to the waste holdup tank. None of this water need be released.

Subsystem of K: Secondary/Non-nuclear Systems (SNS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Cooling, heating and ventilation systems	CHVS	Systems necessary for heating and ventilation of the reactor building, control building, and auxiliary buildings.	KB	Z	AA
Chilled water systems	CHWS	Provides cooling to 45°F to the RWST and other ESF systems.	KC	U	WB
Power conversion/generator systems	PCS	Systems and controls necessary for the proper operation of the turbine and/or generator.	KD		HA
Turbine bypass system	TBS	A system of bypass valves and components used for making adjustments to turbine load changes. Also used to bypass the turbine in emergency or unusual conditions, and for main steamline warmup to the turbine.	KE		HE
Main condenser system	MCS	The system of components and controls used for cooling the steam leaving the turbine and for condensing bypassed steam. Includes condensers, cooling towers, cooling ponds, etc.	KF		HC
Emergency condenser system	ECS	The system of components and controls necessary for the proper operation of	KG		

Subsystem of K: Secondary/Non-nuclear Systemes (SNS) (continued)

Subsystem	Abbreviations	Description and Function	NSRG	WASH	NRC
			CODE	1400 CODE	CODE
		the emergency condenser.			
Water treatment systems (non-nuclear)	WTS	Auxiliary systems used for water purification in the secondary side of the generating plant. (Demineralized water make-up systems, etc.)	KH		WG
Water supply systems (non-nuclear)	WSS	The system of components used for providing a water supply to the plant.	KI		WG
Water exhaust systems (non-nuclear)	WES	The system of components used for exhausting water back to the water supply.	KJ		WE
Compressed air systems	CAS	The systems and controls used for the air supply to various plant components.	KK		PA
Process sampling systems	PSS	The system of components and controls used for various sampling procedures.	KL		PB
Seismic control systems	SCS	Hydraulic snubbers support structures, and other components used for the protection of NSSS components during seismic events.	KM		AD
Fire protection systems	FPS	All components, equipment and systems used for fire protection.	KN		AB
Other			KO		

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Subsystem of L: Instrumentation and Monitoring Systems (IMS)

Subsystem	Abbreviation	Description and Function	NSRG CLASS CODE	WASH 1400 CODE	NRC CODE
Leak detection system	LDS	Its function is the detection of leaks occurring within the reactor dry well and leaks occurring outside the reactor dry well, including the containment, fuel and auxiliary equipment building, and steam line tunnel. Uses sensing and monitoring instrumentation for indication of abnormal flows in piping systems, abnormal pressure and temperature changes, increased equipment drain and floor drain sump flow activity, and abnormal radiation levels in the dry well.	LA		BB
Area radiation monitoring systems	ARMS	It includes a number of gamma-sensitive detectors located throughout the plant and recorded in the control room. Monitors are available in several sensitivity ranges and are chosen to match the expected radiation levels. Local indication and annunciation are also available for frequently occupied areas.	LB		BA
Process radiation monitoring system	PRMS	Its function is to monitor certain plant processes to detect radioactivity in excess of acceptable limits. 1. Main steam line radiation monitoring. 2. Air ejector off-gas radiation monitoring and sampling - prior to treatment.	LC		MC

Subsystem of L: Instrumentation and Monitoring Systems (IMS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG : CODE	WASH : 1400 CODE	NRC CODE
		<ol style="list-style-type: none"> 3. Air ejector off-gas radiation monitoring and sampling - following treatment. 4. Off-gas vent pipe radiation monitoring. 5. Post-accident radiation monitoring system. 6. Containment ventilation exhaust monitoring and sampling. 7. Liquid process radiation monitoring. 			
B-30 Reactor instrumentation neutron monitoring system	RINMS	<p>Its function is to monitor reactor power in the following three ranges.</p> <ol style="list-style-type: none"> 1. Source range (SRM) Neutron flux is monitored by fission counters which are inserted to about midplane of the core by the drive mechanisms which move each chamber into the core through inverted thimbles. A range from below the source level <u>to 10^9 nv</u> is covered. 2. Intermediate range (IRM) Neutron flux is monitored by a system using a voltage variance method (or Campbell method). This is accomplished by using <u>fission chambers</u> which can be withdrawn during full power operation to maintain their expected 	LD		IB

Subsystem of L: Instrumentation and Monitoring Systems (IMS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
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life and to reduce activation.
IRM covers a range of about 10^8
to 1.5×10^{13} nv.

3. Local power (LPRM)

Neutron flux is monitored by fixed
in-core ion chambers which are
arranged in a uniform pattern
throughout the core. These cham-
bers cover a range of about 1% to
125% of rated power on a linear
scale.

4. Average power range monitors (APRM)

Each monitor measures bulk power in
the core by averaging signals from
as many as 24 detectors distributed
throughout the core. The output
signals from these monitors are
displayed and are also used to
operate trips in the reactor pro-
tection system.

5. Traversing in-core probe (TIP)

The calibration guide tube included
in each fixed in-core assembly
permits the insertion of a traver-
sing ion chamber to obtain vertical
flux profiles and to calibrate the
chambers. Flux readings along the
axial length of the core are obtained
by fully inserting the traversing ion
chamber into one of the calibration

Subsystem of L: Instrumentation and Monitoring Systems (IMS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
		guide tubes; then taking data as the chamber is withdrawn. One TIP is provided for each group of in-core assemblies.			
Reactor control and information system	RCIS	Each of the hydraulic control rods is controlled manually by the multiple solid state rod drive control system from the control room. The rods to be moved are selected by the use of a pushbutton array. A separate control switch is used to energize the valves in the hydraulic system to control the movement of the selected rod. Rods may be moved in groups under appropriate conditions. Motion is expressed by steps or notches (1 notch = 6 inches). The positions of CR's are sensed by a redundant series of magnetically operated reed switches. The positions are displayed in the operator's console.	LE		RB
In-core instrumentation system	ICIS	It provides information on the fuel assembly outlet temperatures at selected core locations. The ICIS consists of chromelalumel thermocouples. The thermocouples are positioned at preselected locations to measure fuel assembly and coolant outlet temperatures for use in monitoring the core radial power shaping and coolant enthalpy distribution.	LF	C	IB
Other instrumentation and monitoring systems	IMS	Or unknown subsystems	LG		

PRESSURIZED WATER REACTORS (PWR)

PWR SYSTEM CODE

Code	System	Abbreviation
A	Auxiliary Electrical Power Systems	AEPS
B	Reactor Protection Systems	RPS
C	Emergency Core Coolant Injection Systems	ECCIS
D	Emergency Cooling Recirculation Systems	ECRS
E	Main Reactor Cooling Systems	MRCS
F	Containment Spray and Recirculation Systems	CSRS
G	Other Containment Systems	CS
H	Reactor Power Control Systems	RPCS
I	Auxiliary Systems for Normal Operation	ASNO
J	Radioactive Waste Processing Systems	WPS
K	Secondary Non-Nuclear Systems	SNS
L	Instrumentation and Monitoring Systems	IMS
O	Other Systems	O
U	Unknown	U
X	None/Event	X

Subsystem of A: Auxiliary Electrical Power Systems (AEPS)

Subsystems	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Off-site AC power system	EPS-OFF	Two AC power sources to supply the emergency power needs for the ESF systems, and safe shutdown. (The preferred source)	AA	J	EA
On-site AC power system	EPS-AC	Two D-G sets which are required only upon loss of both off-site sources.	AB	J	EB
On-site DC power system	EPS-DC	Four 125V batteries and accessories. Each battery is aligned to serve a 125V DC bus, to provide power to several ESF systems upon the loss of AC power. In addition, the four batteries are paired by connecting two in series to provide two sources of 250V DC power.	AC	J	EC
Auxiliary equipment for AEPS/EPS	EPS-EQP	This includes transformers, cables, buses, protective devices, etc.	AD	J	EG

Subsystems of B: Reactor Protection System (RPS)

Subsystem	Abbreviation	Description and Function	NSRG: CODE	WASH 1400 CODE	NRC CODE
Reactor protection control rod system	RPCRS	This system is made up of the control rod drive mechanisms, the control rods, and the hydraulic control modulus. These components provide for the rapid insertion of the control rods when a trip condition exists.	BA	I	RB
Reactor protection logic system	RPLS	It senses improper operating conditions and removes power from the control rod drives thus initiating a reactor trip. It consists of two independent trip systems.	BB	I	IA

Subsystem of C: Emergency Core Coolant Injection System (ECCIS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Accumulator system	ACC	Passive injection system. One accumulator is attached to the cold leg of each loop of the reactor coolant system (RCS) to provide a source of emergency borated make-up water to that loop in the event that a LOCA occurs.	CA	A	SF
Low pressure injection system	LPIS	It's function is to provide a large volume of low pressure water from the RWST to the reactor pressure vessel during the early post accident period following a large LOCA. (LPRS takes over when RWST reaches 7% full level) It consists of two separate loops.	CB	B	SF
Safety injection system	SIS	Active injection system. Low-level system utilizes two RHR pumps and heat exchangers. Injects borated water into each hot leg loop, during large LOCA. High-head system utilizes a boron injection tank, CVCS charging pumps, and SIS pumps. For small LOCA, source of water for both systems is RWST.	CE		SF
Safety injection control system	SICS	It is the electronic logic which provides initiating signals to ESF systems such as LPIS, HPIS, SIS, and RPS. It consists of two separate logic trains.	CF	M	SF

Subsystem of C: Emergency Core Coolant Injection System (ECCIS) (continued)

Subsystem	Abbreviations	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
High pressure injection system	HPIS	It's function is to provide a source of high pressure water to the RCS. The function is primarily for small LOCA or secondary steam system ruptures. Another function is to push the boric acid solution from BIT into the RCS for fast reactivity suppression. It consists of three loops.	CG	F	SF
Residual heat removal system - Shutdown Cooling function	RHR-SHC	It removes residual heat from the nuclear boiler system after shutdown in preparation for refueling or plant servicing. It is manually initiated when vessel pressure is reduced to 400 psig after shutdown. It has the capability of reducing reactor vessel to a temperature of 140°F, including draining and flushing within 20 hours after the CRD are inserted. Reactor water is taken from one of the reactor water recirculation loops, pumped through the heat exchanger, and returned to the vessel by way of the feedwater lines.	CQ		CF
Chemical volume and control system	CVCS	It performs the following functions: -Fills the reactor coolant system, -Maintains the water level in the pressurizer when the RCS is hot, -Reduces the concentration of corro-	CP		SF

Subsystem of C: Emergency Core Coolant Injection System (ECCIS) (continued)

Subsystem	Abbreviations	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Other		<p>sion and fission products in the reactor coolant,</p> <ul style="list-style-type: none"> -Adjusts the boric acid concentration of the reactor coolant for chemical shim control -Provides high pressure seal water for the reactor coolant pump seals. 			CS

Subsystem of D: Emergency Core Coolant Recirculation Systems (ECCRS)

Subsystem	Abbreviations	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Low pressure recirculation system	LPRS	It provides a low pressure source of water to the RCS during the recirculation phase of the emergency core cooling. Uses the same delivery system as LPIS, except the source of water is the containment sump. Not an automatic initiated system. Consists of two subsystems.	DA	E	SF
High pressure recirculation system	HPRS	It provides a high pressure source of water to the RCS during the recirculation phase of emergency core cooling following a LOCA. The primary function of HPRS is for small LOCA when the RCS pressure may not be low enough for the low pressure recirculation system (LPRS). The HPRS also can serve a secondary function as an alternate discharge path for the LPRS. Uses the same delivery system as HPIS, except the source of water is the discharge from the LPRS pumps. Consists of three loops.	DB	H	SF

Subsystem of E: Main Reactor Coolant System (MRS)

Subsystem	Abbreviation	Description and Function	NSRG : CODE	WASH 1400 CODE	NRC CODE
Main steam line system	MSLS	The system of pipes, pumps, valves, pipe supports and controls from the pressure vessel up to and including the isolation valves outside of the primary containment. (Includes steam generators and pressurizers.)	EA		CD
Other reactor vessel internals	RVI	Includes the reactor pressure vessel and the core support structure.	EC		RA
Other	RCS	Includes all other aspects of the reactor cooling system, or unknown subsystems.	ED		

Subsystem of P: Containment Spray and Recirculation Systems (CSRS)

Subsystem	Abbreviations	Description and Function	GEN CLASS CODE	WASH 1400 CODE	NRC CODE
Containment spray injection system	CSIS	It delivers cold water containing boron through spray heads to the containment volume from the refueling water storage tank (RWST) during the first half hour after the postulated LOCA incident. The principal function of CSIS is to reduce the pressure in the containment. The CSIS also provides the preferred path for delivery of sodium hydroxide to the containment atmosphere for initial fission product removal. It consists of two identical systems.	FB	C	SA
Containment spray recirculation system	CSRS	It provides for recirculation of the containment sump water through the heat exchanger of the CHRS to spray headers inside the containment for the purpose of pressure control, fission product removal, and long term energy removal in the event of LOCA. It consists of four loops.	FC	D	SA
Sodium hydroxide addition system	SHAS	It's function is to add, automatically, sodium hydroxide to the refueling water storage tank, RWST, when an accident causes pressure conditions in the containment to exceed a preset level. The SHAS provides an active solution for radioactivity removal by CSIS, and CSRS.	FE	L	PC

Subsystem of F: Containment Spray and Recirculation System (CSRS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Containment heat removal system	CHRS	To cool containment sump water being recirculated through the containment spray recirculation system, CSRS. The CSRS is automatically started following a LOCA. And in conjunction with CHRS provides heat removal from the containment. There is one loop for each CSRS loop.	FF	K	SB

Subsystem of G: Other Containment Systems (CS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Containment leakage Containment isolation system	CL CIS	It's function is to automatically seal the containment following an accident by closing isolation valves in all lines penetrating the containment, including MSIV's, which are not required by safety systems. ESF logic systems initiate signals which are used to close the isolating valves. Containment leakage includes airlocks, manways, equipment hatches, and the containment building itself.	GA	G	SD
Consequence limiting control system	CLCS	It is designed to detect out-of-order tolerance conditions within the containment, by measuring containment pressure, and to initiate operation of equipment and systems designed to limit and counteract these conditions. It consists of four measurement channels and four logic trains.	GB	N	SA
Secondary contain- ment system	SCS	It's function is, within certain bounds, to limit the ground level release of radioactive materials that may be released beyond the confines of the primary containment (PC), also SCS is designed to provide a means of controlled elevated release of the reactor building atmosphere. SCS is designed as a back-up to the PC for small break areas; a gross breach of that barrier would render the SCS ineffective. Operation of the SCS must be considered in	GC		SA

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Subsystem of G: Other Containment Systems (CS) (continued)

Subsystem	Abbreviations	Description and Function	GEN CLASS CODE	WASH 1400 CODE	NRC CODE
		concert with the status of PC integrity.			
Containment atmosphere dilution system	CADS	It has two principle functions to perform in the event of a LOCA. To limit the ground level release of contaminants by providing a negative pressure within the RB. And to filter and re-release any air within the SC at an elevated release point. (Normal operation events are usually concerned with pressure and temperature differentials outside of limits.)	GE		SA
Containment fan cooler system	CFCS	It is designed to remove heat from the containment building during both normal operation and in the event of LOCA. The CFCS units are an engineered safe guard system. There are a total of five units per containment operating in parallel. During normal operation a maximum of four units are required to remove the design heat load. For post-accident operation a minimum of three units must function to satisfy safeguards requirements.	GF		SB
Ice condenser reactor contain- ment system	ICRCS	It is a static system that rapidly absorbs the energy release resulting from a pipe rupture. The steam is condensed in an ice bed (the ice condenser) located inside the containment structure. The	GG	SE	

Subsystem of G: Other Containment Systems (CS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
		containment pressure is reduced to a few psi within minutes after an accident. In addition much of the radioactivity released within the containment is condensed with the steam. Finally, because the ice is a static heat sink that is not dependent upon any external power source for its operation, its reliability as an engineered safeguard is maximized.			
Containment purge and exhaust system	CPES	Includes systems used for nitrogen supply (combustible control) and RB ventilation.	GH		SF
Primary containment	PC	The reactor building concrete dome which provides for the reactor building environment and limits the level of radioactivity release to the environment both during normal and emergency operations.	GI		
Other			GI		

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Subsystem of H: Reactor Power Control Systems (RPCS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Chemical power control systems	CPCS	Consists of CVCS when used for reactor control only.	HA		PC
Control rod systems	CRS	Includes the system of control rods, drive mechanisms, and supports necessary for proper control rod movement. It is not a scram function, but rather shim control.	HC		RB
Other	RPCS	Principally used for unknown subsystems.	HD		

Subsystem of I: Auxiliary Systems For Normal Operation (ASNO)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Spent fuel pit cooling system	SFPCS	Designed to remove the heat generated by the stored spent fuel elements. A pump draws water from the pit, circulates it through a heat exchanger and returns it to the pit. The clarity and purity of the pit is maintained by passing the water through a filter and demineralizer.	IA		FC
Reactor water cleanup system	RWCUS	Its purpose is to maintain high reactor water quality by removing fission products, corrosion products, and other soluble and insoluble impurities. In addition, the system provides a means for water removal from the primary system during periods of increasing water volume. The system can be operated during start-up, shutdown, and refueling operation, as well as during plant operation.	IB		CG
Component cooling system	CCS	It is designed to remove heat from heat exchangers, pumps, and waste disposal systems. Component cooling water flows through these units in parallel flow circuits, picks up heat from the various components, and flows to the component cooling heat exchangers which are cooled by the SWS. The CC loop, therefore, acts as an intermediate radiation barrier for the SWS. The system operates under both normal and emergency situations. It consists of three CC pumps, two CC heat exchangers, a surge tank, associated pipes, and valves.	IC	E	WA

Subsystem of I: Auxiliary Systems For Normal Operation (ASNO)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Reactor coolant chemistry systems	RCCS	Includes systems used for RCS chemistry control, other than CVCS (i.e., systems for H ₂ /O ₂ conc. control, etc.)	ID		PC
Service water system	SWS	Supplies all the equipment cooling water for the plant, including the emergency shutdown requirements.	IF		FA FB FC
Main feedwater system	MFS	Supplies water to the secondary side of the steam generators during normal operating conditions	IG		

Subsystem of J: Radioactive Waste Processing Systems (WPS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Waste processing system - liquid handling	WPS-LH	<p>Its design allows for operational flexibility and also provides for segregation of drains to allow separate handling of potentially irradiated and non-irradiated effluents.</p> <p>The various process wastes are collected by suitable connections of drains, piping and tanks or sumps in the various station buildings and piped to the collection tanks in the radwaste building.</p> <p>Oil is removed from sump and equipment drains by means of oil separators. Normally the high purity waste is filtered, demineralized, monitored and returned to condensate storage for further use. The low-purity and chemical wastes are batch treated by chemical neutralization processes and then concentrated by evaporation for packaging for off-site shipment. Water boiled off in the concentrator is processed through a demineralizer, monitored and returned to condensate storage.</p>	JA		MA
Waste processing system - gas handling	WPS-GH	<p><u>Types of radioactive gases:</u></p> <ol style="list-style-type: none"> 1. Activation gases: elements which become radioactive from exposure to radiation (N-12, O-16, O-19, F-18). 2. Fission gases: gases released by fuel defects such as the radioisotopes of Kr, Xe. 	JB		MB

Subsystem of J: Radioactive Waste Processing Systems (WPS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
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Release paths:

1. Steam jet ejector off gases.
2. Turbine steam seal system off gases.
3. Mechanical vacuum pump exhaust.
4. Leaks from radioactive systems or components where leakage enters ventilation pathways.

This system, by batch processing and/or continuous monitoring before release, assures that any planned permissible releases, of gases from paths listed above, are "as low as reasonable achievable."

Waste processing
system -
Spent resin/solid
handling

WPS-SH

Potential radioactive solid wastes:

1. Filter and resin sludges.
2. Concentrated wastes from liquid waste treatment concentrators.
3. Air filters from off gas and ventilation systems.
4. Solid laboratory wastes.
5. Containment clothing, tools, and small pieces of equipment which cannot be economically decontaminated.
6. Miscellaneous paper rags, etc., from containment areas.
7. Used reactor equipment such as spent control rod blades, fuel channels and in-core ion chambers.

JC

MD

Subsystem of J: Radioactive Waste Processing Systems (WPS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG	WASH	NRC
			CODE	1400 CODE	CODE

The function of this system is to process spent resins, produced from sources shown above, by flushing to the spent resin tank for storage before drumming. No resin in the NSSS is produced by chemical regeneration; hence there is no need for spent regeneration chemical processing. Flush water for spent resin flushing is supplied from the reactor make-up water tank. When decanted from the spent resin tank, the liquid is recycled to the waste holdup tank. None of this water need be released.

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Subsystem of K: Secondary/Non-nuclear Systems (SNS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Auxiliary feed water system	AFWS	It provides feed water to the secondary side of the steam generator upon loss of main feed water. It includes auxiliary pumps and condensate tanks. Three AFW pumps are included. One is turbine powered, the other two are diesel driven. One system feeds all secondary loops.	KA	P	HH
Cooling, heating and ventilation systems	CHVS	Systems necessary for heating and ventilating of the reactor building, including the control building.	KB	Z	AA
Power conversion/ generator systems	PCS	Systems and controls necessary for the proper operation of the turbine and/or generator.	KD		HA
Turbine bypass system	TBS	A system of bypass valves and components used for making adjustments to turbine load changes. Also used to bypass the turbine in emergency or unusual conditions.	KE		HE
Main condenser system	MCS	The system of components and controls used for cooling the steam leaving the turbine and for condensing bypassed steam. Includes cooling towers, cooling ponds, etc.	KF		HC
Emergency condenser system	ECS	The system of components and controls necessary for the proper operation of the emergency condenser.	KG		

Subsystem of K: Secondary/Non-nuclear Systems (SNS) (continued)

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Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Water treatment systems (non-nuclear)	WTS	Auxiliary systems used for water purification in the secondary side of the generating plant. (Demineralized water make-up systems, etc.)	KH		WG
Water supply systems (non-nuclear)	WSS	The systems of components used for providing a water supply to the plant.	KI		WG
Water exhaust systems (non-nuclear)	WES	The system of components used for exhausting water back to the water supply.	KJ		WE
Compressed air system	CAS	The systems and controls used for the air supply to various plant components.	KK		PA
Process sampling systems	PSS	The system of components and controls used for various sampling procedures.	KL		PB
Seismic control systems	SCS	Hydraulic snubbers support structures, and other components used for the protection of NSSS components during seismic events.	KM		AD
Fire protection systems	FPS	All components, equipment and systems used for fire protection.	KN		AB
Main feedwater system	MFWS	Supplies water to the secondary side of the steam generator during normal operation. There is one MFW pump for each loop.	KO		

Subsystem of L: Instrumentation and Monitoring Systems (IMS)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
Leak detection system	LDS	Its function is the detection of leaks occurring within the reactor dry well and leaks occurring out side the reactor dry well, including the containment, fuel and auxiliary equipment building, and steam line tunnel. Uses sensing and monitoring instrumentation for indication of abnormal flows in piping systems, abnormal pressure and temperature changes, increased equipment drain and floor drain sump flow activity, and abnormal radiation levels in the dry well.	LA		BB
Area radiation monitoring systems	ARMS	It includes a number of gamma-sensitive detectors located throughout the plant and recorded in the control room. Monitors are available in several sensitivity ranges and are chosen to match the expected radiation levels. Local indication and annuciation are also available for frequently occupied areas.	LB		BA
Process radiation monitoring system	PRMS	Its function is to monitor certain plant processes to detect radioactivity in excess of acceptable limits. 1. Main steam line radiation monitoring. 2. Air ejector off-gas radiation monitoring and sampling - prior to treatment.	LC		MC

Subsystem of L: Instrumentation and Monitoring System (IMS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
		<ol style="list-style-type: none"> 3. Air ejector off-gas radiation monitoring and sampling - following treatment. 4. Off-gas vent pipe radiation monitoring. 5. Post-accident radiation monitoring system. 6. Containment ventilation exhaust monitoring and sampling. 7. Liquid process radiation monitoring. 			
Reactor instrumentation neutron monitoring system	RINMS	<p>Its function is to monitor reactor power in the following three ranges.</p> <ol style="list-style-type: none"> 1. Source range (SRM) Neutron flux is monitored by fission counters which are inserted to about midplane of the core by the drive mechanisms which move each chamber into the core through inverted thimbles. A range from below the source level to 10^9 nv is covered. 2. Intermediate range (IRM) Neutron flux is monitored by a system using a voltage variance method (or Campbell method). This is accomplished by using <u>fission chambers</u> which can be <u>withdrawn during full power operation</u> to maintain their expected 	LD		IB

Subsystem of L: Instrumentation and Monitoring Systems (IMS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
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life and to reduce activation.
IRM covers a range of about 10^8
to 1.5×10^{13} nv.

3. Local power (LPRM)

Neutron flux is monitored by fixed
in-core ion chambers which are
arranged in a uniform pattern
throughout the core. These cham-
bers cover a range of about 1% to
125% of rated power on a linear
scale.

4. Average power range monitors (APRM)

Each monitor measures bulk power in
the core by averaging signals from
as many as 24 detectors distributed
throughout the core. The output
signals from these monitors are
displayed and are also used to
operate trips in the reactor pro-
tection system.

5. Traversing in-core probe (TIP)

The calibration guide tube included
in each fixed in-core assembly
permits the insertion of a traver-
sing ion chamber to obtain vertical
flux profiles and to calibrate the
chambers. Flux readings along the
axial length of the core are obtained
by fully inserting the traversing ion
chamber into one of the calibration

Subsystem of L: Instrumentation and Monitoring Systems (IMS) (continued)

Subsystem	Abbreviation	Description and Function	NSRG CODE	WASH 1400 CODE	NRC CODE
		guide tubes; then taking data as the chamber is withdrawn. One TIP is provided for each group of in-core assemblies.			
Reactor control and information system	RCIS	Each of the hydraulic control rods is controlled manually by the multiple solid state rod drive control system from the control room. The rods to be moved are selected by the use of a pushbutton array. A separate control switch is used to energize the valves in the hydraulic system to control the movement of the selected rod. Rods may be moved in groups under appropriate conditions. Motion is expressed by steps or notches (1 notch = 6 inches). The positions of CRs are sensed by a redundant series of magnetically operated reed switches. The positions are displayed in the operator's console.	LE		RB
In-core instrumentation system	ICIS	It provides information on the fuel assembly outlet temperatures at selected core locations. The ICIS consists of chromelalumel thermocouples. The thermocouples are positioned at preselected locations to measure fuel assembly and coolant outlet temperatures for use in monitoring the core radial power shaping and coolant enthalpy distribution.	LF	C	IB
Other instrumentation and monitoring systems	IMS	Or unknown subsystems	LG		

COMPONENT CODE (USED FOR ENCODING)

Mechanical Components

CZ - Cabinet
CY - Cable Tray/Panel
CM - Cam
CW - Clamp
CL - Clutch
CN - Condenser
CR - Control Rod(s)
CD - Control Rod Drive Unit
CC - Cooler/Chiller
FA - Cover Plate
CX - Crane
DM - Damper
DR - Door/Hatch
DW - Drywell
DU - Duct
OO - Event (No component Involved)
FL - Filter or Strainer
FT - Fitting (for pipes/lines, etc.)
FG - Flange
FD - Floor Drain
GB - Gas Bottle
GK - Gasket
GR - Governor

LK - Tank, Demineralized Water Storage
JK - Tank, Fuel
TK - Tank, Other
RK - Tank, Refueling Water Storage
SK - Tank, Surge
WK - Tank, Waste Processing/Storage
TN - Tendon
TG - Tubing
TB - Turbine
CV - Valve, Check
EV - Valve, Explosive Operated
HV - Valve, Hydraulic Operated
XV - Valve, Manual
MV - Valve, Motor Operated
OV - Valve Operator
AV - Valve, Pneumatic Operated
RV - Valve, Relief
SV - Valve, Safety
FV - Valve, Safety-Relief
KV - Valve, Solenoid Operated
DV - Valve, Stop Check
UV - Valve, Unknown
VV - Valve, Vacuum Relief
VT - Vent
WL - Well, other
WW - Wetwell/Torus

IO - Instrumentation (Other)
IV - Inverter (Solid State)
JP - Jumper/Contact Block
LG - Light
LA - Lightning Arrester
ME - Meter
MN - Monitor, Other than Radiation
MO - Motor
MT - Motor Starter
ND - Neutron Detector
PR - Potentiometer
PW - Power Supply (Other than DC)
PB - Pushbutton
RM - Radiation Monitor
RC - Recorder
RG - Regulator
RE - Relay
RT - Resistor, Temperature Device
AD - Signal Comparator
SD - Smoke Detector
SM - Summator (for Logic System)
NS - Switch, Contact
CS - Switch, Control
FS - Switch, Flow
GS - Switch, Ground
LS - Switch, Level

VS - Switch, Limit
MS - Switch, Manual
PS - Switch, Pressure
RS - Switch, Reset
TS - Switch, Temperature
SS - Switch, Test
QS - Switch, Torque
OS - Switch, Unknown
TM - Terminal Board
OL - Thermal Overload
TH - Thermostat
TI - Timer
CT - Transformer, Current
OT - Transformer, Potential
WT - Transformer, Power (or control)
ST - Transmitter, Flow
LT - Transmitter, Level
ZT - Transmitter, Other
PT - Transmitter, Pressure
TT - Transmitter, Temperature
UU - Unknown
WR - Wire/Lead

COMPONENT CODE (USED FOR DECODING)

Mechanical Components

AK - Accumulator Tank
AV - Pneumatic Operated Valve
BK - Boron Injection Tank
CC - Cooler/Chiller
CD - Control Rod Drive Unit
CK - Boric Acid Storage Tank
CL - Clutch
CM - Cam
CN - Condenser
CP - Pipe Gap/Joint
CR - Control Rod(s)
CV - Check Valve
CW - Clamp
CX - Crane
CY - Cable Tray/Panel
CZ - Cabinet
DK - Chemical Addition Tank
DM - Damper
DR - Door/Hatch
DU - Duct
DV - Stop Check Valve
DW - Drywell
EK - Condensate Storage Tank

EV - Explosive Operated Valve
FA - Cover Plate
FD - Floor Drain
FG - Flange
FK - Core Flood Tank
FL - Filter or Strainer
FT - Fitting (for pipes/lines/etc.)
FV - Safety-Relief Valve
GB - Gas Bottle
GK - Gasket
GR - Governor
HE - Heat Exchanger
HV - Hydraulic Operated Valve
IJ - Injectors/Injector Racks for Diesel
JK - Fuel Tank
KV - Solenoid Operated Valve
LE - Line
LK - Demineralized Water Storage Tank
LN - Linkage
MV - Motor Operated Valve
NZ - Nozzle
OR - Orifice
OV - Valve Operator
PG - Plug
PL - Pool
PM - Pump

Electrical Components

AD - Signal Comparator
AL - Alarm
AM - Amplifier
AN - Annunciator
AZ - Analyzer
BC - Battery Charger
BI - Bistable
BL - Blower
BS - Bus
BY - Battery/DC Power Supply
CA - Cable
CB - Circuit Breaker
CE - Computer
CO - Coil
CS - Control Switch
CT - Current Transformer
DE - Diode or Rectifier
DH - Dehumidifier
DI - Dial
FM - Film Badge/Dosimeter
FS - Flow Switch
FU - Fuse
GE - Generator
GS - Ground Switch
HD - Heat Detector

HG - Heating Element
HT - Heat Tracing Element
IM - Input Module
IO - Instrumentation (Other)
IP - Incore Probe/TIP/Thimble
IV - Inverter (Solid State)
JP - Jumper/Contact Block
LA - Lightning Arrester
LG - Light/Bulb/Etc.
LS - Light Switch
LT - Level Transmitter
ME - Meter
MN - Other than Radiation Monitor
MO - Motor
MS - Manual Switch
MT - Motor Starter
ND - Neutron Detector
NS - Switch Contact
OL - Thermal Overload
OO - Event (No Component Involved)
OS - Unknown Switch
OT - Potential Transformer
PB - Pushbutton
PR - Potentiometer
PS - Pressure Switch
PT - Pressure Transmitter

PW - Power Supply
QS - Torque Switch
RC - Recorder
RE - Relay
RG - Regulator
RM - Radiation Monitor
RS - Reset Switch
RT - Temperature Device Resistor
SD - Smoke Detector
SS - Test Switch
ST - Transmitter, Flow
TH - Thermostat
TI - Timer
TM - Terminal Board
TS - Temperature Switch
TT - Temperature Transmitter
UU - Unknown
VB - Vacuum Breaker
VS - Limit Switch
WR - Wire
WT - Power (or control) Transformer
ZT - Transmitter, Other

DD - Deenergize/Disengage/Stop, did not
DS - Deenergized/ Disengaged/Stopped/Tripped
DL - Deenergized, left
DV - Deenergization, Inadvertant
DF - Defective
DR - Drift
ED - Energize/Engage/Stop, did not
ES - Energized/Engaged/Started
EL - Energized, left
EI - Energization, Inadvertant
EV - Event (No failure mode)
EX - Experience, Lack of
FA - Fatigue
FD - Fill, did not
FO - Filled, over
FR - Flow Rate, Improper
HI - Handling, Improper
IA - Inadvertant Actuation
IS - Installation
LK - Leakage
LL - Limit, Exceeds lower
LU - Limit, Exceeds upper
LD - Lock, did not
LF - Locked, left

LI - Locking, Improper
LO - Loose/Loosened
LB - Lubrication
ML - Malfunction
MD - Monitor/Inattention/Failure to observe/Failure to
Identify, did not
MI - Misinterpretation/Misunderstanding
MJ - Misjudgement
OL - Open/did not close, left
OP - Open, left partially
OD - Opened
OI - Operation (other), Improper
OR - Overloaded
OZ - Overpressurized
OT - Overtorqued
PT - Painted
PG - Plugged
WP - Position (other), Left in Wrong
MP - Positioning, mis-/Misalignment/Improper setting
PI - Procedure Inadequacy
PR - Procedure Violation (other)
PU - Procedure Unfamiliarity
PW - Procedure, Followed Wrong
PD - Procedure, did not follow
RA - Record, did not
RM - Recording/Misread, Incorrect

RC - Removed from Service
RR - Removed after repair, did not
RB - Remove from Service, did not
RJ - Removed/Secured from Service, Inadvertantly
RK - Replace, did not
RG - Replacement, Improper
RE - Repair, Erroneous
RI - Repair, Improper
RL - Repair, Lack of
RH - Reset, did not
RN - Response, no
RO - Response/Overcompensation, Over
RS - Response/Time-too long, slow
RF - Response/Time-too short, fast
RT - Return to service, did not
RZ - Returned to service, Improperly
RD - Ruptured/Deformed
SP - Separated
SQ - Sequence, Improper
SV - Severed
ST - Sticking/Stuck/Binding
TG - Tag, did not
TD - Test/Check, did not
TN - Tighten, did not

FAILURE MODE CODE* (USED FOR DECODING)

AD - Out of Adjustment
AM - Misadjustment
AN - Did not Adjust
AR - Improper Assembly
BP - Did not Bypass
CA - Calculation
CB - Calibration
CC - Did not Connect
CD - Closed
CE - Computer Input Error
CG - Loose Connection
CL - Left Closed
CM - Communication
CN - Carelessness/Negligence/Oversight
CO - Open Circuit
CP - Left Partially Closed
CR - Did not Reconnect
CS - Short Circuit
CT - Improper Connection (other)
CU - Disconnected
CX - Cleaning (other)
CZ - Did not Clean
DD - Deenergize/Disengage/Stop/did not,
DF - Defective
DS - Damage (other)

DI - Inadvertant Damage
DL - Left Deenergized
DR - Drift
DS - Deenergized/Disengaged/Stopped
DV - Inadvertant Deenergization
ED - Did not, Energize/Engage/Start
EI - Inadvertant Energization
EL - Left Energized
ES - Energized/Engaged/Started
EV - Event (no failure mode)
EX - Lack of experience
FA - Fatigue
FD - Did not Fill
FO - Over Filled
FR - Improper Flow Rate
HI - Improper Handling
IA - Inadvertant Actuation
IS - Installation
LB - Lubrication
LD - Did not Lock
LF - Left Locked
LI - Improper Locking
LK - Leakage
LL - Exceeds Lower Limit

RE - Erroneous Repair
RF - Fast Response/Time too Short
RG - Improper Replacement
RH - Did not Reset
RI - Improper Repair
RJ - Inadvertantly Removed from Service
RK - Did not Replace
RL - Lack of Repair
RM - Incorrect Recording/Misread
RN - No Response
RO - Qver Response/Overcompensation
RR - Did not Remove after Repair/Test
RS - Slow Response/Time-Too Long
RT - Did not Return to Service
RZ - Improperly Returned to Service
SP - Separated
SQ - Improper Sequence
ST - Sticking/Stuck/Binding
SV - Severed
TD - Did not Test/Check
TE - Excessive Tightening
TG - Did not Tag
TN - Did not Tighten
TR - Tripped
UL - Left Unattended

UU - Unknown
VI - Improper Verification
WE - Improper Welding
WI - Improper Withdrawal
WL - Left Withdrawn
WO - Worn-Out/End of Life/Deteriorated
WP - Left in Wrong Position (other)
WR - Wiring

Failure Mode Code* (Used for Encoding)

AR - Improper Addition Rate
AD - Out of Adjustment
AM - Misadjustment
AN - Did not Adjust
AS - Improper Assembly
BP - Did not Bypass
CN - Carelessness/Negligence/Oversight
CP - Left Partially Closed
CL - Left Closed
CD - Closed
CM - Communication
CE - Computer Input Error
CC - Did Not Connect
CG - Loose Connection
CR - Did Not Reconnect
CU - Disconnected
CT - Improper Connection (Other)
CB - Calibration
CA - Calculation
CO - Open Circuit
CS - Short Circuit
CX - Cleaning (Other)
CZ - Did Not Clean
DG - Damage (Other)
DI - Inadvertant Damage
DD - Did Not Deenergize/Disengage/Stop
DV - Inadvertant Deenergization
DL - Left Deenergized
DS - Deenergized/Disengaged/Stopped/Tripped
DF - Defective
DR - Drift
ED - Did Not Energize/Engage/Start

EI - Inadvertant Energization
 EL - Left Energized
 ES - Energized/Engaged/Started
 EV - Event (No Failure Mode)
 EX - Lack of Experience
 FA - Fatigue
 FD - Did Not Fill
 FO - Overfilled
 FR - Improper Flow Rate
 HI - Improper Handling
 IA - Inadvertant Actuation
 IS - Installation
 LK - Leakage
 LU - Exceeds Upper Limit
 LL - Exceeds Lower Limit
 LD - Did Not Lock
 LF - Left Locked
 LI - Improper Locking
 LO - Loose/Loosened
 LB - Lubrication
 ML - Malfunction
 MD - Did Not Monitor/Inattention/Failure to Observe/Failure to
 MT - Misinterpretation/Misunderstanding Identify
 MJ - Misjudgment
 MP - Mispositioning /Misalignment/Improper Setting
 OO - Other, Miscellaneous Failure Mode
 OP - Left Partially Open
 OL - Left Open/Did Not Close
 OD - Opened
 OI - Improper Operation; Other
 OR - Overloaded
 OZ - Overpressurized
 OT - Overtorqued
 PT - Painted

PG - Plugged
WP - Left in Wrong Position (Other)
PI - Procedure Inadequacy
PR - Procedure Violation, Other
PD - Did Not Follow Procedure
PW - Wrong Procedure Followed
PU - Procedure Unfamiliarity
RA - Did Not Record
RM - Incorrect Recording/Misread
RR - Did Not Remove After Repair/Test
RB - Did Not Remove From Service
RC - Removed From Service
RJ - Inadvertantly Removed/Secured From Service
RK - Did Not Replace
RG - Improper Replacement
RI - Improper Repair
RL - Lack of Repair
RE - Erroneous Repair
RH - Did Not Reset
RS - Slow Response/Time-Too Long
RF - Fast Response/Time-Too Short
RN - No Response
RO - Over Response/Overcompensation
RT - Did Not Return To Service
RZ - Improperly Returned to Service
RD - Ruptured/Deformed
SQ - Improper Sequence
SP - Separated
SV - Severed
ST - Sticking/Stuck/Binding
TG Did Not Tag
TD - Did Not Test/Check
TN - Did Not Tighten
TE - Excessive Tightening/Overtorqued

UL - Left Unattended
TR - Tripped
UU - Unknown
VI - Improper Verification
WE - Improper Welding
WO - Worn-out/End of Life/Deteriorated
WL - Left Withdrawn
WI - Improper Withdrawal
WR - Wiring

*The word underlined in the key word of the phrase.

Failure Mode Code* (Used For Decoding)

AD - Out of Adjustment
AM - Misadjustment
AN - Did Not Adjust
AR - Improper Assembly
BP - Did Not Bypass
CA - Calculation
CB - Calibration
CC - Did Not Connect
CD - Closed
CE - Computer Input Error
CG - Loose Connection
CL - Left Closed
CM - Communication
CN - Carelessness/Negligence/Oversight
CO - Open Circuit
CP - Left Partially Closed
CR - Did Not Reconnect
CS - Short Circuit
CT - Improper Connection (other)
CU - Disconnected
CX - Cleaning (Other)
CZ - Did Not Clean
DD - Did Not Deenergize/Disengage/Stop
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DG - Damage (Other)
DI - Inadvertant Damage
DL - Left Deenergized
DR - Drift
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EI - Inadvertant Energization

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EX - Lack of Experience
FA - Fatigue
FD - Did Not Fill
FO - Overfilled
FR - Improper Flow Rate
HI - Improper Handling
IA - Inadvertant Actuation
IS - Installation
LB - Lubrication
LD - Did Not Lock
LF - Left Locked
LI - Improper Locking
LK - Leakage
LL - Exceeds Lower Limit
LO - Loose/Loosened
LU - Exceeds Upper Limit
MD - Did Not Monitor/Inattention/Failure to Observe/Failure to
Identify
ML - Malfunction
MJ - Misjudgment
MP - Mispositioning/Misalignment/Improper Setting
MT - Misinterpretation/Misunderstanding
OD - Opened
OI - Improper Operation; Other
OL - Left Open/Did Not Close
OO - Other, Miscellaneous Failure Mode
OP - Left Partially Open
OR - Overloaded
OT - Overtorqued
OZ - Overpressurized
PD - Did Not Follow Procedure
PG - Plugged

PI - Procedure Inadequacy
PR - Procedure Violation, Other
PT - Painted
PU - Procedure Unfamiliarity
PW - Wrong Procedure Followed
RA - Did Not Record
RB - Did Not Remove From Service
RC - Removed From Service
RD - Ruptured/Deformed
RE - Erroneous Repair
RF - Fast Response/Time-Too Short
RG - Improper Replacement
RH - Did Not Reset
RI - Improper Repair
RJ - Inadvertantly Removed From Service
RK - Did Not Replace
RL - Lack of Repair
RM - Incorrect Recording/Misread
RN - No Response
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WP - Left in Wrong Position, Other
WR - Wiring

*The work underlined is the key word of the phrase.

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FAILURE MODE

AF	FAILURE TO ACTUATE
AI	INADVERTANT ACTUATION
AO	OUT OF ADJUSTMENT
BD	BINDING
BN	BROKEN
BO	BURNED-OUT
BP	BYPASSED
CA	CALIBRATION
CB	OUT OF CALIBRATION
CC	REDUCED CAPABILITY
CD	REDUCED CAPACITY
CE	FAILURE TO CLOSE
CF	FAILURE TO FULLY CLOSE
CG	LEFT CLOSED
CH	CLOSED
CI	CONTAMINATED
CJ	INADEQUATE CONTROL
DA	DAMAGED
DE	DEENERGIZED
DI	DILUTED
DL	DISABLED
DN	DISCONNECTED
DS	FAILURE TO DISENGAGE
EF	FAILURE TO ENERGIZE
EV	EVENT (NO FAILURE MODE)
EX	EXPLOSION
FE	FIRE
FI	IMPROPER FLOW
FN	NO FLOW
FR	REDUCED FLOW
IA	IMPROPER INDICATION
ID	INOPERABLE
IF	FAILURE TO INSERT
II	ISOLATED
IJ	INSTABILITY/ERRATIC OPERATION
IL	NOT INSTALLED
IN	IMPROPERLY INSTALLED
LA	FAILURE TO LATCH
LC	LEAKAGE
LE	EXCEEDS LIMITS
LL	EXCEEDS LOWER LIMITS
LU	EXCEEDS UPPER LIMITS
LV	FAILURE TO LOCK-UP
LX	LOOSE
MF	MALFUNCTION
MI	MISSING INTERNALS
OB	OBSTRUCTED
OC	OPEN
OE	FAILURE TO OPEN
OF	FAILURE TO FULLY OPEN
OV	OVERFLOW

OZ	OVERPRESSURE/OVERPRESSURIZED
PL	LOSS OF POWER
PR	FAILURE TO PRESSURIZE/UNPRESSURIZED
RC	NOT RECORDED
RF	FAILURE TO RESET
RI	IMPROPER/INCORRECT RESPONSE
RN	NO RESPONSE
RS	SLOW RESPONSE
RU	RUPTURED
SA	SEPARATED
SC	SHORT-CIRCUIT
SP	SPRAYED
SR	FAILURE TO START
ST	FAILURE TO STOP
SU	STUCK/STICKING
TA	NOT TESTED
TC	IMPROPER CLOSURE TIME
TF	TIME-TOO FAST
TL	TIME-TOO LONG/START TIME-TOO LONG
TP	TRIPPED
TR	FAILURE TO TRIP
TX	TRIP EXCEEDS LIMITS
UC	UNCOUPLED
UK	UNKNOWN/NONE-EVENT

COMPONENTS

AL	ALARM
AM	AMPLIFIER
AZ	ANALYZER
AN	ANNUCIATOR
BC	BATTERY CHARGER
BY	BATTERY/DC POWER SUPPLY
BI	BISTABLE
BL	BLOWER/FAN
CB	BREAKER, CIRCUIT
VB	BREAKER, VACUUM
BS	BUS
CA	CABLE
CO	COIL
CE	COMPUTER
DH	DEHUMIDIFIER
DI	DIAL
DE	DIODE OR RECTIFIER
FE	FUEL ELEMENT/ROD
FM	FILM BADGE/DOSIMETER
FU	FUSE
GE	GENERATOR
HO	HEAT DETECTOR
HG	HEAT ELEMENT
HT	HEAT TRACING ELEMENT
IP	INCORE PROBE/TIP-THIMBLE
IM	INPUT MODULE
IO	INSTRUMENTATION (OTHER)
IV	INVERTER (SOLID STATE)
JP	JUMPER/CONTACT BLOCK
LG	LIGHT
LA	LIGHTNING ARRESTER
ME	METER
MN	MONITOR, OTHER THAN RADIATION
MO	MOTOR
MT	MOTOR STARTER
ND	NEUTRON DETECTOR
PW	POWER SUPPLY (OTHER THAN DC)
PB	PUSHBUTTON
RM	RADIATION MONITOR
RC	RECORDER
RG	REGULATOR
RE	RELAY
RT	RESISTOR, TEMPERATURE DEVICE
AD	SIGNAL COMPARATOR
SD	SMOKE DETECTOR
SM	SUMMATOR (FOR LOGIC SYSTEM)
NS	SWITCH, CONTACT
CS	SWITCH, CONTROL
FS	SWITCH, FLOW
GS	SWITCH, GROUND

LS	SWITCH, LEVEL
VS	SWITCH, LIMIT
MS	SWITCH, MANUAL
PS	SWITCH, PRESSURE
RS	SWITCH, RESET
TS	SWITCH, TEMPERATURE
SS	SWITCH, TEST
QS	SWITCH, TORQUE
OS	SWITCH, UNKNOWN
TM	TERMINAL BOARD
OL	THERMAL OVERLOAD
TH	THERMOSTAT
TI	TIMER
CT	TRANSFORMER, CURRENT
OT	TRANSFORMER, POTENTIAL
WT	TRANSFORMER, POWER (OR CONTROL)
ST	TRANSMITTER, FLOW
LT	TRANSMITTER, LEVEL
ZT	TRANSMITTER, OTHER
PT	TRANSMITTER, PRESSURE
TT	TRANSMITTER, TEMPERATURE
UU	UNKNOWN
WR	WIRE/LEAD/CONNECTOR ASSEMBLY
CZ	CABINET
CY	CABLE TRAY/PANEL
CM	CAM
CW	CLAMP
CL	CLUTCH
CN	CONDENSER
CR	CONTROL ROD(S)
CD	CONTROL ROD DRIVE UNIT
CC	COOLER/CHILLER
FA	COVER PLATE
CX	CRANE
DM	DAMPER
DR	DOOR/HATCH
DW	DRYWELL
DU	DUCT
DO	EVENT (NO COMPONENT INVOLVED)
FL	FILTER OR STRAINER
FT	FITTING (FOR PIPES/LINES, ETC.)
FG	FLANGE
FD	FLOOR DRAIN
GB	GAS BOTTLE
GK	GASKET
GR	GOVERNOR
HE	HEAT EXCHANGER
IJ	INJECTORS/INJECTOR RACKS FOR DIESEL
LE	LINE
LN	LINKAGE
NZ	NOZZLE
OR	ORIFICE
PP	PIPE
CP	PIPE GAP/JOINT

DG	PLUG
PL	POOL
PV	PRESSURE VESSEL
PZ	PRESSURIZER
PM	PUMP
RF	REFRIGERATION UNIT
RW	ROD WORTH MINIMIZER
SA	SHOCK ABSORBER/HYDRAULIC SNUBBERS
SL	SLUICE GATE
SG	STEAM GENERATOR
SP	SUMP
SR	STRAINER
AK	TANK, ACCUMULATOR
CK	TANK, BORIC ACID STORAGE
BK	TANK, BORON INJECTION
DK	TANK, CHEMICAL ADDITION
EK	TANK, CONDESATE STORAGE
FK	TANK, CORE FLOOD
LK	TANK, DEMINERALIZED WATER STORAGE
JK	TANK, FUEL
TK	TANK, OTHER
RK	TANK, REFUELING WATER STORAGE
SK	TANK, SURGE
WK	TANK, WASTE PROCESSING/STORAGE
TN	TENDON
TG	TUBING
TB	TURBINE
CV	VALVE, CHECK
EV	VALVE, EXPLOSIVE OPERATED
HV	VALVE, HYDRAULIC OPERATED
BV	VALVE, ISOLATION
XV	VALVE, MANUAL
MV	VALVE, MOTOR OPERATED
OV	VALVE OPERATOR
AV	VALVE, PNEUMATIC OPERATED
RV	VALVE, RELIEF
SV	VALVE, SAFETY
FV	VALVE, SAFETY-RELIEF
KV	VALVE, SOLENOID OPERATED
DV	VALVE, STOP CHECK
UV	VALVE, UNKNOWN
VV	VALVE, VACUUM RELIEF
VT	VENT
WL	WELL, OTHER
WW	WETWELL/TORUS

M&T FAILURE MODES

AD	ADJUSTMENT, OUT OF
AR	ADDITION RATE, IMPROPER
AN	ADJUST, DID NOT
AM	ADJUSTMENT, MIS-
AS	ASSEMBLY, IMPROPER
BD	BUMPED
BP	BYPASS, DID NOT
CN	CARELESSNESS/NEGLIGENCE/OVERSIGHT
CI	CHARGING, IMPROPER
CD	CLOSED
CL	CLOSED, LEFT
CP	CLOSED, LEFT PARTIALLY
CM	COMMUNICATION
CE	COMPUTER, INPUT ERROR
CC	CONNECT, DID NOT/LATCH
CR	CONNECT, DID NOT RE-
CU	CONNECTION, DIS-
CG	CONNECTION, LOOSE
CT	CONNECTION (OTHER), IMPROPER/LATCHING
CA	CALCULATION
CB	CALIBRATION
CO	CIRCUIT, OPEN
CS	CIRCUIT, SHORT
CZ	CLEAN, DID NOT
CX	CLEANING (OTHER)
DG	DAMAGE (OTHER)
DI	DAMAGE, INADVERTANT
DD	DEENERGIZE/DISENGAGE/STOP, DID NOT
DS	DEENERGIZED/DISENGAGED/STOPPED/TRIPPED
DL	DEENERGIZED, LEFT
DV	DEENERGIZATION, INADVERTANT
DF	DEFECTIVE
DR	DRIFT
ED	ENERGIZE/ENGAGE/STOP, DID NOT
ES	ENERGIZED/ENGAGED/STARTED
EL	ENERGIZED, LEFT
EI	ENERGIZATION, INADVERTANT
EV	EVENT (NO FAILURE MODE)
EX	EXPERIENCE, LACK OF
FA	FATIGUE
FD	FILL, DID NOT
FO	FILLED, OVER
FR	FLOW RATE, IMPROPER
HI	HANDLING, IMPROPER
IA	INADVERTANT ACTUATION
IS	INSTALLATION
LK	LEAKAGE
LL	LIMIT, EXCEEDS LOWER
LU	LIMIT, EXCEEDS UPPER
LD	LOCK, DID NOT

LF	LOCKED, LEFT
LI	LOCKING, IMPROPER
LO	LOOSE/LOOSENEED
LB	LUBRICATION
ML	MALFUNCTION
MT	MISINTERPRETATION/MISUNDERSTANDING
MJ	MISJUDGEMENT
MO	MONITOR/OBSERVE/IDENTIFY;FAILURE TO
OL	OPEN/DID NOT CLOSE, LEFT
OP	OPEN, LEFT PARTIALLY
OD	OPENED
OI	OPERATION (OTHER), IMPROPER
OO	OTHER. MISCELLANEOUS FAILURE MODE
OR	OVERLOADED
OZ	OVERPRESSURIZED
OT	OVERTORQUED
PT	PAINTED
PG	PLUGGED
WP	POSITION (OTHER), LEFT IN WRONG
MP	POSITION, MIS-/MISALIGN/IMPROPER SETTING
PI	PROCEDURE INADEQUACY
PR	PROCEDURE VIOLATION (OTHER)
PU	PROCEDURE UNFAMILIARITY
PW	PROCEDURE, FOLLOWED WRONG
PD	PROCEDURE, DID NOT FOLLOW
RA	RECORD, DID NOT
RM	RECORDING/MISREAD, INCORRECT
RC	REMOVED FROM SERVICE
RR	REMOVED AFTER REPAIR, DID NOT
RB	REMOVE FROM SERVICE, DID NOT
RJ	REMOVED FROM SERVICE, INADVERTANTLY
RK	REPLACE, DID NOT
RG	REPLACEMENT, IMPROPER
RE	REPAIR, ERRONEOUS
RI	REPAIR, IMPROPER
RL	REPAIR, LACK OF
RP	REPORT, DID NOT
IRH	RESET, DID NOT
IRN	RESPONSE, NO
RO	RESPONSE/OVERCOMPENSATION, OVER
RS	RESPONSE/TIME-TOO LONG, SLOW
PF	RESPONSE/TIME-TOO SHORT, FAST
RT	RETURN TO SERVICE, DID NOT
RZ	RETURNED TO SERVICE, IMPROPERLY
RO	RUPTURED/DEFORMED
SP	SEPARATED
SO	SEQUENCE, IMPROPER
SV	SEVERED
ST	STICKING/STUCK/BINDING

TG	TAG, DID NOT
TD	TEST/CHECK, DID NOT
TN	TIGHTEN, DID NOT
TE	TIGHTENING, EXCESSIVE
TR	TRIPPED
UL	UNATTENDED, LEFT
UU	UNKNOWN
VI	VERIFICATION, IMPROPER
WE	WELDING, IMPROPER
WR	WIRING
WI	WITHDRAWAL, IMPROPER
WL	WITHDRAWN, LEFT
WO	WORN-OUT/END OF LIFE/DETERIORATED

LWR - MTC 3

1. Record Identification Number (1 Digit)
Used for addition and deletion of events
2. SRG Identification Number (5 Digits)
3. Control Number (6 Digits)
4. Cross Reference Number (6 Characters)
Characters 1 - 2: LER Report Month
JA - January JL - July
FE - February AG - August
MR - March SP - September
AP - April OC - October
MA - May NO - November
JU - June DE - December
Characters 3 - 5: LER Page Number
5. Facility Identification Number^a (3 Digits)
6. Data of Report (6 Digits)
7. Date of Event (6 Digits)
8. Error Mode (2 Characters)
M - Maintenance
P - Procedural Resulting in Significant Maintenance Consequences
(e.g., Exposure)
MT - Maintenance During Testing
OT - Operator During Testing
AT - Administrative During Testing
PT - Procedural During Testing
XT - Other Unknown Personnel During Testing
ST - Inherent System Fault During Testing
ZT - Other Testing
X - Other Leading to Exposure
PM - Event Which is Possibly Due to Inadequate Preventative Maintenance
Schedules

9. M&T Mode (2 Characters)
10. System Involved* (2 Characters)
11. Effect on System Involved (1 Character)
 - U - Unknown/Not Applicable
 - N - None
 - D - Degraded
 - F - Failed
12. Component Involved (2 Characters)
13. Number of Components Involved (2 Digits)
14. Effect on Component Involved (1 Character)
 - U - Unknown/Not Applicable
 - N - None
 - D - Degraded
 - F - Failed
15. System Affected (2 Characters)
16. Effect on Systems Affected (1 Character)
 - U - Unknown/Not Applicable
 - N - None
 - D - Degraded
 - F - Failed
17. Component Affected (2 Characters)
18. Number of Components Affected (2 Digits)
19. Effect on Component Affected (1 Character)
 - U - Unknown/Not Applicable
 - N - None
 - D - Degraded
 - F - Failed

20. Failure Mode (2 Characters)

21 Facility Operational Phase Before Event Occurrence (1 Digit)

- 0 - Startup
- 1 - Power Operation
- 2 - Hot Standby
- 3 - Hot Shutdown
- 4 - Warm Shutdown
- 5 - Cold Shutdown
- 6 - Refueling
- 8 - Shutdown (Unknown Mode)
- 9 - Unknown

22. Facility Operational Phase After Event Occurrence (1 Digit)

- 0 - Startup
- 1 - Power Operation
- 2 - Hot Standby
- 3 - Hot Shutdown
- 4 - Warm Shutdown
- 5 - Cold Shutdown
- 6 - Refueling
- 8 - Shutdown (Unknown Mode)
- 9 - Unknown

23. Duration of Event Consequences; Hours (6 Digits)

- Digit 1 - Thousands of Hours
- Digit 2 - Hundreds of Hours
- Digit 3 - Tens of Hours
- Digit 4 - Hours
- Digit 5 - Tenths of Hours
- Digit 6 - Hundredths of Hours

24. Radiation Release to Environment (3 Characters)

- U - Unknown
- NO - No Release
- RWL - Release Within Limits
- REL - Release Exceeds Limits
- RU - Release, Limits Unknown

(See 20 for Limits when available)

25. Radiation Exposure

a. (2 Characters)

U - Unknown
NO - No Exposure
XP - Exposure

b. Dose - Millierems (4 Digits)

26. Common Mode/Recurring/Unusual Event (1 Digit)

C - Common Mode Occurrence
R - An Incident Which Recurs at a Particular Facility
X - An Event Which Disables Redundant Trains of a System, Violates
a Significant Safety Technical Specification, or is Extremely
Unusual
- Not Applicable/Unknown

27. Description

A Short Description of the Event Expanding its Characteristics

APPENDIX C

HISTOGRAMS FOR INDIVIDUAL FACILITIES AND REACTOR TYPES (BWRs)

C-2

Distributor	III	Switch	II	Valve	II	Nozzle	IV	Wall	II	Motor	II	Dosimeter	I
								Valve	III	Valve			

Dosimeter	Unknown	Switch	RPS	Distributor	AEPS	Nozzle	CSRS
		Valve	ECCIS	Valve	OCS		
		Motor					
		Wall	OCS				
		Valve	ASNO				

I	II	III	IV	V	VI	VII
---	----	-----	----	---	----	-----

Facility 110B	Nine Mile Point-1	No. of Years 4.49	No. of M&T Events 16
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AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Battery	I	Switch	II	Pump	I	Breaker	I	Heater	I	Rad. Monitor	I	Dosimeter	I
Fuse	II			Switch	III	Valve	I	Bistable	V			Valve	II
Relay	IV					Relay	II						
						Valve							
						Breaker	III						

Dosimeter	■	Valve	U
Heater	SRS	Rad. Monitor	IMS
Valve	OCS	Valve	OCS
Breaker		Relay	
Pump	ECCIS	Switch	RPS
Battery	AEPS	Fuse	AEPS

Breaker	OCS
---------	-----

Relay	AEPS	Bistable	SIS
-------	------	----------	-----

11

IV

VI

VII

[illegible]

Facility 130B Vermont Yankee-1 No. of Years 3.89 No. of M&T Events 27

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Control Rod Monitor Control Rod	I	Valve	I	Switch	III	Event	I	Test Device	I	Instrument	II	Breaker	I
	II	Switch				Door						Line	
	V	Valve	II			Clutch	II					Rad. Monitor	
		Valve				Valve	III					Valve	
		Switch				Filter	V						
		Relay										Valve	III
		Switch	III									Rad. Monitor	IV

Valve	IMS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			</
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C-5

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

[illegible]

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Dial	I	Valve	I	Pipe	I	Switch	II	Event	I	Switch	III	Switch	II	Fan	III	Event	I	Pump	I
D G	I	Switch	IV	Jumper	I			Flange	I	Switch	IV			Switch	IV	Rad.	I		
D G	II	Control Rod	V	Valve				Fuse								Monitor			
Relay	VI	Jumper		Switch	II			Valve								Rad. Monitor	II		
				Relay				Valve	II							Cable	III		
				Motor				Switch	III										
				Switch	III			Switch	V										
				Starter				Breaker	III										
				Recorder	V			Event	V										
				Valve	VI														

Pump	Unknown
Rad. Monitor	IMS
Event	
Valve	
Fuse	
Flange	
Event	
Pipe	
Jumper	
Valve	
D G	
Dial	

Rad. Monitor	IMS
Switch	WPS
Valve	
Switch	OCS
Switch	MRCIS
Valve	
Switch	ECCIS
Relay	
D G	AEPS

Cable	IMS
Fan	SNS
Switch	ASNO
Breaker	OCS
Starter	
Switch	ECCIS
Motor	

Switch	SNS
Switch	ASNO
Switch	RPS

Event	OCS
Recorder	ECCIS
Jumper	
Control Rod	

Valve	ECCIS
Relay	AEPS

I	II	III	IV	V	VI	VII
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Facility 43B Cooper-1 No. of Years 2.91 No. of M&T Events 14

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

C-8

Facility 23B Browns Ferry-1 No. of Years 1.74 No. of M&T Events 32

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Valve	I	Valve	II	Relay	II	Meter	II	Breaker	I	Cable	IV
		Breaker Flange Valve	III	Strainer	III			Cable	I	Alarm	VII
								Switch	II		
								Cable	IV		
								Rad. Monitor	VII		

Event	I	Switch	II	Switch	III	Pump	V
Relay							
Valve							
Generator Governor							

Switch	IMS	Strainer	ASNO	Cable	Unknown	Alarm	Unknown
Meter	WPS	Valve	OCs	Cable	IMS	Rad. Monitor	IMS
Relay	ASNO	Flange		Pump	ECCIS		
Valve	OCs	Breaker					
Switch	ECCIS	Switch	ECCIS				
Governor Generator		Starter	AEPS				
Starter		Governor					
Breaker	IMS	DG					
Cable	CSRS						
Valve							
Valve	ECCIS						
Relay							
Event							

DG	I	Event	I	Valve	I	Valve	II	Relay	II	Meter	II	Breaker	I	Cable	IV
Governor		Relay				Breaker Flange Valve	III	Strainer	III			Cable	I	Alarm	VII
Starter		Valve										Switch	II		
Governor	II	Generator Governor	II									Cable	IV		
Starter		Switch										Rad. Monitor	VII		
		Switch	III												
		Pump	V												

I	II	III	IV	V	VI	VII
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Facility 58B Hatch-1 No. of Years 1.43 No. of M&T Events 7

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

C-10

Facility 62B Fitzpatrick-1 No, of Years No, of M&T Events 2

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

C-11

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Facility 54B Dresden-1 No. of Years 4.07 No. of M&T Events 3

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

C-13

C-14

<table><tr><td>Switch</td><td>VI</td></tr><tr><td>Relay</td><td>V</td></tr><tr><td>Battery</td><td>IV</td></tr><tr><td>Switch</td><td>IV</td></tr></table>		Switch	VI	Relay	V	Battery	IV	Switch	IV	<table><tr><td>Control Rod</td><td>V</td></tr><tr><td>Jumper</td><td>IV</td></tr><tr><td>Switch</td><td>IV</td></tr><tr><td>Cable</td><td>IV</td></tr><tr><td>Switch</td><td>II</td></tr><tr><td>Rad. Mon.</td><td>II</td></tr><tr><td>Pump</td><td>II</td></tr><tr><td>Relay</td><td>II</td></tr><tr><td>Fitting</td><td>II</td></tr></table>		Control Rod	V	Jumper	IV	Switch	IV	Cable	IV	Switch	II	Rad. Mon.	II	Pump	II	Relay	II	Fitting	II	<table><tr><td>Valve</td><td>I</td></tr><tr><td>Switch</td><td>I</td></tr><tr><td>Relay</td><td>I</td></tr><tr><td>Pipe</td><td>I</td></tr><tr><td>Event</td><td>I</td></tr><tr><td>Pump</td><td>I</td></tr></table>		Valve	I	Switch	I	Relay	I	Pipe	I	Event	I	Pump	I	<table><tr><td>Valve</td><td>IV</td></tr><tr><td>Valve</td><td>III</td></tr><tr><td>valve</td><td>II</td></tr><tr><td>switch</td><td>I</td></tr></table>		Valve	IV	Valve	III	valve	II	switch	I	<table><tr><td>Nozzle</td><td>IV</td></tr><tr><td>Switch</td><td>III</td></tr><tr><td>Valve</td><td>I</td></tr><tr><td>Motor</td><td>I</td></tr><tr><td>Pump</td><td>I</td></tr><tr><td>Valve</td><td>I</td></tr><tr><td>Breaker</td><td>I</td></tr></table>		Nozzle	IV	Switch	III	Valve	I	Motor	I	Pump	I	Valve	I	Breaker	I	<table><tr><td>Event</td><td>V</td></tr><tr><td>Filter</td><td>V</td></tr><tr><td>Valve</td><td>III</td></tr><tr><td>Breaker</td><td>III</td></tr><tr><td>Switch</td><td>II</td></tr><tr><td>Relay</td><td>II</td></tr><tr><td>Flange</td><td>II</td></tr><tr><td>Valve</td><td>II</td></tr><tr><td>Switch</td><td>II</td></tr><tr><td>Wall</td><td>II</td></tr><tr><td>Relay</td><td>II</td></tr><tr><td>Clutch</td><td>II</td></tr><tr><td>Breaker</td><td>II</td></tr><tr><td>Valve</td><td>I</td></tr><tr><td>Event</td><td>I</td></tr><tr><td>Fuse</td><td>I</td></tr><tr><td>Plug</td><td>I</td></tr><tr><td>Flange</td><td>I</td></tr><tr><td>Door</td><td>I</td></tr></table>		Event	V	Filter	V	Valve	III	Breaker	III	Switch	II	Relay	II	Flange	II	Valve	II	Switch	II	Wall	II	Relay	II	Clutch	II	Breaker	II	Valve	I	Event	I	Fuse	I	Plug	I	Flange	I	Door	I	<table><tr><td>Switch</td><td>IV</td></tr><tr><td>Switch</td><td>III</td></tr><tr><td>Strainer</td><td>III</td></tr><tr><td>Motor</td><td>II</td></tr><tr><td>Valve</td><td>II</td></tr><tr><td>Switch</td><td>II</td></tr><tr><td>Relay</td><td>II</td></tr><tr><td>Fuse</td><td>II</td></tr><tr><td>Valve</td><td>I</td></tr><tr><td>Test Device</td><td>I</td></tr><tr><td>Jumper</td><td>I</td></tr></table>		Switch	IV	Switch	III	Strainer	III	Motor	II	Valve	II	Switch	II	Relay	II	Fuse	II	Valve	I	Test Device	I	Jumper	I	<table><tr><td>Event</td><td>V</td></tr><tr><td>Switch</td><td>II</td></tr><tr><td>Meter</td><td>II</td></tr><tr><td>Instr.</td><td>I</td></tr><tr><td>Line</td><td>I</td></tr></table>		Event	V	Switch	II	Meter	II	Instr.	I	Line	I	<table><tr><td>Valve</td><td>VI</td></tr><tr><td>Distable</td><td>V</td></tr><tr><td>Switch</td><td>IV</td></tr><tr><td>Fan</td><td>III</td></tr><tr><td>Snubber</td><td>I</td></tr><tr><td>Switch</td><td>I</td></tr><tr><td>Event</td><td>I</td></tr><tr><td>Heater</td><td>I</td></tr></table>		Valve	VI	Distable	V	Switch	IV	Fan	III	Snubber	I	Switch	I	Event	I	Heater	I	<table><tr><td>Rad. Mon.</td><td>VII</td></tr><tr><td>Rad. Mon.</td><td>V</td></tr><tr><td>Rad. Mon.</td><td>IV</td></tr><tr><td>Cable</td><td>IV</td></tr><tr><td>Valve</td><td>III</td></tr><tr><td>Rad. Mon.</td><td>III</td></tr><tr><td>Meter</td><td>III</td></tr><tr><td>Cable</td><td>III</td></tr><tr><td>Amp.</td><td>III</td></tr><tr><td>Switch</td><td>II</td></tr><tr><td>Rad. Mon.</td><td>II</td></tr><tr><td>Fitting</td><td>II</td></tr><tr><td>Cord</td><td>II</td></tr><tr><td>Rad. Monitor</td><td>I</td></tr><tr><td>Valve</td><td>I</td></tr><tr><td>Event</td><td>I</td></tr><tr><td>Breaker</td><td>I</td></tr><tr><td>Line</td><td>I</td></tr><tr><td>Cable</td><td>I</td></tr></table>		Rad. Mon.	VII	Rad. Mon.	V	Rad. Mon.	IV	Cable	IV	Valve	III	Rad. Mon.	III	Meter	III	Cable	III	Amp.	III	Switch	II	Rad. Mon.	II	Fitting	II	Cord	II	Rad. Monitor	I	Valve	I	Event	I	Breaker	I	Line	I	Cable	I	<table><tr><td>Alarm</td><td>VII</td></tr><tr><td>Cable</td><td>IV</td></tr><tr><td>Door</td><td>III</td></tr><tr><td>Valve</td><td>II</td></tr><tr><td>Dosimeter</td><td>I</td></tr><tr><td>Pump</td><td>I</td></tr></table>		Alarm	VII	Cable	IV	Door	III	Valve	II	Dosimeter	I	Pump	I	UNKNOWN	
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AEPS		RPS		ECCIS		MRCs		CSRS		OCS		ASNO		WPS		SNS		IMS		UNKNOWN																																																																																																																																																																																																							

C-15

[illegible]

APPENDIX D

HISTOGRAMS FOR INDIVIDUAL FACILITIES AND REACTOR TYPES (PWRs)

U 11

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Battery	II
Relay	VI
Tank	V
Thermostat	II
Breaker	
Switch	
Valve	
Valve	I
Tube	VI
Valve	I
Pump	Valve
I	
Tendor	III
Switch	
Valve	II
Switch	
Valve	I

Line	WPS				
Valve	ASNO				
Valve					
Valve	Switch	OCS			
Valve	OCS	Valve	ECCIS /ECRS		
Pump	Thermostat				
Valve	ECRS	Breaker			
Valve	MRC	Switch			
Valve	ECCIS /ECRS	Battery	AEPS	Switch	OCS
Linkage	Unknown	Tank	ECCIS /ECRS	Relay	
Tube	MRC				

I

II

III

IV

V

VI

VII

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

D G	I		Relay	II	Relay	II	Valve	II	Valve	I	Valve	I	Valve	I	Cam.	II	Switch	
Switch	II								Door	I	Switch				Heat Detector	VI	Recorder	I
Relay	III								Fan	II					Breaker	VII	Line	
									Switch	II	Breaker						Valve	
									Valve	II							Valve	I
									Valve	II	Valve	III					Rad. Monitor	II

		Rad Monitor	IMS															
		Cam	SNS															
		Switch																
Switch		Breaker	ASNO															
Recorder																		
Line	IMS	Fan																
Valve		Switch	OCS															
Valve	WPS	Valve																
Valve	ASNO	Valve	CSRS															
Valve		Relay	MRES															
Door	OCS	Relay	ECCIS CSRS	Valve	ASNO													
D G	AEPS	Switch	AEPS	Relay	AEPS										Heat Detector	SNS	Breaker	SNS

I	II	III	IV	V	VI	VII
---	----	-----	----	---	----	-----

Facility 83P Indian Point-2 No. of Years 2.82 No. of M&T Events 16

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Bistable	I	Transmitter	II	Valve	I	Pump	I	Door	I	Breaker	I	Switch	III
None		Bistable	VI					Breaker	II	Valve			
Relay	II							Fuse		Valve	II		
Governor										Cooler	IV		

Valve	ASNO	Valve	ASNO
Breaker			
Door	DCS	Fuse	DCS
Pump	CSRS	Breaker	
Valve	ECCIS	Transmitter	RPS
None	AEPS	Relay	AEPS
Bistable		Governor	

Switch	SNS	Cooler	ASNO	Bistable	RPS
--------	-----	--------	------	----------	-----

I	II	III	IV	V	VI	VII
---	----	-----	----	---	----	-----

D-5

Facility 193P Zion-1 No. of Years 2.75 No. of M&T Events 19

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

[illegible]

Facility 64Y Ft. Calhoun-1 No. of Years 3.24 No. of M&T Events 27

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Lightning Arrestor		Amplifier	I	Switch	II			Pump	II	Door	II			Switch	II			Relay	III
Motor	III	Light Bulb		Switch	III					Switch	III	Valve	III						
		Relay	II					Fan											
		Valve				Valve													
Relay		Relay	III																
Motor	VI	Relay	IV																
Motor	II	Potential- meter	V																

				Relay	Unknown															
				Valve	ASNO															
				Switch	OCS															
				Fan																
				Valve	ECCIS															
		Switch	SNS	Switch																
		Door	OCS																	
		Pump	CSRS	Relay	RPS															
		Switch	ECCIS	Relay	AEPS															
		Valve	RPS	Motor																
		Relay																		
		Light Bulb																		
Amplifier	RPS	Motor	AEPS	Lightning Arrestor				Relay	RPS	Potential- meter	RPS	Motor	AEPS							

I

II

III

IV

V

VI

VII

U-7

Facility 105P Millstone-2 No. of Years 1.42 No. of Events 6

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

8-8

Facility 73P Haddam Neck-1 No. of Years 4.95 No. of M&T Events 13

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Facility 82P- Indian Point-1 No. of Years 1.86 No. of M&T Events 5

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

Facility 192P Yankee Rowe No. of Years 4.79 No. of M&T Events 2

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

D-11

Facility 144P Rancho Seco-1 No. of Years 1,51 No. of M&T Events 5

AEPS 1 RPS 2 ECCIS 3 MRCS 4 CSRS 5 OCS 6 ASNO 7 WPS 8 SNS 9 IMS 10 U 11

D-12

D-13

[illegible]

APPENDIX E

FORTRAN PROGRAM FOR M&T DATA CLUSTERING

0	1	2	3	4	5	6	7	8	9
FORTRAN IV G LEVEL 21			MAIN			DATE = 80042			21/09/38
0001			DIMENSION X(10,100),Z(10),ZZ(10),A(10),B(10),						
			SUMS1(10),SUMS2(10)						
0002	3		READ (5,10,END=36,ERR=30) M,N						
0003	10		FORMAT (213)						
0004			WRITE (6,41) M,N						
0005	41		FORMAT ('1',/, M=' ,14', N=' ,14')						
	C								
0006			DO 1 J=1,N						
0007	1		READ (5,11,END=34,ERR=32) (X(I,J),I=1,M)						
0008	11		FORMAT (10F8.0)						
	C								
0009			DO 12 I=1,M						
0010			Z(I) = X(1,1)						
0011			ZZ(I) = X(1,2)						
0012	12		CONTINUE						
	C								
0013			WRITE (6,21) (Z(I),ZZ(I),I=1,M)						
0014	21		FORMAT (// (2(3X,F10.5)))						
	C								
0015			MM = 0						
0016	2		MM = MM+1						
0017			IF (MM.GT.10) GO TO 20						
0018			L=0						
0019			K=0						
0020			DO 24 J=1,M						
0021			SUMS1(J)=0						
0022			SUMS2(J)=0						
0023	24		CONTINUE						
	C								
0024			DO 13 J=1,N						
0025			SUM1=0						
0026			SUM2=0						
0027			DO 14 I=1,M						
0028			A(I)=X(I,J)-Z(I)						
0029			B(I)=X(I,J)-ZZ(I)						
0030			SUM1=SUM1+A(I)**2						
0031			SUM2=SUM2+B(I)**2						
0032	14		CONTINUE						
	C								
0033			IF (SUM1.GT.SUM2) GO TO 15						
0034			L=L+1						
0035			DO 16 JJ=1,M						
0036			SUMS1(JJ)=SUMS1(JJ)+X(JJ,J)						
0037	10		CONTINUE						
0038			GO TO 13						
	C								
0039	15		K=K+1						
0040			DO 66 JJ=1,M						
0041			SUMS2(JJ)=SUMS2(JJ)+X(JJ,J)						
0042	60		CONTINUE						
0043	13		CONTINUE						
0044			DO 17 I=1,M						
0045			SUMS1(I)=SUMS1(I)/L						
0046			SUMS2(I)=SUMS2(I)/K						
0047	17		CONTINUE						
	C								
0048			SS1=0						

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

FORTN IV G LEVEL 21 MAIN DATE = 000-3 21/59/30

```

0049 SS2=0
0050 CO 18 I=1,M
0051 SS1=SS1+(SUMS1(I)-Z(I))*2
0052 SS2=SS2+(SUMS2(I)-ZZ(I))*2
0053 CONTINUE
18
C
0054 WRITE (6,22) (SUMS1(I),SUMS2(I),I=1,M)
0055 FORMAT (/ (2(3X,F10.5)))
22
C
0056 WRITE (6,23) MM,L,K
0057 FORMAT ('OND. OF ITERATIONS',I2,2X,2I3,/)
23
C
0058 IF ((SS1.EQ.0).AND.(SS2.EQ.0)) GC TC 20
0059 DO 100 I=1,M
0060 Z(I)=SUMS1(I)
0061 ZZ(I)=SUMS2(I)
0062 CONTINUE
0063 GO TO 2
100
C
0064 WRITE (6,25) (SUMS1(I),SUMS2(I),I=1,M)
0065 FORMAT (' CONVERGENCE IF MM < 10',/(2(3X,F10.5)))
0066 GO TO 3
25
C
0067 WRITE (6,31)
0068 FORMAT (/// 'IMPRCER SUBSCRIPTS')
0069 STOP
31
0070 WRITE (6,33)
0071 FORMAT (/// 'IMPROPER/NCN-NUMERIC VALUES READ')
0072 STOP
33
0073 NUMIN=(J-1)*M+I-1
0074 MXN=M*N
34
0075 WRITE (6,35) NUMIN,MXN
0076 FORMAT (/// 'NOT ENOUGH VALUES READ IN',/,I5,' OUT OF',I5)
0077 STOP
35
0078 END
36

```

E-3

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

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