

WESTINGHOUSE CLASS 3

WCAP-11293-A

AMSAC GENERIC DESIGN PACKAGE

M. R. Adler

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

Mr. L. D. Butterfield, Chairman
ATWS Subcommittee
Westinghouse Owner's Group
Commonwealth Edison
P.O. Box 767
Chicago, Illinois 60690

JUL 07 1986

Dear Mr. Butterfield:

SUBJECT: ACCEPTANCE FOR REFERENCING OF LICENSING TOPICAL REPORT

The Nuclear Regulatory Commission (NRC) staff has completed its review of the Topical Report WCAP-10858.

We find the report to be acceptable for referencing in license applications to the extent specified and under the limitations delineated in the report and the associated NRC evaluation, which is enclosed. The evaluation defines the basis for acceptance of the report.

In accordance with procedures established in NUREG-0390, it is requested that Westinghouse publish an accepted version of this report within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed evaluation after the title page. The accepted version shall include an -A (designating accepted) following the report identification symbol.

Should our criteria or regulations change such that our conclusions as to the acceptability of the report are invalidated, Westinghouse and/or the applicants referencing the topical report will be expected to revise and resubmit their respective documentation, or submit justification for the continued effective applicability of the topical report without revision of their respective documentation.

Sincerely,

A handwritten signature in cursive script that reads "Charles E. Rossi".

Charles E. Rossi, Assistant Director
Division of PWR Licensing-A
Office of Nuclear Reactor Regulation

Enclosure:
Safety Evaluation

cc: See attached list

L. D. Butterfield

-2-

cc: M. Adler, Westinghouse
M. Burzynski, TVA
T. Lordi, Westinghouse
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SAFETY EVALUATION OF TOPICAL REPORT (WCAP-10858)
"AMSAC GENERIC DESIGN PACKAGE"

1.0 INTRODUCTION

In response to 10 CFR 50.62 "Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water-Cooled Nuclear Power Plants", Westinghouse on behalf of the Westinghouse Owner's Group (WOG) has submitted for review WCAP-10858 "AMSAC Generic Design Package." This document details the WOG's proposed generic ATWS Mitigation System Actuation Circuitry (AMSAC) designs for compliance with 10 CFR 50.62.

2.0 BACKGROUND

On July 26, 1984 the Code of Federal Regulations (CFR) was amended to include Section 10 CFR 50.62, "Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water-Cooled Nuclear Power Plants" (known as the "ATWS Rule"). An ATWS is an expected operational transient (such as loss of feedwater, loss of condenser vacuum, or loss of offsite power) which is accompanied by a failure of the reactor trip system (RTS) to shut down the reactor. The ATWS rule requires specific improvements in the design and operation of commercial nuclear power facilities to reduce the likelihood of failure to shut down the reactor following anticipated transients, and to mitigate the consequences of an ATWS event.

3.0 CRITERIA

The basic requirement for Westinghouse plants is specified in paragraph (c)(1) of 10 CFR 50.62, "Each pressurized water reactor must have equipment from sensor output to final actuation device, that is diverse from the reactor trip system,

to automatically initiate the auxiliary (or emergency) feedwater system and initiate a turbine trip under conditions indicative of an ATWS. This equipment must be designed to perform its function in a reliable manner and be independent (from sensor output to the final actuation device) from the existing reactor trip system."

The criteria used in evaluating the Westinghouse report include; (1) 10 CFR 50.62, (2) guidance and information published as the preamble to that Rule, and (3) Generic Letter 85-06 "Quality Assurance Guidance for ATWS Equipment that is not Safety-Related." The evaluation was done on a generic basis, and the relevant criteria is presented below.

The systems and equipment required by 10 CFR 50.62 do not have to meet all of the stringent requirements normally applied to safety-related equipment. However, this equipment is part of the broader class of structures, systems, and components defined in the introduction to 10 CFR 50, Appendix A (General Design Criteria). GDC-1 requires that "structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed." Generic Letter 85-06 "Quality Guidance for ATWS Equipment that is not Safety-Related" details the quality assurance that must be applied to this equipment.

In general, the equipment to be installed in accordance with the ATWS rule is required to be diverse from the existing RTS, and must be testable at power. This equipment is intended to provide needed diversity (where only minimal diversity currently exists) to reduce the potential for common mode failures that could result in an ATWS leading to unacceptable plant conditions.

The ATWS mitigation design is not required to be safety-related (e.g., meet IEEE-279). However, the implementation should incorporate good engineering practice and must be such that the existing protection system continues to meet all applicable safety related criteria. Equipment diversity to the extent reasonable and practicable to minimize the potential for common cause failures is required from the sensors to, but not including the final actuation device. All mitigating system instrument channel components (excluding sensors and isolation devices) must be diverse from the existing RTS. It is desirable, but not required, to use sensors and isolation devices that are not part of the RTS.

The basis for not requiring diverse isolators is that the RTS unavailability and AMSAC availability (without a reactor trip signal) are similar with or without the addition of a diverse isolator. Furthermore, with the addition of a new component (e.g., the diverse isolator) within AMSAC, the probability of not getting a reactor trip signal or AMSAC signal will be increased somewhat by the additional failure rate of the diverse isolator. However, if existing RTS sensors and isolators are utilized, particular emphasis should be placed on the method(s) used to qualify the isolators for their particular function. This

should include an analysis and tests which will demonstrate that the existing isolator will function under the maximum worst case fault conditions. The required method for qualifying the isolators is presented in Appendix A.

The capability for test and surveillance at power is required, however, surveillance frequencies have not been established at this time. During surveillance at power, the mitigating system may be bypassed, however, the bypass condition must be automatically and continuously indicated in the main control room. The AMSAC system design may also permit bypass of the mitigating function to allow for maintenance, repair, test, or calibration to prevent inadvertent actuation of the protective action at the system level. Where operating requirements necessitate automatic or manual bypass of a mitigating system, the design should be such that the bypass will be removed automatically whenever permissive conditions are not met.

The use of a maintenance bypass should not involve lifting leads, pulling fuses or tripping breakers or physically blocking relays. A permanently installed bypass switch or similar device should be used.

The design should be such that once the ATWS mitigation system has been initiated, the protective action at the system level shall go to completion. Return to operation should require subsequent deliberate operator action.

Manual initiation capability of the mitigating systems at the system level is desirable but not required. Manual initiation should depend upon the operation

of a minimum of equipment. The mitigating system should be designed to provide the operator with accurate, complete and timely information pertinent to its own status.

Displays and controls for manual bypass and initiation of the mitigating system should be integrated into the main control room through system functional analysis and should conform to good human engineering practices in design and layout. It is important that the displays and controls added to the control room as a result of the ATWS rule not increase the potential for operator error. A human factor analysis should be performed taking into consideration:

- (a) the use of this information and equipment by an operator during both normal and abnormal plant conditions,
- (b) integration into emergency procedures,
- (c) integration into operator training, and
- (d) the presence of other alarms during an emergency and need for prioritization of alarms.

The power supplies are not required to be safety-related but they must be capable of performing safety functions with a loss of offsite power. Logic power must be from an instrument power supply independent from the power supplies for the existing reactor trip system. Existing RTS sensor and instrument channel power

supplies may be used only if the possibility of common mode failure is prevented.

The most severe ATWS scenarios were determined (see NUREG-0460 Appendix IV, WCAP-8330 and subsequent Westinghouse submittals) to be those in which there was a complete loss of normal feedwater. These included:

Loss of Normal Feedwater/ATWS Transient (LONF/ATWS)

A complete loss of normal feedwater occurs which results from a malfunction in the feedwater condensate system or its control system from such causes as the simultaneous trip of all condensate pumps, the simultaneous trip of all main feedwater pumps or the simultaneous closure of all main feedwater control, pump discharge or block valves. Because of a postulated common mode failure in the RPS, the reactor is incapable of being automatically tripped when any of several plant process variables have reached their reactor trip setpoints.

Loss of Load/ATWS Transient (LOL/ATWS)

The most severe plant conditions that could result from a loss of load occur following a turbine trip from full power when the turbine trip is caused by a loss of main condenser vacuum. Because of a common mode failure in the protection system, the reactor is incapable of being automatically tripped as a result of the turbine trip or as the result of any of several other reactor trip signals that occur later in time when several plant process variables reach their reactor trip setpoints.

Upon loss of the main condenser vacuum, the main feedwater turbine-driven pumps that exhaust into the main condenser are tripped, thereby cutting off feedwater flow to the steam generators. Not all nuclear plants are subject to this transient since many plants have motor-driven main feedwater pumps or they have turbine-driven pumps which do not exhaust into the main condenser. Since there is a complete loss of normal feedwater during both these transients (LONF/ATWS and LOL/ATWS), both transients assumed auxiliary feedwater (AFW) flow is started 60 seconds after the initiating event for long term reactor protection. Also the Complete Loss of Normal Feedwater transient assumed a turbine trip 30 seconds after the initiating event to maintain short term RCS pressures below 3200 psig. Normally these features would be actuated by the Reactor Protection System (RPS) and the Engineered Safety Features Actuation System (ESFAS).

The primary safety concern from these two transients is the potential for high pressure within the RCS. If a common mode failure in the RPS and the ESFAS incapacitates AFW flow initiation and/or turbine trip in addition to prohibiting a scram, then an alternate method of providing AFW flow and a turbine trip is required to maintain the RCS pressure below 3200 psig. The final rule which was approved by the Commissioners on November 11, 1983, requires that Westinghouse designed plants install ATWS Mitigating System Actuation Circuitry (AMSAC) to initiate a turbine trip and actuate AFW flow independent of the RPS (from the sensor output). These two functions, turbine trip and AFW flow actuation, are provided via the AMSAC.

4.0 DESIGN DESCRIPTION

The Westinghouse Owners Group (WOG) has developed generic designs to meet the requirements of 10 CFR 50.62. Three designs were developed which permits each utility to select the design which best fits a particular plant's needs. Factors that may determine the design utilized at a plant range from the current control and protection system design to the ease and cost of installation. The three designs are as follows:

The first design would actuate a turbine trip and auxiliary feedwater flow upon sensing that the steam generator inventory is below the low-low level setpoint. This logic senses conditions indicative of an ATWS event when a loss of heat sink has occurred but will not actuate until after the reactor protection signals should have been generated. A turbine trip and start-up of all auxiliary feedwater pumps will occur upon receipt of an AMSAC signal.

The steam generator blowdown isolation and sample isolation valves would be automatically closed in all loops when AMSAC is actuated.

The AMSAC signal will be generated by low water level signals in the steam generators using existing sensor/transmitter units. For two loop plants, AMSAC will use two channels per loop with 3/4 coincidence to actuate AMSAC. The AMSAC coincidence logic for three loop plants is 2/3 with one channel per steam generator and the four loop plants coincidence logic is 3/4 with one channel per steam generator.

The AMSAC signal will be automatically blocked below 70% power since short term protection against high reactor coolant system pressure is not required until 70% of nominal power. This will prevent spurious AMSAC actuation during start-up. To ensure that AMSAC remains armed long enough to perform its function in the event of a turbine trip, a C-20 permissive signal will be maintained for approximately 60 seconds. The AMSAC signal will be delayed by approximately 25 seconds to permit the RPS to respond first.

The second design mitigates the consequences of an ATWS loss of heat sink event by initiating AMSAC on low main feedwater flow measurements.

Actuation of AMSAC will occur on low main feedwater flow as measured by existing main feedwater flow sensor/transmitters. The setpoint to actuate AMSAC is 50% of nominal main feedwater flow. Although 50% flow is more than ample to protect against overpressure in the event of an ATWS, instrumentation error would become unacceptably large if a substantially lower setpoint were used.

To avoid inadvertent AMSAC actuation on the loss of one main feedwater pump, AMSAC actuation will be delayed approximately 25 seconds to permit the unfaulted main feedwater pump(s) to automatically increase the flow rate to above the AMSAC actuation setpoint. Recovery in this circumstance is possible since each main feedwater pump is capable of delivering typically 60% of full load capacity.

A turbine trip and start-up of all auxiliary feedwater pumps will occur upon receipt of an AMSAC signal. The steam generator blowdown isolation and sample

isolation valves should be automatically closed in all loops when AMSAC is actuated.

The AMSAC signal will be generated by low main feedwater flow to the steam generators. The AMSAC logic is two channels per loop with 3/4 coincidence logic for two loop plants; one channel per loop with 2/3 coincidence logic for three loop plants; and 3/4 coincidence logic for four loop plants.

As in the first design, the AMSAC signal will be automatically blocked below 70% power; the AMSAC signal will be delayed by 25 seconds; removal of the C-20 permissive signal will be delayed by approximately 60 seconds.

The third design determines that conditions indicative of an ATWS event are present by monitoring the feedwater control and isolation valves and the feedwater pump status.

Actuation of AMSAC will occur when it has been determined that all main feedwater pumps have been tripped or when main feedwater flow to the steam generators has been blocked due to valve closures.

Failures in the main feedwater system upstream of the main feedwater pumps that could result in the loss of main feedwater to the steam generators, e.g., tripping of all condensate pumps, will result in automatic main feedwater pump trips on low suction pressure. Therefore, explicit actuation of AMSAC based on failures of components upstream of the main feedwater pumps is not necessary.

Since AMSAC anticipates the plant response due to the loss of main feedwater pumps prior to the reactor protection system detecting an anticipated operational occurrence, it is desirable to delay AMSAC actuation. A 30 second delay is sufficient to allow the reactor protection system to respond.

Either of two different AMSAC concepts may be used, depending upon whether or not the main feedwater flow to the steam generators is split during normal power operation. Plants which contain D-4 and D-5 steam generators have split flow during normal power operation. All other plants do not, although all plants with preheaters will have a minimal bypass flow through the feedwater bypass tempering valve (FBTV). For preheater plants which have split flow during normal power operation, approximately 10 to 20% of the total feedwater flow is passed through the feedwater preheater bypass valves (FPBV), while most of the remaining flow is passed through the feedwater isolation valve (FIV). If all FIVs were to close simultaneously, the flow through the FPBV would increase substantially and still provide protection against RCS overpressurization in the event of an ATWS. Therefore the accidental closure of all FIVs is not a factor for plants which contain D-4 or D-5 steam generators. All other plants however must account for the accidental closure of all FIVs as well as the accidental closure of all feedwater control valves (FCVs) and the accidental tripping of all main feedwater pumps.

A turbine trip and start-up of all auxiliary feedwater pumps will occur upon receipt of an AMSAC signal. The steam generator blowdown isolation and sample

isolation valves should be automatically closed in all loops when AMSAC is actuated.

The AMSAC signal will be generated by the simultaneous tripping of all main feedwater pumps or the blocking of all main feedwater lines to the steam generators due to valve malfunctions. The AMSAC coincidence logic is as follows:

Loops	Coincidence	
	FW Valves Closed	FW Pumps Tripped
2	3/4	N/N
3	2/3	N/N
4	3/4	N/N

where N is the number of main feedwater pumps.

As in the first two designs, the AMSAC signal will be automatically blocked below 70% power and the removal of the C-20 permissive signal shall be delayed by approximately 60 seconds.

5.0 CONCLUSION:

Generic

The staff has reviewed the Westinghouse Topical Report WCAP-10858, "AMSAC Generic Design Package" and has concluded that the generic designs presented in WCAP-10858 adequately meet the requirements of 10 CFR 50.62 and follow the review guidelines that have been discussed previously.

Plant specific

WCAP-10858 presents a generic design, however many details and interfaces are of a plant specific nature. The staff will review the implementation of plant specific designs to evaluate compliance with ATWS rule requirements. Key elements of the plant specific design reviews are denoted below.

o Diversity

The plant specific submittal should indicate the degree of diversity that exists between the AMSAC equipment and the existing Reactor Protection System. Equipment diversity to the extent reasonable and practicable to minimize the potential for common cause failures is required from the sensors output to, but not including, the final actuation device, e.g., existing circuit breakers may be used for the auxiliary feedwater initiation. The sensors need not be of a diverse design or manufacture. Existing protection system instrument-sensing lines, sensors, and sensor power supplies may be used. Sensor and instrument sensing lines should be selected such that adverse interactions with existing control systems are avoided.

o Logic power supplies

The plant specific submittal should discuss the logic power supply design. According to the rule, the AMSAC logic power supply is not required to be safety-related (Class 1E). However, logic power should be from an instrument power supply that is independent from the reactor protection system (RPS) power supplies. Our review of additional information submitted by WOG indicated that power to the logic circuits will utilize RPS batteries and inverters. The staff finds this portion of the design unacceptable, therefore, independent power supplies should be provided.

o Safety-related interface

The plant specific submittal should show that the implementation is such that the existing protection system continues to meet all applicable safety criteria.

o Quality assurance

The plant specific submittal should provide information regarding compliance with Generic Letter 85-06, "Quality Assurance Guidance for ATWS Equipment that is not Safety-Related."

o Maintenance bypasses

The plant specific submittal should discuss how maintenance at power is accomplished and how good human factors engineering practice is incorporated into the continuous indication of bypass status in the control room.

o Operating bypasses

The plant specific submittal should state that operating bypasses are continuously indicated in the control room; provide the basis for the 70% or plant specific operating bypass level; discuss the human factors design aspects of the continuous indication; and discuss the diversity and independence of the C-20 permissive signal (Defeats the block of AMSAC).

o Means for bypassing

The plant specific submittal should state that the means for bypassing is accomplished with a permanently installed, human factored, bypass switch or similar device, and verify that disallowed methods mentioned in the guidance are not utilized.

o Manual initiation

The plant specific submittal should discuss how a manual turbine trip and auxiliary feedwater actuation are accomplished by the operator.

o Electrical independence from existing reactor protection system

The plant specific submittal should show that electrical independence is achieved. This is required from the sensor output to the final actuation device at which point non-safety-related circuits must be isolated from safety related circuits by qualified Class 1E isolators. Use of existing isolators is acceptable. However, each plant specific submittal should provide an analysis and tests which demonstrates that the existing isolator will

function under the maximum worst case fault conditions. The required method for qualifying either the existing or diverse isolators is presented in Appendix A.

o Physical separation from existing reactor protection system

Physical separation from existing reactor protection system is not required, unless redundant divisions and channels in the existing reactor trip system are not physically separated. The implementation must be such that separation criteria applied to the existing protection system are not violated. The plant specific submittal should respond to this concern.

o Environmental qualification

The plant specific submittal should address the environmental qualification of ATWS equipment for anticipated operational occurrences only, not for accidents.

o Testability at power

Measures are to be established to test, as appropriate, non safety related ATWS equipment prior to installation and periodically. Testing of AMSAC may be performed with AMSAC in bypass. Testing of AMSAC outputs through the final actuation devices will be performed with the plant shutdown. The plant specific submittals should present the test program and state that the output signal is indicated in the control room in a manner consistent with plant practices including human factors.

o Completion of mitigative action

AMSAC shall be designed so that, once actuated, the completion of mitigating action shall be consistent with the plant turbine trip and auxiliary feed-water circuitry. Plant specific submittals should verify that the protective action, once initiated, goes to completion, and that the subsequent return to operation requires deliberate operator action.

o Technical specifications

Technical specification requirements related to AMSAC will have to be addressed by plant specific submittals.

APPENDIX A
AMSAC ISOLATION DEVICE -
REQUEST FOR ADDITIONAL INFORMATION

Each light water cooled nuclear reactor shall be provided with a system for the mitigation of the effects from anticipated transients without scram (ATWS). The Commission approved requirements for the ATWS are defined in the Code of Federal Regulations (CFR) Section 10, paragraph 50.62.

The staff has reviewed the Westinghouse Owner's Group generic functional AMSAC designs for compliance with the ATWS Rule. As a result, the staff has determined that the use of isolators within AMSAC will be reviewed on a plant specific basis. The following additional information is required to continue and complete the plant specific isolator review:

Isolation Devices

Please provide the following:

- a. For the type of device used to accomplish electrical isolation, describe the specific testing performed to demonstrate that the device is acceptable for its application(s). This description should include elementary diagrams when necessary to indicate the test configuration and how the maximum credible faults were applied to the devices.
- b. Data to verify that the maximum credible faults applied during the test were the maximum voltage/current to which the device could be exposed, and define how the maximum voltage/current was determined.
- c. Data to verify that the maximum credible fault was applied to the output of the device in the transverse mode (between signal and return) and other faults were considered (i.e., open and short circuits).
- d. Define the pass/fail acceptance criteria for each type of device.
- e. Provide a commitment that the isolation devices comply with the environment qualifications (10 CFR 50.49) and with the seismic qualifications which were the basis for plant licensing.
- f. Provide a description of the measures taken to protect the safety systems from electrical interference (i.e., Electrostatic Coupling, EMI, Common Mode and Crosstalk) that may be generated by the ATWS circuits.
- g. Provide information to verify that the Class 1E isolator is powered from a Class 1E source.

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1.0 INTRODUCTION

This package has been developed in order to identify three conceptual designs, generic to most Westinghouse plants, for the ATWS equipment required by 10CFR50.62(C)(1) - AMSAC. This design is generic in its applicability to Westinghouse plants however it does not represent the only acceptable means by which AMSAC could be incorporated by taking advantage of plant specific design details. The intent is to present the designs for generic review by the Nuclear Regulatory Commission to facilitate regulatory review on a plant specific basis.

Included in this package are design bases and three functional requirements (one for each design) for the AMSAC equipment.

2.0 DESIGN BASIS - ATWS MITIGATING SYSTEM ACTUATION CIRCUITRY

1. Purpose

To provide a design basis for the addition of an ATWS Mitigating System Actuation Circuitry (AMSAC) feature to Westinghouse designed nuclear power plants.

2. Introduction

Anticipated transients without scram (ATWS) were first raised as a safety issue by Dr. Epler, a consultant to the NRCs Advisory Committee on Reactor Safeguards (ACRS), in a paper that questioned the consequences of a common mode failure in a nuclear power plant. The worst common mode failure considered by Dr. Epler was a failure to scram the reactor after an anticipated transient (Reference 1) had occurred. Hence, the acronym ATWS was coined to identify this class of nuclear accident. Following an ATWS, the reactor must depend upon natural feedback mechanisms (Doppler and moderator) to aid in bringing the reactor under control. Although a benefit would also be realized from control rod motion, if the rod control system is in the automatic mode, no credit is taken for this benefit because the rod control system may not be in the automatic mode when the ATWS occurs.

Since the ATWS issue was first raised, the problem has been studied extensively at Westinghouse as well as throughout the industry. In October 1973, the NRC staff issued WASH-1270 (Reference 2) which outlined the original ATWS requirements. In consideration of the low probability of an ATWS, the NRC permitted nominal initial conditions, nominal system parameters and the availability of all system functions except reactor trip to be assumed. Westinghouse responded to WASH-1270 with a series of generic ATWS studies (WCAP-8330, Reference 3 et al). These studies showed acceptable consequences would result if nominal conditions as noted above are assumed, provided the turbine trips and auxiliary feedwater flow is initiated in a timely manner.

Additional ATWS analyses were later requested by the NRC. These analyses conformed with guidelines specified in NUREG-0460 (Reference 4). The additional studies (Reference 5) were similar to the Reference 3 studies but assumed more restrictive pressurizer liquid relief assumptions than previously. Two sets of results were developed in Reference 5, applicable for 95 and 99 percent of nominal core life. Here again, the analysis predicted acceptable consequences.

A review of References 3 and 5 shows the Complete Loss of Normal Feedwater/ATWS and the Loss of Load/ATWS transients result in very high reactor coolant system (RCS) pressures, but they still remain less than 3200 psig, the pressure corresponding to the ASME Boiler and Pressure Vessel Code Level C service limit stress criteria (Reference 6). Since there is a complete loss of normal feedwater during both these transients, both transients assumed auxiliary feedwater (AFW) flow is started 60 seconds after the initiating event for long term reactor protection. Also, the Complete Loss of Normal Feedwater transient assumed a turbine trip 30 seconds after the initiating event to maintain short term RCS pressures below 3200 psig. Normally these features would be actuated by the Reactor Protection System (RPS). However, if a common mode failure in the RPS incapacitates AFW flow initiation and/or turbine trip in addition to prohibiting a scram, then an alternate method of providing AFW flow and a turbine trip is required to maintain the RCS pressure below 3200 psig. These two functions, turbine trip and AFW flow actuation, are provided via the AMSAC.

A turbine trip is only necessary for the Complete Loss of Normal Feedwater/ATWS transient since a turbine trip occurs as part of the initiating event for a Loss of Load/ATWS transient. In either case, the AMSAC need not be initiated below 70% power to avoid the short term consequence of reactor coolant pressures greater than 3200 psig. On the other hand, should an ATWS occur below 70% of nominal power, operator action will be required to manually actuate auxiliary feedwater flow to avoid the long term consequences of operating without any heat sink.

Since the issuance of WASH-1270, several ATWS rules were proposed. These included: (1) the Staff Rule which emphasized individual reactor evaluations to identify needed improvements, (2) the Hendrie Rule which emphasized reliability assurance and would have also required certain hardware modifications and (3) the Utility Rule (Reference 7) which prescribed specific hardware changes/additions that were keyed to the type of reactor and its manufacturer.

As proposed in SECY-82-275 and the Commission briefing on July 13, 1982, an ATWS task force and steering group of NRC personnel was formed to review the ATWS history and promulgate a final ATWS rule. The final rule (Reference 8), which was approved by the Commissioners on November 11, 1983, requires that Westinghouse designed plants install an AMSAC to initiate a turbine trip and actuate AFW flow independent of the RPS (from the sensor output). The preamble to the ATWS final rule also included a proposed rule that, if adopted, would have required Westinghouse plants to also install a diverse scram system. The proposed diverse scram rule, however, was deleted as a requirement by the NRC before it went out for public comment; thus a diverse scram system is not part of this design basis.

3. Criteria

The criteria for the AMSAC are based on the following.

a. The ATWS Rule (Reference 8)

In addition to requiring that an AMSAC be installed in all domestic Westinghouse designed plants, the ATWS rule also provides explicit guidance on design, testing, maintenance and surveillance practices in Reference 9.

b. WCAP-8330 (Reference 3) and Letter NS-TMA-2182 (Reference 5)

Generic ATWS analyses are provided in WCAP-8330 and Letter NS-TMA-2182 for NSSS designs that utilize a 12 foot core and a Model 51 steam

generator. ATWS studies of other Westinghouse designs (WCAP-8404, WCAP-8420, WCAP-8440) yielded similar results.

The most severe ATWS scenarios were determined to be those in which there was a complete loss of normal feedwater. These included:

Loss of Normal Feedwater/ATWS Transient (LONF/ATWS)

A complete loss of normal feedwater occurs which results from a malfunction in the feedwater condensate system or its control system from such causes as the simultaneous trip of all condensate pumps, the simultaneous trip of all main feedwater pumps or the simultaneous closure of all main feedwater control, pump discharge or block valves. Because of a postulated common mode failure in the RPS, the reactor is incapable of being automatically tripped when any of several plant process variables have reached their reactor trip setpoints.

Loss of Load/ATWS Transient (LOL/ATWS)

The most severe plant conditions that could result from a loss of load occur following a turbine trip from full power when the turbine trip is caused by a loss of main condenser vacuum. Because of a common mode failure in the protection system, the reactor is incapable of being automatically tripped as a result of the turbine trip or as the result of any of several other reactor trip signals that occur later in time when several plant process variables reach their reactor trip setpoints. Upon loss of the main condenser vacuum, the main feedwater turbine-driven pumps that exhaust into the main condenser are tripped, thereby cutting off feedwater flow to the steam generators. Not all nuclear plants are subject to this transient since many plants have motor-driven main feedwater pumps or they have turbine-driven pumps which do not exhaust into the main condenser.

The primary safety concern for these two transients is the potential for high pressures within the RCS. Based on the analyses of references 3 and 5, the NRC determined tripping the turbine and actuating auxiliary feedwater are appropriate to require as mitigating functions. (Reference 8).

c. Good Engineering Practices

Consideration to human factors principles shall be given to the development of test features, indications and procedures such that testing avoids the generation of spurious trips.

The following criteria shall be used in designing the AMSAC.

<u>Criteria</u>	<u>Justification</u>
(1) <u>Technical Basis</u> The AMSAC design shall be consistent with past technical studies	WCAP-8330 (Reference 3) and supplemental information.
(2) <u>Safety related:</u> Not required, but the implementation must be such that the existing reactor protection system continues to meet applicable criteria.	NS-TMA-2182 (Reference 5), ATWS Final Rule (Reference 8)
(3) <u>Redundancy:</u> Redundancy is not required.	ATWS Final Rule (Reference 8)
(4) <u>Diversity from existing reactor protection systems:</u> Equipment diversity to the extent reasonable and practicable to minimize the potential for common cause failures is required from the sensors output to, but not including, the final actuation device, e.g., existing circuit breakers may be used for the auxiliary feedwater initiation. The	ATWS Final Rule (Reference 8)

Criteria

Justification

sensors need not be of a diverse design or manufacture. Existing protection system instrument-sensing lines, sensors, and sensor power supplies may be used. Sensors and instrument sensing lines should be selected such that adverse interactions with existing control systems are avoided.

- | | |
|---|-------------------------------|
| (5) <u>Electrical independence from existing reactor protection system:</u>
Required from the sensor output to the final actuation device at which point non-safety related circuits must be isolated from safety related circuits. | Final ATWS Rule (Reference 8) |
| (6) <u>Physical separation from existing reactor protection system:</u>
Not required, unless redundant divisions and channels in the existing reactor trip system are not physically separated. The implementation must be such that separation criteria applied to the existing protection system are not violated. | Final ATWS Rule (Reference 8) |
| (7) <u>Environmental qualification:</u>
For anticipated operational occurrences only, not for accidents. | Final ATWS Rule (Reference 8) |
| (8) <u>Seismic qualification:</u>
Not required. | Final ATWS Rule (Reference 8) |
| (9) <u>Quality assurance for test, maintenance and surveillance:</u>
Consistent with current QA practices for non-safety related equipment. | QA Guidance (Reference 9) |

Criteria

Justification

- (10) Safety-related (1-E) power supply:
Not required, but must be capable of performing design functions with loss of offsite power. Logic power should be from an instrument power supply independent from power supplies for the existing reactor protection system. Existing RTS sensor power supplies may be used provided the possibility of common mode failure is prevented.
- (11) Testing:
Measures are to be established to test, as appropriate, non safety related ATWS equipment prior to installation and operation and periodically. Testing of AMSAC may be performed with AMSAC in bypass. Testing of AMSAC outputs through the final actuation devices will be performed with the plant shutdown.
- (12) Inadvertent actuation:
The design shall be such that the frequency of inadvertent actuations are minimized.
- (13) Component reliability:
A high system and component reliability shall be a design objective.
- (14) Completion of mitigating action once it is initiated:
AMSAC shall be designed so that, once actuated, the completion of mitigating action shall be consistent with the plant turbine trip and auxiliary feed-water circuitry.
- Final ATWS Rule (Reference 8)
- QA Guidance (Reference 9)
Good Engineering Practice
- Final ATWS Rule (Reference 8)
- Good Engineering Practice
- Good Engineering Practice

4. Applicability

All domestic Westinghouse designed PWR systems.

5. Function

AMSAC shall provide a backup to the existing RPS to initiate a turbine trip and actuate auxiliary feedwater flow in the event an anticipated transient results in the complete loss of main feedwater while the power level is above a specified value. AMSAC actuation will ensure the RCS pressure will remain below the pressure that will satisfy the ASME Boiler and Pressure Vessel Code Level C service limit stress criteria.

7. References

1. "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants," ANSI N18.2-1973.
2. "Technical Report on Anticipated Transients Without Scram for Water-Cooled Power Reactors," NRC, WASH-1270, September 1973.
3. "Westinghouse Anticipated Transients Without Trip Analysis," WCAP-8330, August 1974.
4. "Anticipated Transients Without Scram for Light Water Reactors," NUREG 0460, December 1978.
5. Anderson, T. M., "ATWS Submittal," Westinghouse Letter NS-TMA-2182 to S. H Hanauer of the NRC, December 1979.
6. "ASME Boiler and Pressure Vessel Code, An American National Standard," ACI Standard 359-83, Section III, Division 1, Subsection NB-3224, July 1980.
7. "Electric Utilities; Filing of Petition for Rulemaking," Docket No. PRM 50-29, Federal Register/Vol. 45, No. 215 November 4, 1980 and Supplement, Vol. 46, No. 22, February 3, 1981.
8. ATWS Final Rule - Code of Federal Regulations 10 CFR 50.62 and Supplementary Information Package, "Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water-Cooled Nuclear Power Plants."
9. "Quality Assurance Guidance for ATWS Equipment That is Not Safety-Related," Generic Letter 85-06; April 16, 1985.

3.0 FUNCTIONAL REQUIREMENTS

ATWS MITIGATING SYSTEM ACTUATION CIRCUITRY

(LOGIC 1: AMSAC ACTUATION ON LOW STEAM GENERATOR WATER LEVEL)

0.0 SYSTEM DESCRIPTION (For Information Only)

ATWS Mitigating System Actuation Circuitry (AMSAC) provides an alternate means of tripping the turbine and actuating auxiliary feedwater (AFW) flow apart from the reactor protection system (RPS). The NRC decided turbine trip and AFW flow actuation will provide an adequate assurance the reactor coolant system (RCS) would not be subject to potential damage as a result of overpressure. The pressure limit (3200 psig) corresponds to the ASME Boiler and Pressure Vessel Code Level C Service Limit stress criteria. Past ATWS analyses, see WCAP-8330 for example, show there are only two ATWS transients for which the ASME Service level limit may be approached. These transients are the Complete Loss of Normal Feedwater Without Scram and the Loss of Load Without Scram.

The Complete Loss of Normal Feedwater transient can occur due to the simultaneous tripping of the main feedwater or condensate pumps or the simultaneous closing of the main feedwater control valves, pump discharge valves or block valves.

The Loss of Load transient considered for ATWS is one in which the vacuum in the main condenser is lost, resulting in a complete loss of normal feedwater. This could occur, for example, if the circulating water pump trips. The main turbine will then trip on high backpressure as will any turbine-driven main feedwater pumps that exhaust into the main condenser. Hence, not all nuclear plants are subject to this transient since many plants have motor-driven main feedwater pumps or they have turbine-driven pumps in which the turbine does not exhaust into the main condenser.

Since, in both of the above described transients (and in only these transients) the heat sink is lost, the AMSAC is designed to actuate the auxiliary feedwater flow when the loss of heat sink is detected.

Short-term protection against high reactor coolant system pressures is not required until 70% of nominal power. Furthermore, the potential exists for spurious AMSAC actuations during start-up at the lower power levels. To assure the above requirements are met, AMSAC will be automatically blocked at turbine loads less than 70%. However, in the event of an ATWS below 70% of nominal load, operator action will be required to provide long-term core protection by initiating auxiliary feedwater flow.

To ensure the AMSAC system remains armed sufficiently long to perform its function in the event of a turbine trip, the C-20 permissive signal shall be maintained for approximately []^{+a,c} after a turbine trip has occurred.

Actuation of AMSAC will occur due to a low water level in the steam generators. The AMSAC actuation logic will depend upon the number of steam generators utilized by the plant.

1.0 APPLICABLE CRITERIA AND STANDARDS

The following criteria apply to this system. (For titles and subject of each document, refer to listing of criteria in Appendix A).

1.1 Institute of Electrical and Electronics Engineers (IEEE) Standards

IEEE Standard 279-1971, Section 4.7.2.

2.0 SYSTEM DIAGRAMS

Refer to Functional Logic Diagrams provided in Figures 1-1, 1-2 and 1-3 for 2, 3 and 4 loop plants respectively.

3.0 ENVIRONMENTAL REQUIREMENTS

The following environmental qualification conditions apply to the AMSAC. It must be demonstrated that the AMSAC can function during and after the following conditions and yet not cause spurious turbine trips or AFW flow actuations to occur.

3.1 Plant Design Normal and Abnormal Operating Conditions

The AMSAC equipment qualification should be consistent with the non-safety related equipment qualification licensing basis for the plant.

Table 1 supplies typical plant normal and abnormal condition parameters for several typical areas within the plant. The AMSAC is located in Zone OC/AC. The sensor/transmitters are located in Zone IC/O. The sensor/transmitters are exposed to their existing environmental envelopes rather than the one shown in Table 1. The loss of heating, ventilation and air conditioning is considered an abnormal event. Abnormal conditions apply only to plants which do not have Class 1E ventilation and/or air conditioning systems. The operating condition parameters include the minimum, normal and maximum expected values for temperature, relative humidity, pressure as specified in Table 1, and radiation as specified in WCAP-8587 Supplement 1. These data are based on available A/E interface information. Environmental conditions due to ambient vibration, radio frequency interference, electro-magnetic interference and environmental duty cycle shall be considered, where appropriate, in the qualification of the AMSAC design. No zone within the plant is subjected to a chemical environment during normal and abnormal operating conditions.

3.2 Plant Operating Conditions for Design Basis Events

Not applicable

3.3 Time Duration of Requirements Following Initiation of Design Basis Events

Not applicable

4.0 INDICATORS, STATUS LIGHTS, AND CONTROLS

A momentary reset switch for unlatching the AMSAC outputs to the turbine trip circuits should be provided consistent with the existing turbine trip circuitry.

5.0 RECORDERS

None

6.0 ALARMS, ANNUNCIATORS AND DIAGNOSTICS

6.1 An output signal shall be provided for alarms, annunciators and/or plant diagnostics when the AMSAC has been actuated.

6.2 An output signal shall be provided for alarms, annunciators, and/or plant diagnostics when AMSAC is removed from service.

6.3 An output signal shall be provided for alarms, annunciators and/or plant diagnostics when an AMSAC system level deviation such as loss of power, partial trip, etc., occurs.

7.0 INTERLOCKS AND PERMISSIVES

<u>Designation</u>	<u>Function</u>	<u>Input</u>	<u>System</u>
C-20	Defeats the block of AMSAC	2/2 turbine impulse chamber pressure high	AMSAC (not redundant circuitry)

8.0 TRIPS/ACTUATIONS AND TRIP/ACTUATION LOGIC

A turbine trip and start-up of all auxiliary feedwater pumps will occur upon receipt of an AMSAC signal.

The steam generator blowdown isolation and sample isolation valves should be automatically closed in all loops when AMSAC is actuated.

The AMSAC signal will be generated by low water level signals in the steam generators using existing sensor/transmitter units. For 2 loop plants, AMSAC shall use 2 channels per loop with 3/4 coincidence to actuate AMSAC. The AMSAC coincidence logic for 3 loop plants is 2/3 with one channel per steam generator and the 4 loop plants coincidence logic is 3/4 with 1 channel per steam generator.

The AMSAC signal shall be automatically blocked below 70% power.

Removal of the C-20 permissive signal will be delayed by approximately []^{+a,c}

The design of AMSAC shall be of high reliability with regards to the system and components. The frequency of inadvertent AMSAC actuations shall be minimized.

Completion of the mitigating action, once actuated shall be consistent with the plant turbine trip and auxiliary feedwater circuitry.

Surveillance and maintenance requirements should be such that they can be incorporated into normal plant surveillance and maintenance programs.

9.0 ACCURACY

Channel accuracy includes the accuracy of the primary element, transmitter, cabinet modules and includes process and environmental effects on field mounted hardware. It does not include cabinet environmental effects or accuracy of the readout device used to measure the parameter at the point specified. Trip accuracy includes comparator accuracy, channel accuracy for each input and rack environmental effects. Trip accuracy is the tolerance within which a comparator is guaranteed to trip and includes all instrument errors and process effects.

9.1 Accuracy Requirements for Normal and Abnormal Operating Conditions

9.1.1 The narrow range steam generator water level Δp AMSAC signals shall have a trip accuracy

^{+a,c}

9.1.2 The AMSAC permissive (C-20) signal should have an actuation/trip accuracy

^{+a,c}

10.0 RANGE

10.1 Narrow Range Steam Generator Water Level:

^{+a,c}

10.2 Turbine impulse chamber pressure:

^{+a,c}

11.0 TIME RESPONSE

The turbine trip response time from an AMSAC signal must be
 ^{+a,c} including sensor delays.

This time response time shall be that time interval following a step input in the variable being monitored from 5% above to 5% below the trip setpoint (with any externally adjustable delays set to either ON or OFF) until the turbine is tripped.

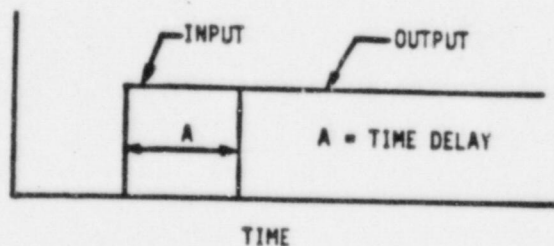
The auxiliary feedwater flow response time from an AMSAC signal must be []^{+a,c} including sensor delays.

This time response time shall be that time interval following a step input in the variable being monitored from 5% above to 5% below the trip setpoint (with any externally adjustable delays set to either ON or OFF) until the auxiliary feedwater systems is capable of performing its intended function.

12.0 CONTROLLER TRANSFER FUNCTIONS

12.1 Removal of the C-20 permissive signal shall be delayed by approximately []^{+a,c} to avoid blocking AMSAC before it can perform its function in the event a turbine trip occurs.

12.2 A delay unit may be used on the steam generator level channels to maximize the AMSAC actuation response time. This will ensure []^{+a,c}



Upon loss of a signal to the delay unit, the unit must reset to its initial state.

13.0 SETPOINTS

Variable

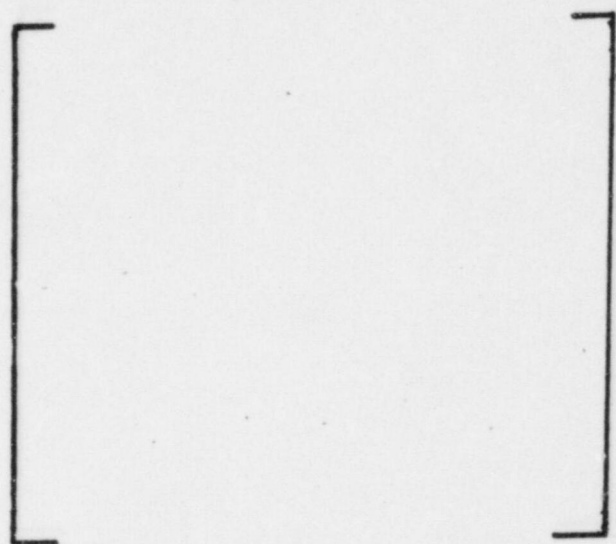
Range of Setpoint

AMSAC low steam generator
water level trip setpoint

C-20 permissive signal

C-20 permissive signal
adjustable delay

AMSAC signal adjustable delay



+a,c

All settings shall be continuously adjustable within each of their ranges.

AMSAC actuation is required at a setpoint [

] +a,c

14.0 REQUIREMENTS FOR TEST AND CALIBRATION

AMSAC may be removed from service for test purposes.

Removal of one AMSAC low steam generator input circuit should be accomplished by placing that circuit in the tripped mode.

15.0 REQUIREMENTS FOR ASSOCIATED EQUIPMENT

The logic power supply should be from an instrument power supply independent from power supplies for the existing protection system. AMSAC should be capable of performing its intended function on loss of offsite power. The power supply need not be safety related.

APPENDIX A

LISTING OF APPLICABLE CRITERIA

CRITERIA	TITLE
1. Institute of Electrical and Electronics Engineers (IEEE) Standards:	
IEEE Std. 279-1971, Section 4.7.2 (ANSI N42.7-1972)	Criteria for Protection Systems for Nuclear Power Generating Stations

NORMAL AND ABNORMAL OPERATING ENVIRONMENTS

General Area	Zone Description	Zone Code	Typical Areas	Range	Normal Operation				Abnormal Operation			
					Temp (°F)	RH (%)	Pres (psig)	Time Limit	Temp (°F)	RH (%)	Press (psig)	
In Containment	Inaccessible	IC/I	Inside Sec. Shield	Max.	135	70	+0.3	8 hours	150	95	Atmos	
				Min.	65	20	-0.1		50	0	Atmos	
	Accessible	IC/O	Outside Sec. Shield	Max.	120	70	+0.3		120	95	Atmos	
				Min.	65	20	-0.1		50	0	Atmos	
	Out of Containment	Air-Conditioned	OC/AC	Control Room Aux. Equip Room	Max.	80	50	Atmos.	12 hrs.	120	35	Atmos
					Min.	60	30	Atmos.		40	0	Atmos
Ventilated		OC/V	Aux. Building Safeguards etc.	Max.	104	70	Atmos	12 hrs.	120	35	Atmos	
				Min.	60	20	Atmos.		40	0	Atmos	
Non-Ventilated		OC/NV	Turbine-Hall	Max.	104	70	Atmos.		120	35	Atmos	
				Min.	60	20	Atmos.		40	0	Atmos	

82 95
to to
82 95
to to

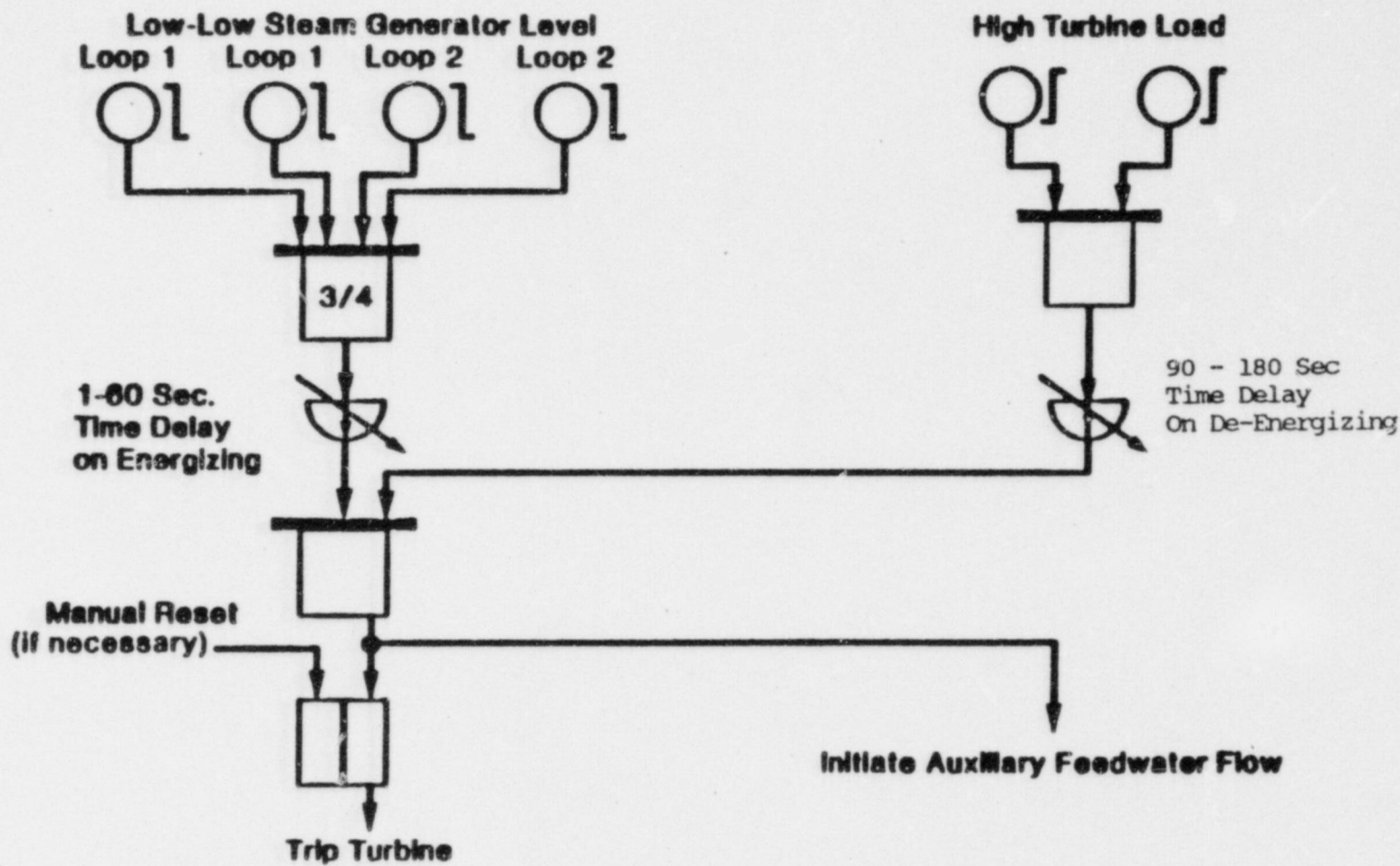


FIGURE 1-1

LOGIC DIAGRAM - STEAM GENERATOR LOW LEVEL

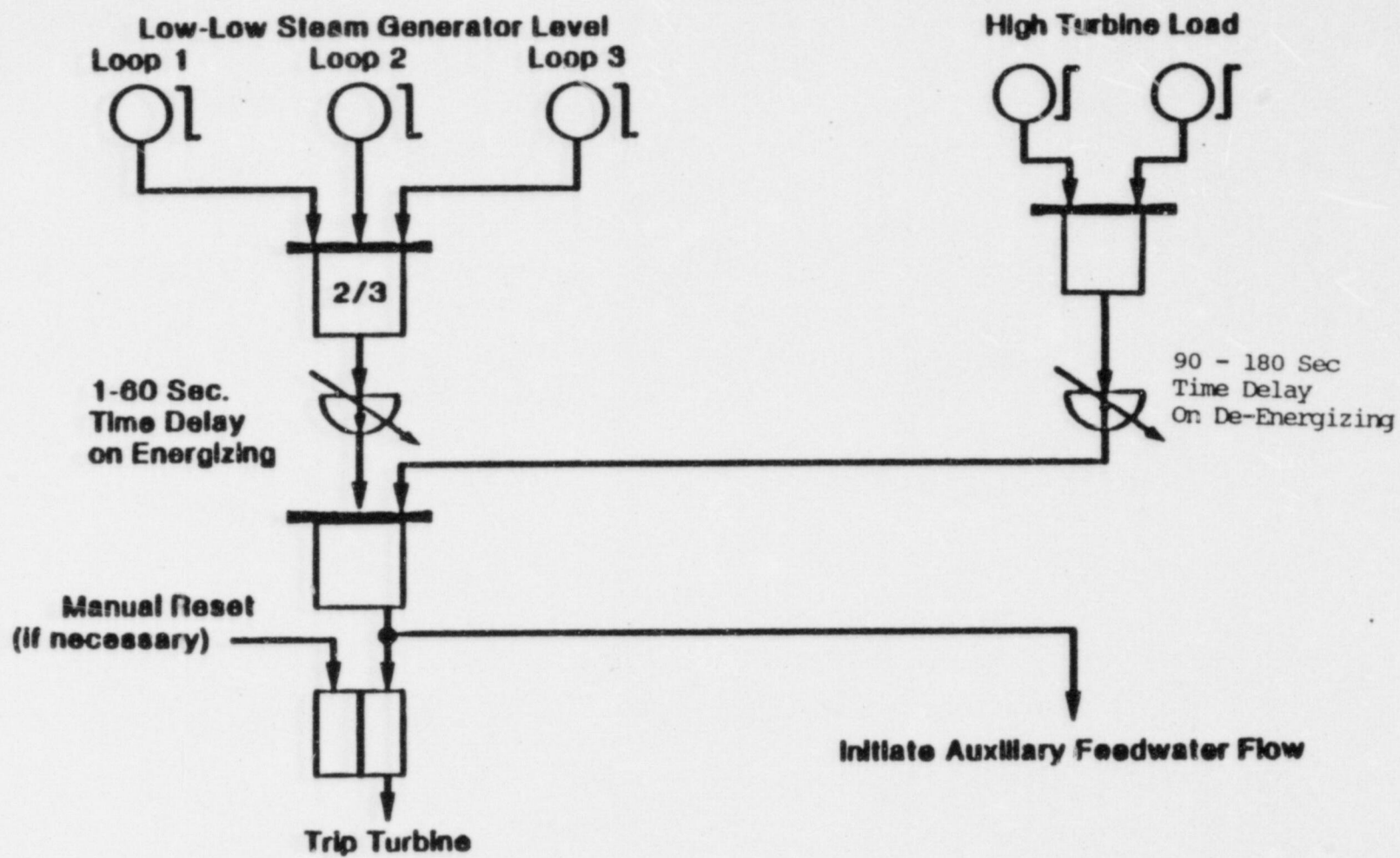
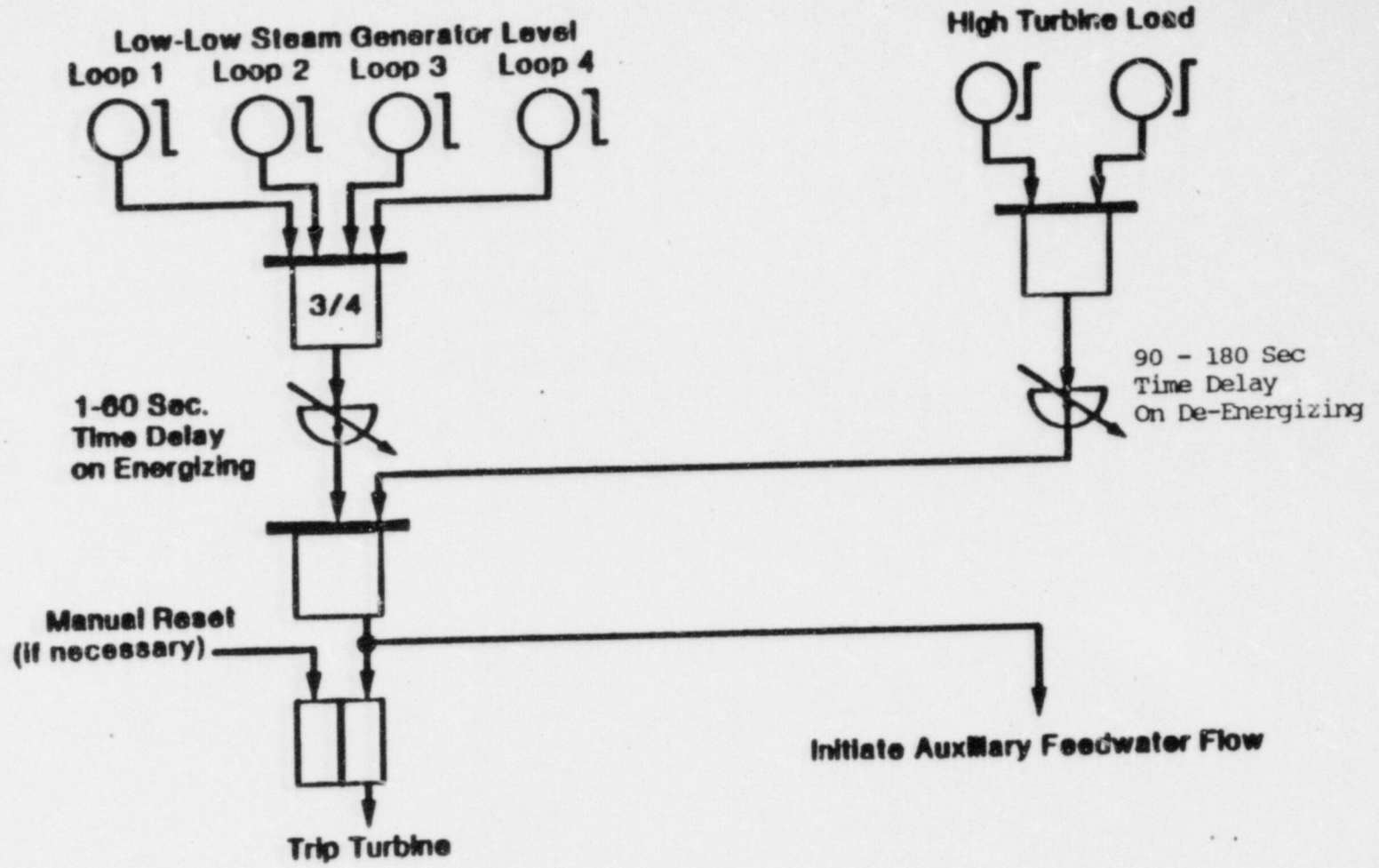


FIGURE 1 - 2

LOGIC DIAGRAM - STEAM GENERATOR LOW LEVEL

FIGURE 1 - 3



LOGIC DIAGRAM - STEAM GENERATOR LOW LEVEL

4.0 FUNCTIONAL REQUIREMENTS

ATWS MITIGATING SYSTEM ACTUATION CIRCUITRY (LOGIC 2: AMSAC ACTUATION ON LOW MAIN FEEDWATER FLOW)

0.0 SYSTEM DESCRIPTION (For Information Only)

ATWS Mitigating System Actuation Circuitry (AMSAC) provides an alternate means of tripping the turbine and actuating auxiliary feedwater (AFW) flow apart from the reactor protection system (RPS). The NRC decided turbine trip and AFW flow actuation will provide an adequate assurance the reactor coolant system (RCS) would not be subject to potential damage as a result of overpressure. The pressure limit (3200 psig) corresponds to the ASME Boiler and Pressure Vessel Code Level C Service Limit stress criteria. Past ATWS analyses, see WCAP-8330 for example, show there are only two ATWS transients for which the ASME Service level limit may be approached. These transients are the Complete Loss of Normal Feedwater Without Scram and the Loss of Load Without Scram.

The Complete Loss of Normal Feedwater transient can occur due to the simultaneous tripping of the main feedwater or condensate pumps or the simultaneous closing of the main feedwater control valves, pump discharge valves or block valves.

The Loss of Load transient considered for ATWS is one in which the vacuum in the main condenser is lost, resulting in a complete loss of normal feedwater. This could occur, for example, if the circulating water pump trips. The main turbine will then trip on high backpressure as will any turbine-driven main feedwater pumps that exhaust into the main condenser. Hence, not all nuclear plants are subject to this transient since many plants have motor-driven main feedwater pumps or they have turbine-driven pumps in which the turbine does not exhaust into the main condenser.

Since, in both of the above described transients (and in only these transients) the main feedwater is completely lost, the AMSAC is designed to actuate the auxiliary feedwater flow when the complete loss of main feedwater flow is anticipated.

Short-term protection against high reactor coolant system pressures is not required until 70% of nominal power. Furthermore, the potential exists for spurious AMSAC actuations during start-up at the lower power levels. To assure the above requirements are met, AMSAC will be automatically blocked at turbine loads less than 70%. However, in the event of an ATWS below 70% of nominal load, operator action will be required to provide long-term core protection by initiating auxiliary feedwater flow.

Actuation of AMSAC will occur on low main feedwater flow as measured by existing main feedwater flow sensor/transmitters. The setpoint to actuate AMSAC is 50% of nominal main feedwater flow. Although 50% flow is more than ample to protect against overpressure in the event of an ATWS, instrumentation error would become unacceptably large if a substantially lower set point were used.

To avoid inadvertent AMSAC actuation on the loss of one main feedwater pump, AMSAC actuation will be delayed approximately 25 seconds to permit the unfaulted main feedwater pump(s) to automatically increase the flow rate to above the AMSAC actuation setpoint. Recovery in this circumstance is possible since each main feedwater pump is capable of delivering 60% of full load capacity.

To ensure the AMSAC system remains armed sufficiently long to perform its function in the event of a turbine trip, the C-20 permissive signal shall be maintained for approximately []^{+a,c} after the turbine trip has occurred.

1.0 APPLICABLE CRITERIA AND STANDARDS

The following criteria apply to this system. (For titles and subject of each document, refer to listing of criteria in Appendix A).

1.1 Institute of Electrical and Electronics Engineers (IEEE) Standards

IEEE Standard 279-1971, Section 4.7.2.

2.0 SYSTEM DIAGRAMS

Refer to Functional Logic Diagrams provided in Figures 2-1, 2-2 and 2-3 for 2, 3 and 4 loop plants respectively.

3.0 ENVIRONMENTAL REQUIREMENTS

The following environmental qualification conditions apply to the AMSAC. It must be demonstrated that the AMSAC can function during and after the following conditions and yet not cause spurious turbine trips or AFW flow actuations to occur.

3.1 Plant Design Normal and Abnormal Operating Conditions

The AMSAC equipment qualification should be consistent with the non-safety related equipment qualification licensing basis for the plant.

Table 1 supplies typical plant normal and abnormal condition parameters for several typical areas within the plant. The AMSAC is located in Zone OC/AC. The main feedwater flow sensor/transmitters are located in Zone OC/V or OC/NV. The sensor/transmitters are exposed to their existing environmental envelopes rather than the

ones shown in Table 1. The loss of heating, ventilation and air conditioning is considered an abnormal event. Abnormal conditions apply only to plants which do not have Class 1E ventilation and/or air conditioning systems. The operating condition parameters include the minimum, normal and maximum expected values for temperature, relative humidity, pressure as specified in Table 1, and radiation as specified in WCAP-8587 Supplement 1. These data are based on available A/E interface information. Environmental conditions due to ambient vibration, radio frequency interference, electro-magnetic interference and environmental duty cycle shall be considered, where appropriate, in the qualification of the AMSAC design. No zone within the plant is subjected to a chemical environment during normal and abnormal operating conditions.

3.2 Plant Operating Conditions for Design Basis Events

Not applicable

3.3 Time Duration of Requirements Following Initiation of Design Basis Events

Not applicable

4.0 INDICATORS, STATUS LIGHTS, AND CONTROLS

A momentary reset switch for unlatching the AMSAC outputs to the turbine trip circuits should be provided consistent with the existing turbine trip circuitry.

5.0 RECORDERS

None

6.0 ALARMS, ANNUNCIATORS AND DIAGNOSTICS

6.1 An output signal shall be provided for alarms, annunciators and/or plant diagnostics when the AMSAC has been actuated.

- 6.2 An output signal shall be provided for alarms, annunciators, and/or plant diagnostics when AMSAC is removed from service.
- 6.3 An output signal shall be provided for alarms, annunciators and/or plant diagnostics when an AMSAC system level deviation such as loss of power, partial trip, etc., occurs.

7.0 INTERLOCKS AND PERMISSIVES

<u>Designation</u>	<u>Function</u>	<u>Input</u>	<u>System</u>
C-20	Defeats the block of AMSAC	2/2 turbine impulse chamber pressure high	AMSAC (not redundant circuitry)

8.0 TRIPS/ACTIONS AND TRIP/ACTION LOGIC

A turbine trip and start-up of all auxiliary feedwater pumps will occur upon receipt of an AMSAC signal.

The steam generator blowdown isolation and sample isolation valves should be automatically closed in all loops when AMSAC is actuated.

The AMSAC signal shall be generated by low main feedwater flow to the steam generators. The AMSAC coincidence logic is 3/4 for two and four loop plants and 2/3 for three loop plants.

The AMSAC signal will be automatically blocked below 70% power.

The AMSAC signal will be delayed by []^{+a,c}

Removal of the C-20 permissive signal will be delayed by approximately []^{+a,c}

The design of AMSAC shall be of high reliability with regards to the system and components. The frequency of inadvertent AMSAC actuations shall be minimized. Completion of the mitigating action once actuated shall be consistent with plant turbine trip and auxiliary feedwater circuitry.

Surveillance and maintenance requirements should be such that they can be incorporated into normal plant surveillance and maintenance programs.

9.0 ACCURACY

Channel accuracy includes the accuracy of the primary element, transmitter, cabinet modules and includes process and environmental effects on field mounted hardware. It does not include cabinet environmental effects or accuracy of the readout device used to measure the parameter at the point specified. Trip (or actuation) accuracy includes comparator accuracy, channel accuracy for each input and rack environmental effects. Trip (or actuation) accuracy is the tolerance within which a comparator is guaranteed to trip (or actuate) and includes all instrument errors and process effects.

9.1 Accuracy Requirements for Normal and Abnormal Operating Conditions

9.1.1 The AMSAC actuation signal (low main feedwater flow) should have an actuation accuracy [

] ^{+a,c}

9.1.2 The AMSAC permissive (C-20) signal should have an actuation/trip accuracy [

] ^{+a,c}

10.0 RANGE

10.1 Main feedwater flow: [] ^{+a,c}

10.2 Turbine impulse chamber pressure: [] ^{+a,c}

11.0 TIME RESPONSE

The turbine trip response time from an AMSAC signal must be []^{+a,c} including sensor delays.

This time response time shall be that time interval following a step input in the variable being monitored from 5% above to 5% below the trip setpoint (with any externally adjustable delays set to either ON or OFF) until the turbine is tripped.

The auxiliary feedwater flow response time from an AMSAC signal must be []^{+a,c} including sensor delays.

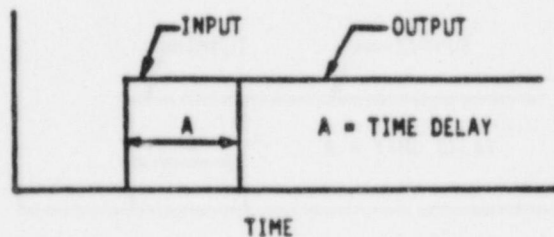
This time response time shall be that time interval following a step input in the variable being monitored from 5% above to 5% below the trip setpoint (with any externally adjustable delays set to either ON or OFF) until the auxiliary feedwater systems is capable of performing its intended function.

12.0 CONTROLLER TRANSFER FUNCTIONS

12.1 Removal of the C-20 permissive signal shall be delayed by approximately []^{+a,c} to avoid blocking AMSAC before it can perform its function in the event a turbine trip occurs.

12.2 A delay unit is required on the low main feedwater flow channels to maximize the AMSAC actuation response time. This allows []

[]^{+a,c}



Upon loss of a signal to the delay unit, the unit must reset to its initial state.

13.0 SETPOINTS

<u>Variable</u>	<u>Range of Setpoint</u>	
C-20 permissive signal	[+a,c
C-20 permissive signal adjustable delay		
AMSAC signal		
AMSAC signal adjustable delay		

All settings shall be continuously adjustable within each of their ranges.

14.0 REQUIREMENTS FOR TEST AND CALIBRATION

AMSAC may be removed from service for test purposes.

Removal of one AMSAC low main feedwater flow input circuit should be accomplished by placing that circuit in the tripped mode.

15.0 REQUIREMENTS FOR ASSOCIATED EQUIPMENT

The logic power supply should be from an instrument power supply independent from power supplies for the existing protection system. AMSAC should be capable of performing its intended function on loss of offsite power. The power supply need not be safety related.

APPENDIX A

LISTING OF APPLICABLE CRITERIA

CRITERIA

TITLE

1. Institute of Electrical
and Electronics Engineers
(IEEE) Standards:

IEEE Std. 279-1971, Section 4.7.2
(ANSI N42.7-1972)

Criteria for Protection Systems for
Nuclear Power Generating Stations

TABLE 1

NORMAL AND ABNORMAL OPERATING ENVIRONMENTS

General Area	Zone Description	Zone Code	Typical Areas	Range	Normal Operation			Time Limit	Abnormal Operation			
					Temp (°F)	RH (%)	Pres (psig)		Temp (°F)	RH (%)	Press (psig)	
In Containment	Inaccessible	IC/I	Inside Sec. Shield	Max.	135	70	+0.3	8 hours	150	95	Atmos	
				Min.	65	20	-0.1		50	0	Atmos	
	Accessible	IC/O	Outside Sec. Shield	Max.	120	70	+0.3		120	95	Atmos	
				Min.	65	20	-0.1		50	0	Atmos	
	Out of Containment	Air-Conditioned	OC/AC	Control Room Aux. Equip Room	Max.	80	50	Atmos.	12 hrs.	82	95	Atmos
					Min.	60	30	Atmos.		40	0	Atmos
Ventilated		OC/V	Aux. Building Safeguards etc.	Max.	104	70	Atmos	12 hrs.	82	95	Atmos	
				Min.	60	20	Atmos.		40	0	Atmos	
Non-Ventilated		OC/NV	Turbine-Hall	Max.	104	70	Atmos.		82	95	Atmos	
				Min.	60	20	Atmos.		40	0	Atmos	

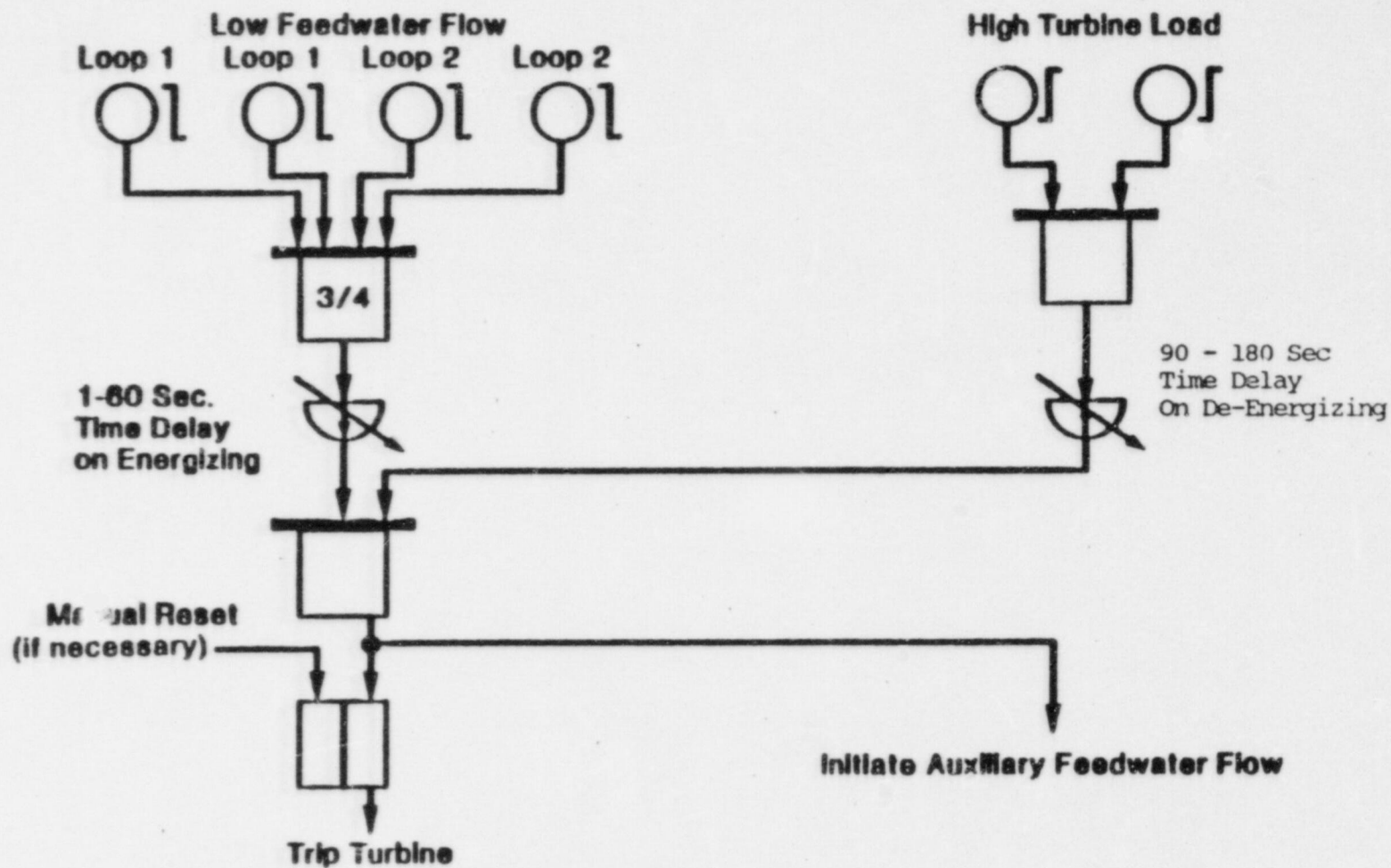
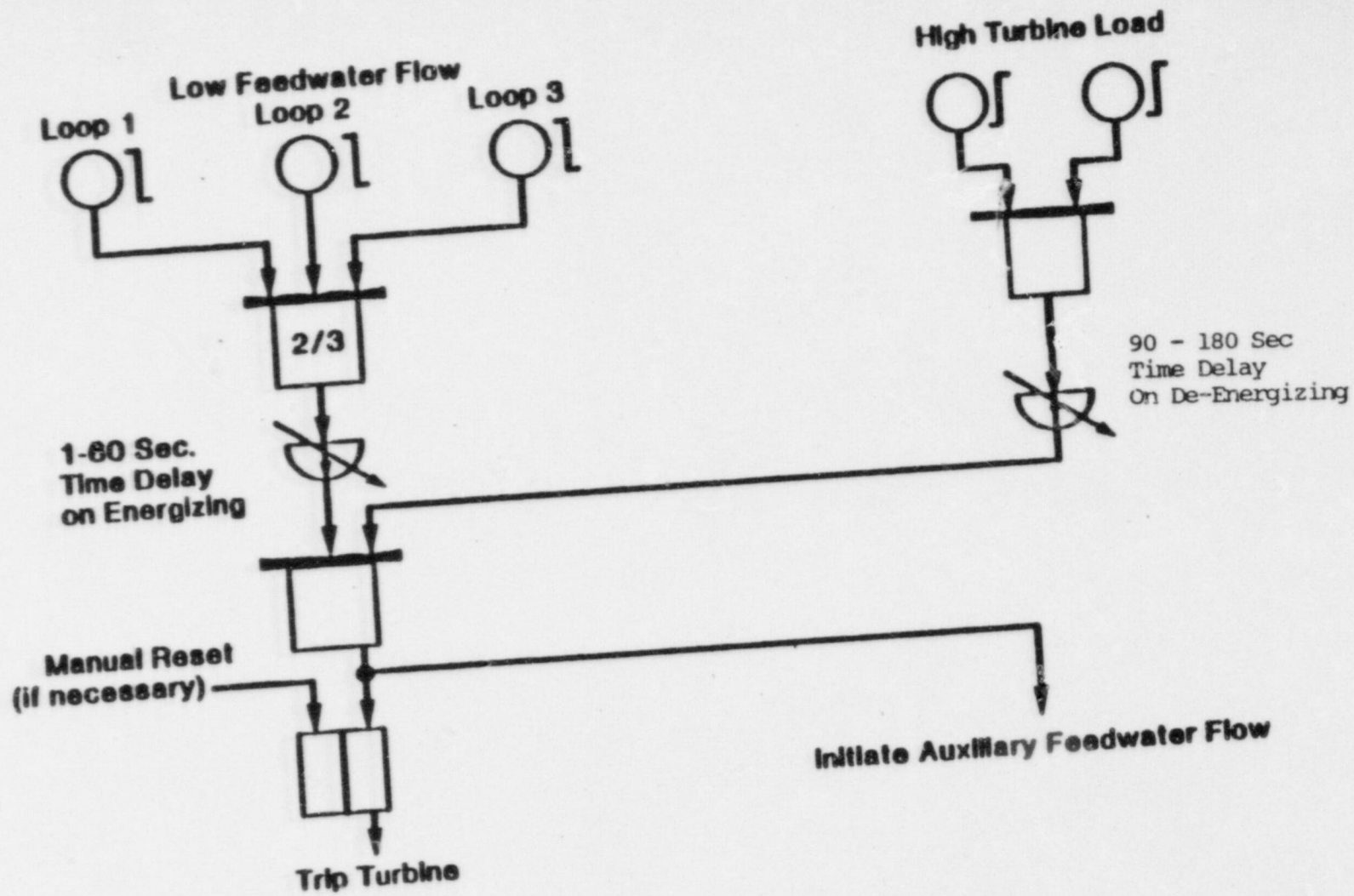


FIGURE 2 - 1

LOGIC DIAGRAM - LOW FEEDWATER FLOW

FIGURE 2-2



LOGIC DIAGRAM - LOW FEEDWATER FLOW



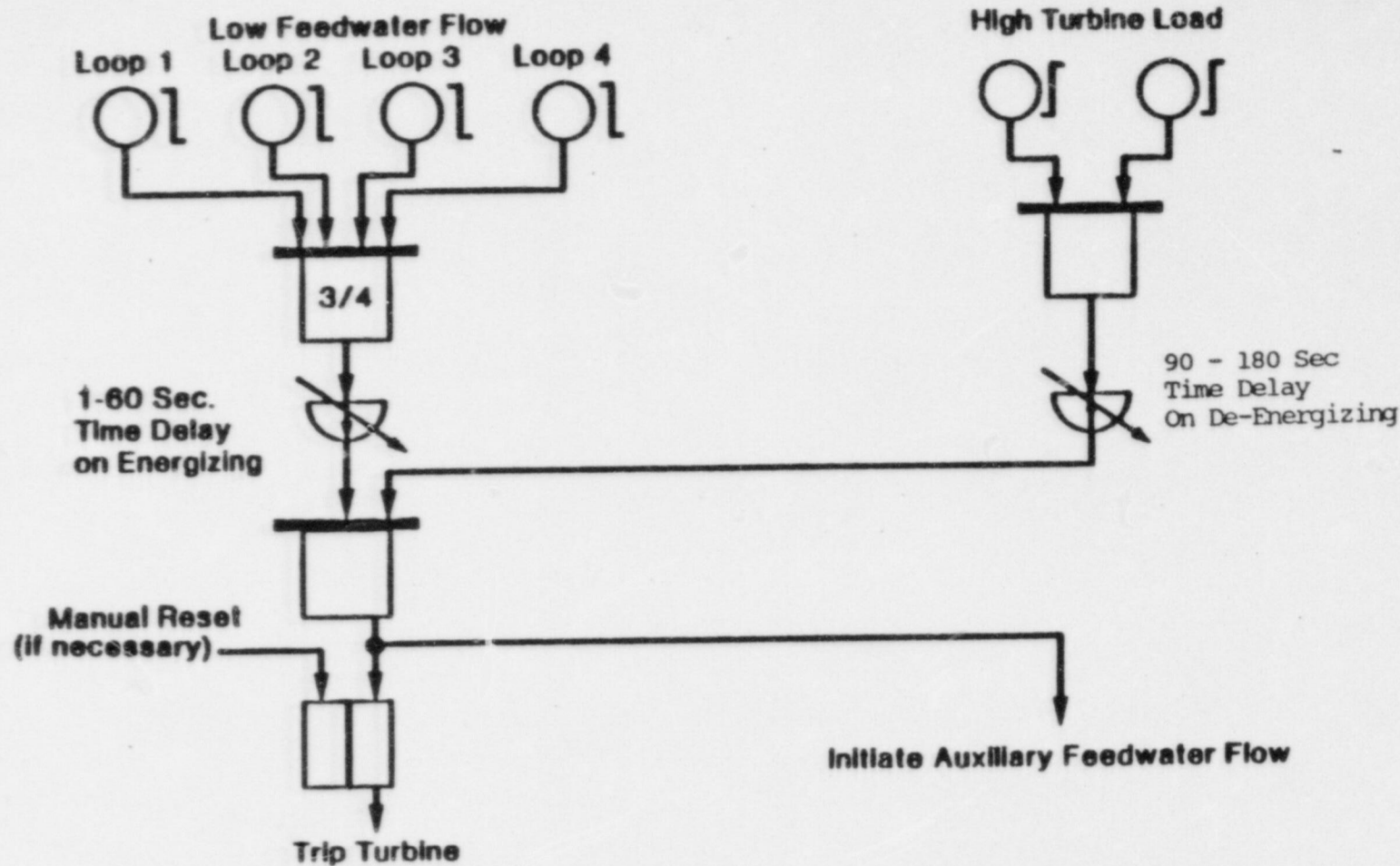


FIGURE 2 - 3

LOGIC DIAGRAM - LOW FEEDWATER FLOW

5.0 FUNCTIONAL REQUIREMENTS

ATWS MITIGATING SYSTEM ACTUATION CIRCUITRY (LOGIC 3: AMSAC ACTUATION ON MAIN FEEDWATER PUMP TRIP OR MAIN FEEDWATER VALVE CLOSURE)

0.0 SYSTEM DESCRIPTION (For Information Only)

ATWS Mitigating System Actuation Circuitry (AMSAC) provides an alternate means of tripping the turbine and actuating auxiliary feedwater (AFW) flow apart from the reactor protection system (RPS). The NRC decided turbine trip and AFW flow actuation will provide an adequate assurance the reactor coolant system (RCS) would not be subject to potential damage as a result of overpressure. The pressure limit (3200 psig) corresponds to the ASME Boiler and Pressure Vessel Code Level C Service Limit stress criteria. Past ATWS analyses, see WCAP-8330 for example, show there are only two ATWS transients for which the ASME Service level limit may be approached. These transients are the Complete Loss of Normal Feedwater Without Scram and the Loss of Load Without Scram.

The Complete Loss of Normal Feedwater transient can occur due to the simultaneous tripping of the main feedwater or condensate pumps or the simultaneous closing of the main feedwater control valves, pump discharge valves or block valves.

The Loss of Load transient considered for ATWS is one in which the vacuum in the main condenser is lost, resulting in a complete loss of normal feedwater. This could occur, for example, if the circulating water pump trips. The main turbine will then trip on high backpressure as will any turbine-driven main feedwater pumps that exhaust into the main condenser. Hence, not all nuclear plants are

subject to this transient since many plants have motor-driven main feedwater pumps or they have turbine-driven pumps in which the turbine does not exhaust into the main condenser.

Since, in both of the above described transients (and in only these transients) the main feedwater is completely lost, the AMSAC is designed to actuate the auxiliary feedwater flow when the complete loss of main feedwater flow is anticipated.

Actuation of AMSAC will occur when it has been determined that all main feedwater pumps have been tripped or when main feedwater flow to the steam generators has been blocked due to valve closures.

Failures in the main feedwater system upstream of the main feedwater pumps that could result in the loss of main feedwater to the steam generators, e.g., tripping of all condensate pumps, will result in automatic main feedwater pump trips on low suction pressure. Therefore, explicit actuation of AMSAC based on failures of components upstream of the main feedwater pumps is not necessary.

Since AMSAC anticipates the plant response due to the loss of main feedwater pumps prior to the reactor protection system detecting an anticipated operational occurrence, it is necessary to delay AMSAC actuation. A 30 second delay is sufficient to allow the reactor protection system to respond.

Either of two different AMSAC concepts may be used, depending upon whether or not the main feedwater flow to the steam generators is split during normal power operation (see Figure 3-1). Plants which contain D-4 and D-5 steam generators have split flow during normal power operation. All other plants do not, although all plants with preheaters will have a minimal bypass flow through the feedwater bypass tempering valve (FBTV). For preheater plants which have split flow during normal power operation, approximately 10 to 20% of the total feedwater flow is passed through the feedwater preheater bypass valves (FPVB), while most of the remaining flow is passed through the

feedwater isolation valve (FIV). If all FIVs were to close simultaneously, the flow through the FPBV would increase substantially and still provide protection against RCS overpressurization in the event of an ATWS. Therefore the accidental closure of all FIVs is not a factor for plants which contain D-4 or D-5 steam generators. All other plants however must account for the accidental closure of all FIVs as well as the accidental closure of all feedwater control valves (FCVs) and the accidental tripping of all main feedwater pumps.

Short-term protection against high reactor coolant system pressures is not required until 70% of nominal power. Furthermore, the potential exists for spurious AMSAC actuations during start-up at the lower power levels. To assure the above requirements are met, AMSAC will be automatically blocked at turbine loads less than 70%. However, in the event of an ATWS below 70% of nominal load, operator action will be required to provide long-term core protection by initiating auxiliary feedwater flow.

To ensure the AMSAC system remains armed sufficiently long to perform its function in the event of a turbine trip, the C-20 permissive signal shall be maintained for approximately []^{a,c} after the turbine trip has occurred.

1.0 APPLICABLE CRITERIA AND STANDARDS

The following criteria apply to this system. (For titles and subject of each document, refer to listing of criteria in Appendix A).

1.1 Institute of Electrical and Electronics Engineers (IEEE) Standards

IEEE Standard 279-1971, Section 4.7.2

2.0 SYSTEM DIAGRAMS

Figure 3-1 shows typical main feedwater piping diagrams for units which have and which do not have steam generator preheaters.

Figures 3-2, 3-3 and 3-4 show Functional Logic Diagrams for 2, 3 and 4 loop plants, except those that have D-4 or D-5 steam generators. Figures 3-5, 3-6 and 3-7 show corresponding Functional Logic Diagrams for plant which have D-4 or D-5 steam generators.

3.0 ENVIRONMENTAL REQUIREMENTS

The following environmental qualification conditions apply to the AMSAC. It must be demonstrated that the AMSAC can function during and after the following conditions and yet not cause spurious turbine trips or AFW flow actuations to occur.

3.1 Plant Design Normal and Abnormal Operating Conditions

The AMSAC equipment qualification should be consistent with the non-safety related equipment qualification licensing basis for the plant.

Table 1 supplies typical plant normal and abnormal condition parameters for several typical areas within the plant. The AMSAC is located in Zone OC/AC. The valves and pumps are located in Zone OC/V or OC/NV. The valves and pumps are exposed to their existing environmental envelopes rather than the ones shown in Table 1. The loss of heating, ventilation and air conditioning is considered an abnormal event. Abnormal conditions apply only to plants which do not have Class 1E ventilation and/or air conditioning systems. The operating condition parameters include the minimum, normal and maximum expected values for temperature, relative humidity, pressure as specified in Table 1, and radiation as specified in WCAP-8587 Supplement 1. These data are based on available A/E interface information. Environmental conditions due to ambient vibration,

radio frequency interference, electro-magnetic interference and environmental duty cycle shall be considered, where appropriate, in the qualification of the AMSAC design. No zone within the plant is subjected to a chemical environment during normal and abnormal operating conditions.

3.2 Plant Operating Conditions for Design Basis Events

Not applicable

3.3 Time Duration of Requirements Following Initiation of Design Basis Events

Not applicable

4.0 INDICATORS, STATUS LIGHTS, AND CONTROLS

A momentary reset switch for unlatching the AMSAC outputs to the turbine trip circuits should be provided consistent with the existing turbine trip circuitry.

5.0 RECORDERS

None

6.0 ALARMS, ANNUNCIATORS AND DIAGNOSTICS

6.1 An output signal shall be provided for alarms, annunciators and/or plant diagnostics when the AMSAC has been actuated.

6.2 An output signal shall be provided for alarms, annunciators, and/or plant diagnostics when AMSAC is removed from service.

6.3 An output signal shall be provided for alarms, annunciators and/or plant diagnostics when an AMSAC system level deviation such as loss of power, partial trip, etc., occurs.

7.0 INTERLOCKS AND PERMISSIVES

<u>Designation</u>	<u>Function</u>	<u>Input</u>	<u>System</u>
C-20	Defeats the block of AMSAC	2/2 Turbine impulse chamber pressure high	AMSAC (not redundant circuitry)

8.0 TRIPS/ACTUATIONS AND TRIP/ACTUATION LOGIC

A turbine trip and start-up of all auxiliary feedwater pumps will occur upon receipt of an AMSAC signal.

The steam generator blowdown isolation and sample isolation valves should be automatically closed in all loops when AMSAC is actuated.

The AMSAC signal shall be generated by the simultaneous tripping of all main feedwater pumps or the blocking of all main feedwater lines to the steam generators due to valve malfunctions. The AMSAC coincidence logic is as follows:

Loops	Coincidence	
	FW Valves Closed	FW Pumps Tripped
2	3/4	N/N
3	2/3	N/N
4	3/4	N/N

where N is the number of main feedwater pumps.

The AMSAC signal shall be automatically blocked below 70% power.

Removal of the C-20 permissive signal shall be delayed by approximately $\left[\quad \right]^{+a,c}$

The design of AMSAC shall be of high reliability with regards to the system and components. The frequency of inadvertant AMSAC actuations shall be minimized. Completion of the mitigating action once actuated shall be consistent with the plant turbine trip and auxiliary feedwater circuitry.

Surveillance and maintenance requirements should be such that they can be incorporated into normal plant surveillance and maintenance programs.

9.0 ACCURACY

Channel accuracy includes the accuracy of the primary element, transmitter, cabinet modules and includes process and environmental effects on field mounted hardware. It does not include cabinet environmental effects or accuracy of the readout device used to measure the parameter at the point specified. Trip accuracy includes comparator accuracy, channel accuracy for each input and rack environmental effects. Trip accuracy is the tolerance within which a comparator is guaranteed to trip and includes all instrument errors and process effects.

9.1 Accuracy Requirements for Normal and Abnormal Operating Conditions

9.1.1 The AMSAC permissive (C-20) signal should have an actuation/trip accuracy [

] ^{+a,c}

10.0 RANGE

10.1 Turbine impulse chamber pressure: [] ^{+a,c}

11.0 TIME RESPONSE

The turbine trip response time from an AMSAC signal must be [] ^{+a,c}

This time response is defined as the time required for a signal to trip the turbine when the monitored main feedwater pump status changes from ON to OFF, or when the monitored feedwater control and isolation valves status changes from OPEN to CLOSED with all externally adjustable delays set to either ON or OFF.

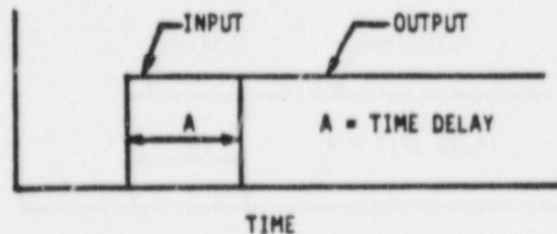
The auxiliary feedwater flow response time from an AMSAC signal must be []^{+a,c} including sensor delays.

This time response is defined as the time required for the auxiliary feedwater system to be capable of performing its intended function when the monitored main feedwater pump status changes from ON to OFF, or when the monitored feedwater control and isolation valves status changes from OPEN to CLOSED with all externally adjustable delays set to either ON or OFF.

12.0 CONTROLLER TRANSFER FUNCTIONS

12.1 Removal of the C-20 permissive signal shall be delayed by approximately []^{+a,c} to avoid blocking AMSAC before it can perform its function in the event a turbine trip occurs.

12.2 A delay unit may be used on the low main feedwater flow channels to maximize the AMSAC actuation response time. This allows []^{+a,c}



Upon loss of a signal to the delay unit, the unit must reset to its initial state.

13.0 SETPOINTS

<u>Variable</u>	<u>Range of Setpoint</u>	
C-20 permissive signal	[]	+a,c
C-20 permissive signal adjustable delay		
AMSAC signal adjustable delay		

The feedwater control valve instrumentation should produce an output signal to AMSAC whenever the valve is positioned to permit flow less than or equal to [] +a,c

All settings shall be continuously adjustable within each of their ranges.

14.0 REQUIREMENTS FOR TEST AND CALIBRATION

AMSAC may be removed from service for test purposes.

Removal of one AMSAC pump trip or valve closure actuation circuit should be accomplished by placing that circuit in the tripped mode.

15.0 REQUIREMENTS FOR ASSOCIATED EQUIPMENT

The logic power supply should be from an instrument power supply independent from power supplies for the existing protection system. AMSAC should be capable of performing its intend function on loss of offsite power. The power supply need not be safety related.

APPENDIX A

LISTING OF APPLICABLE CRITERIA

CRITERIA

TITLE

1. Institute of Electrical
and Electronics Engineers
(IEEE) Standards:

IEEE Std. 279-1971, Section 4.7.2
(ANSI N42.7-1972)

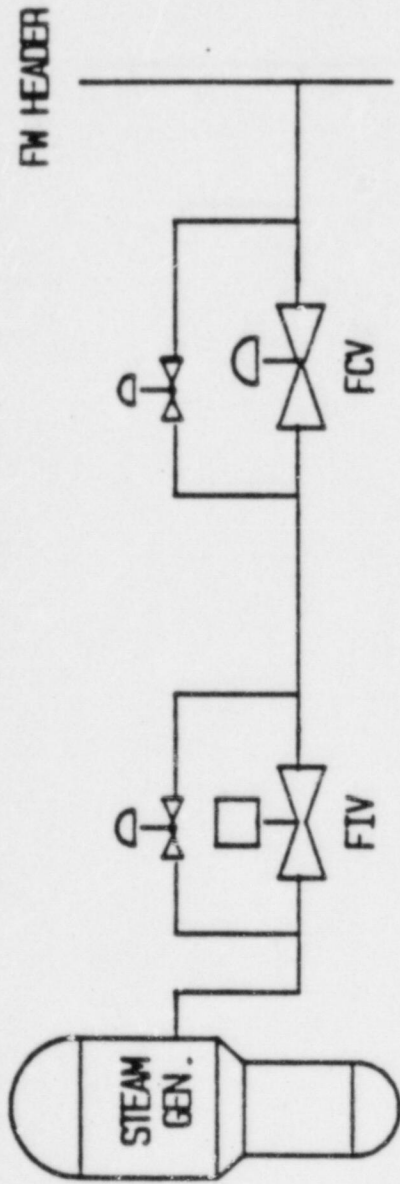
Criteria for Protection Systems for
Nuclear Power Generating Stations

TABLE 1

NORMAL AND ABNORMAL OPERATING ENVIRONMENTS

General Area	Zone Description	Zone Code	Typical Areas	Range	Normal Operation				Abnormal Operation		
					Temp (°F)	RH (%)	Pres (psig)	Time Limit	Temp (°F)	RH (%)	Press (psig)
In Containment	Inaccessible	IC/I	Inside Sec. Shield	Max.	135	70	+0.3	8 hours	150	95	Atmos
				Min.	65	20	-0.1		50	0	Atmos
	Accessible	IC/O	Outside Sec. Shield	Max.	120	70	+0.3		120	95	Atmos
				Min.	65	20	-0.1		50	0	Atmos
									82	95	
									to	to	
Out of Containment	Air- Conditioned	OC/AC	Control Room Aux. Equip Room	Max.	80	50	Atmos.	12 hrs.	120	35	Atmos
				Min.	60	30	Atmos.		40	0	Atmos
									82	95	
									to	to	
	Ventilated	OC/V	Aux. Building Safeguards etc.	Max.	104	70	Atmos	12 hrs.	120	35	Atmos
				Min.	60	20	Atmos.		40	0	Atmos
								82	95		
								to	to		
Non- Ventilated	OC/NV	Turbine-Hall	Max.	104	70	Atmos.		120	35	Atmos	
			Min.	60	20	Atmos.		40	0	Atmos	

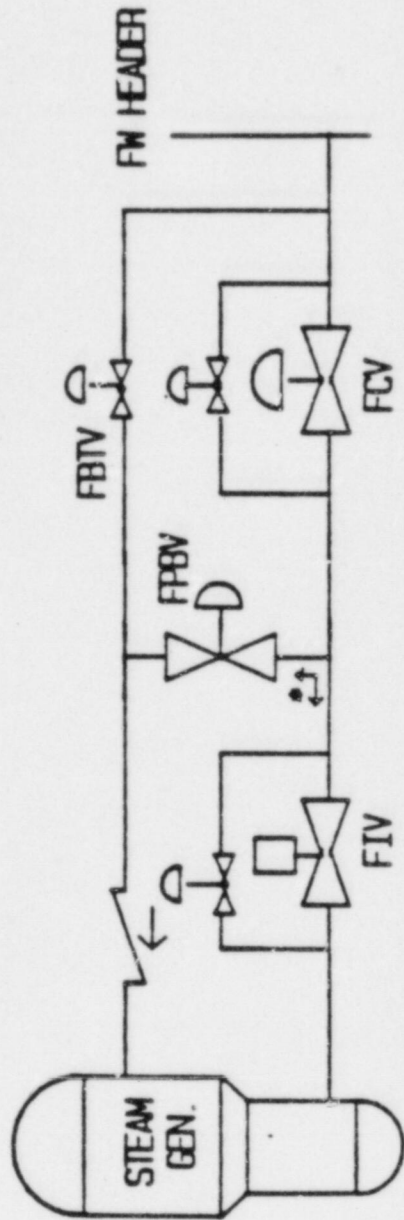
MAIN FEEDWATER PIPING ARRANGEMENTS



STEAM GENERATOR WITHOUT PREHEATER

* FLOW SPLIT AT NOMINAL FULL POWER FOR 0-4 AND 0-5 STEAM GENERATORS ONLY

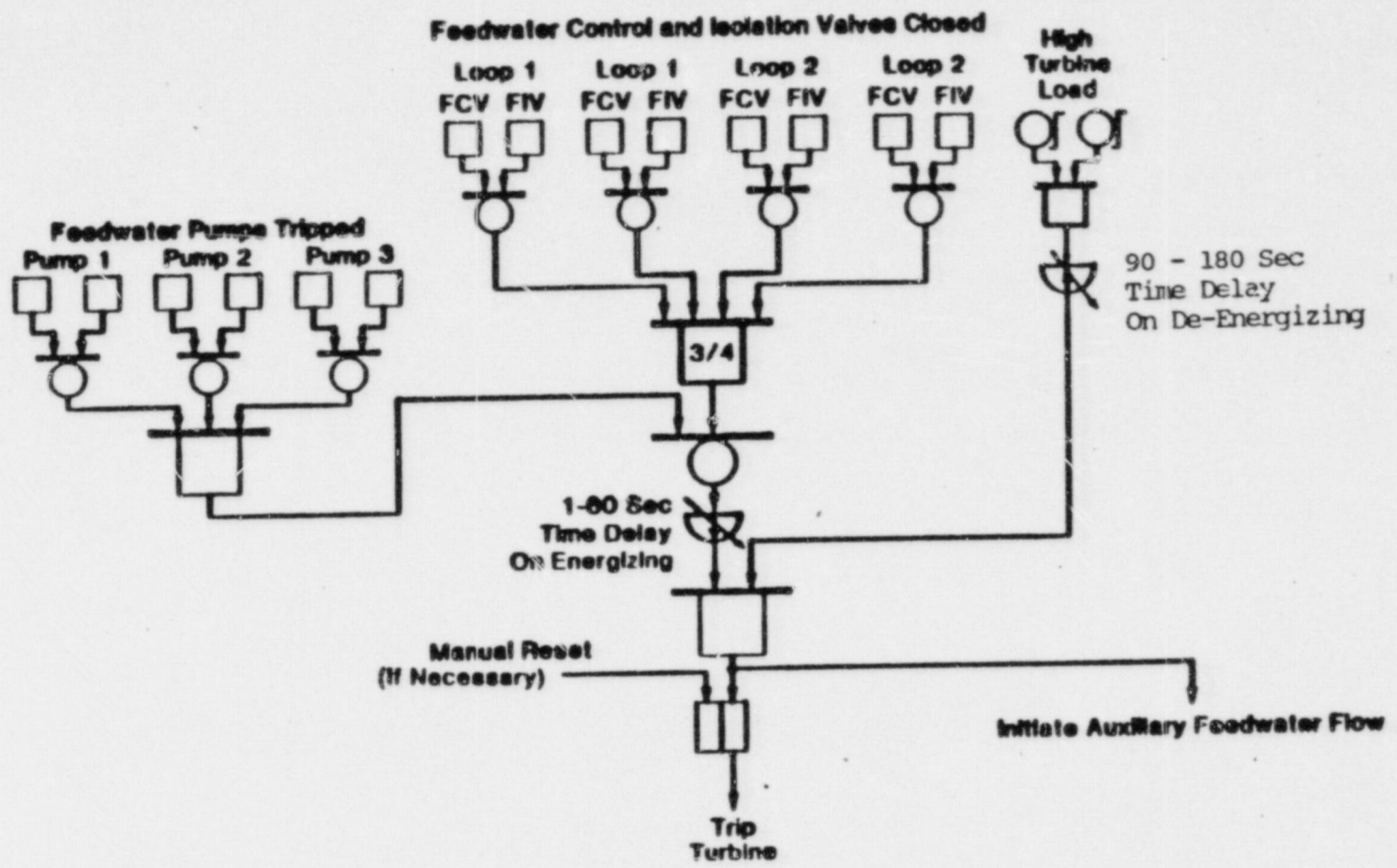
FIV = FM ISOLATION VALVE
 FCV = FM CONTROL VALVE
 FPBV = FM PREHEATER BYPASS VALVE
 FBTV = FM BYPASS TEMPERING VALVE



STEAM GENERATOR WITH PREHEATER

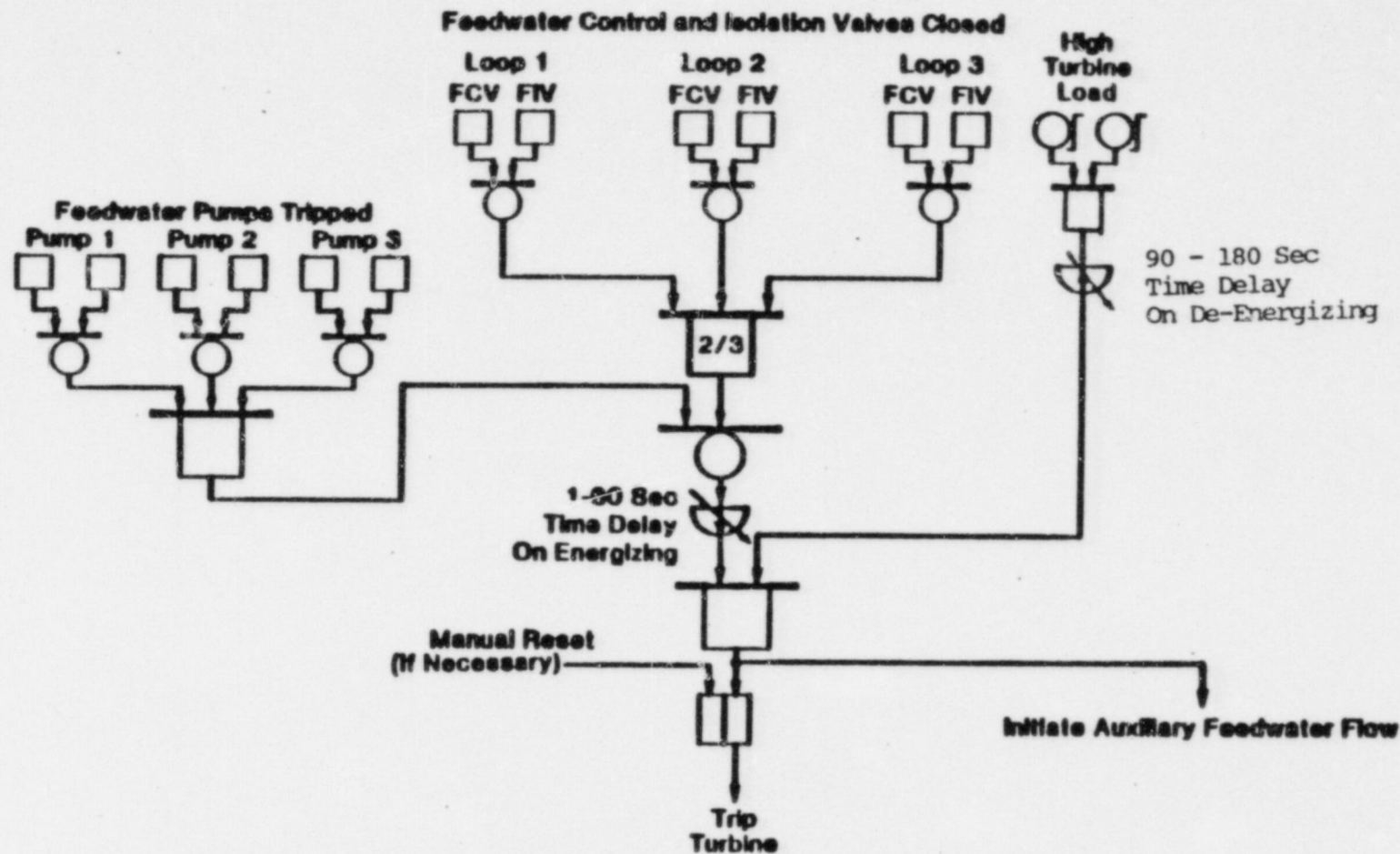
FIGURE 3 - 1

FIGURE 3 - 2



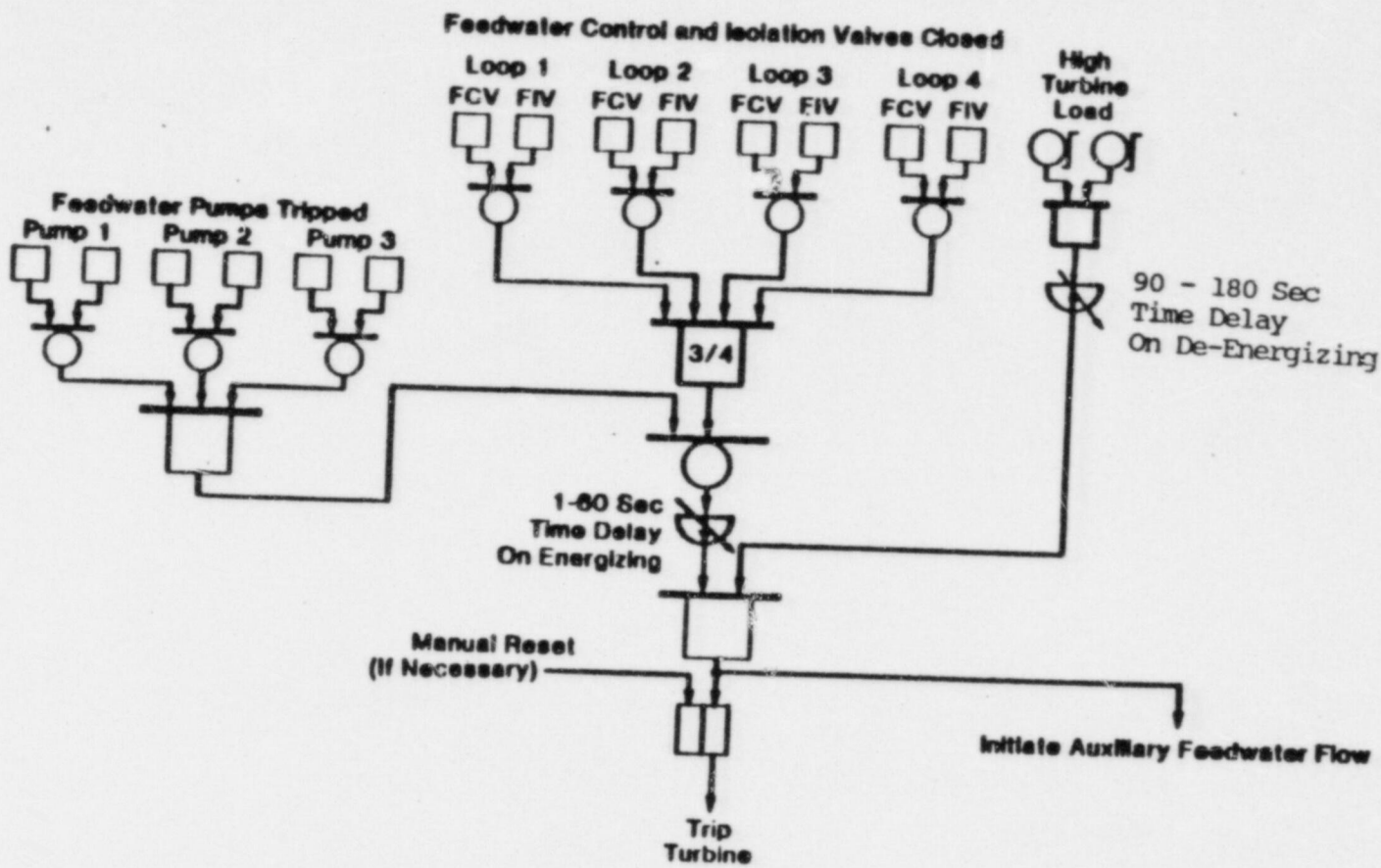
LOGIC DIAGRAM-FEEDWATER PUMP AND VALVE STATUS

FIGURE 3-3



LOGIC DIAGRAM-FEEDWATER PUMP AND VALVE STATUS

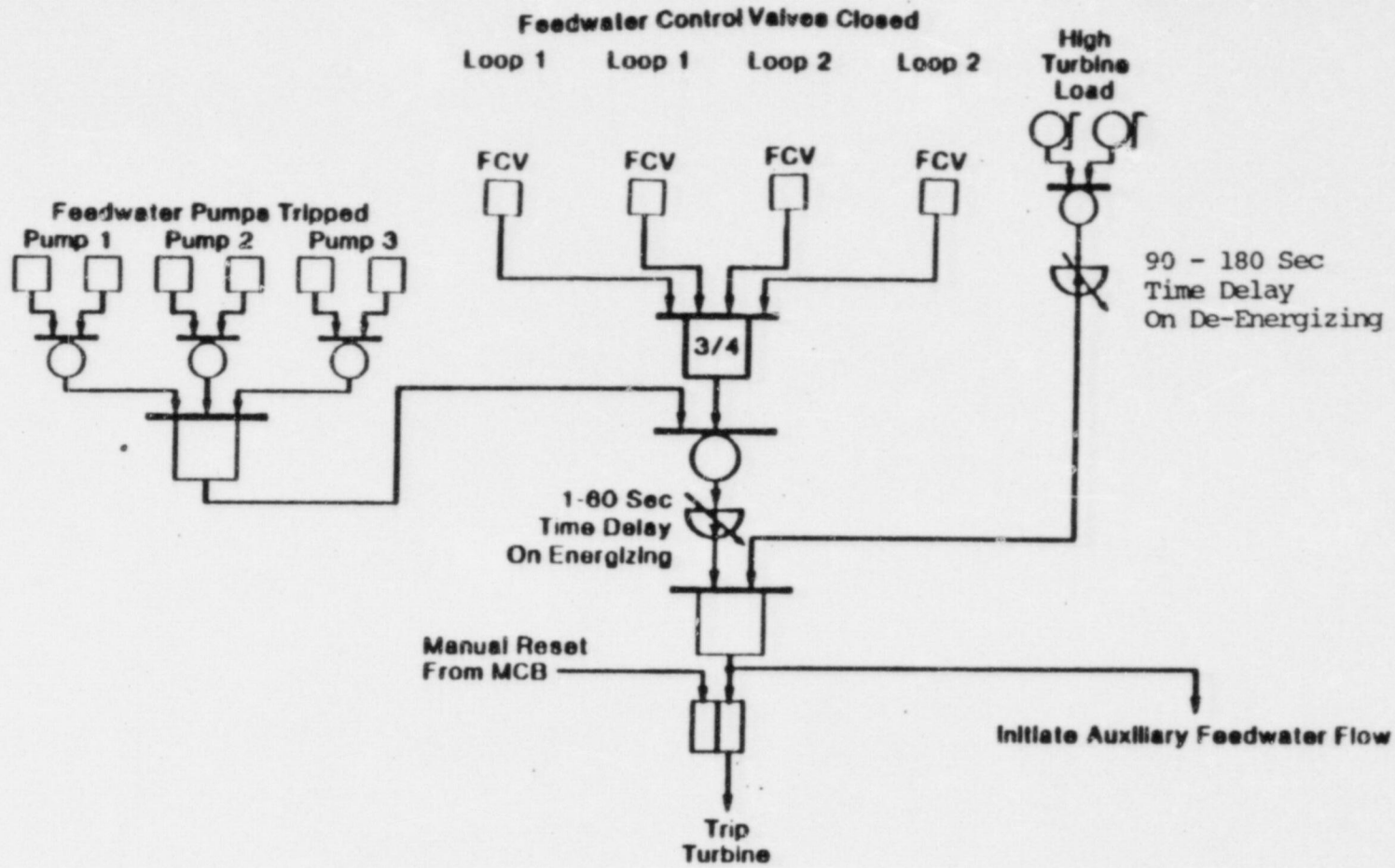
FIGURE 3 - 4



LOGIC DIAGRAM-FEEDWATER PUMP AND VALVE STATUS

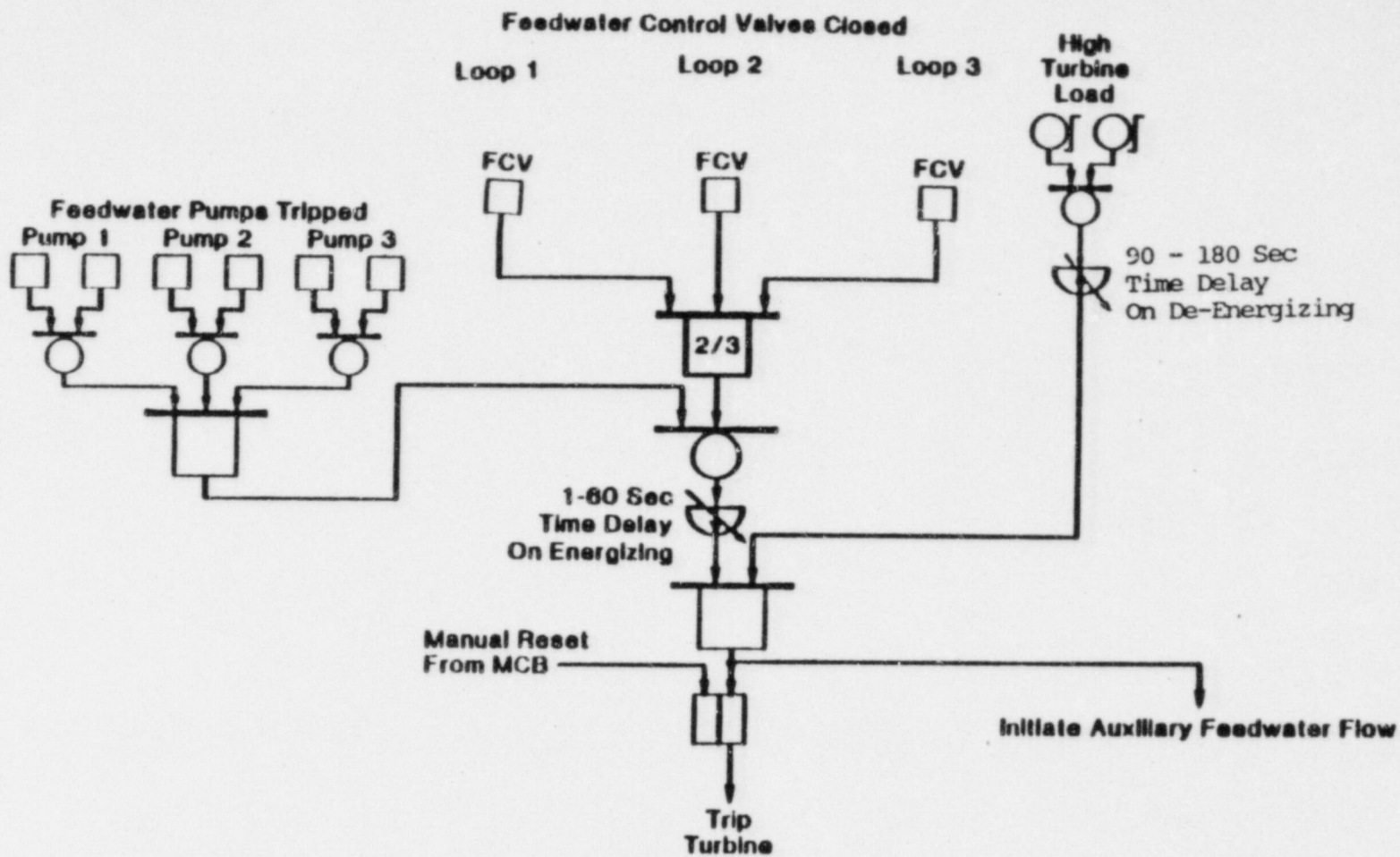
300 123700 006

FIGURE 3-5



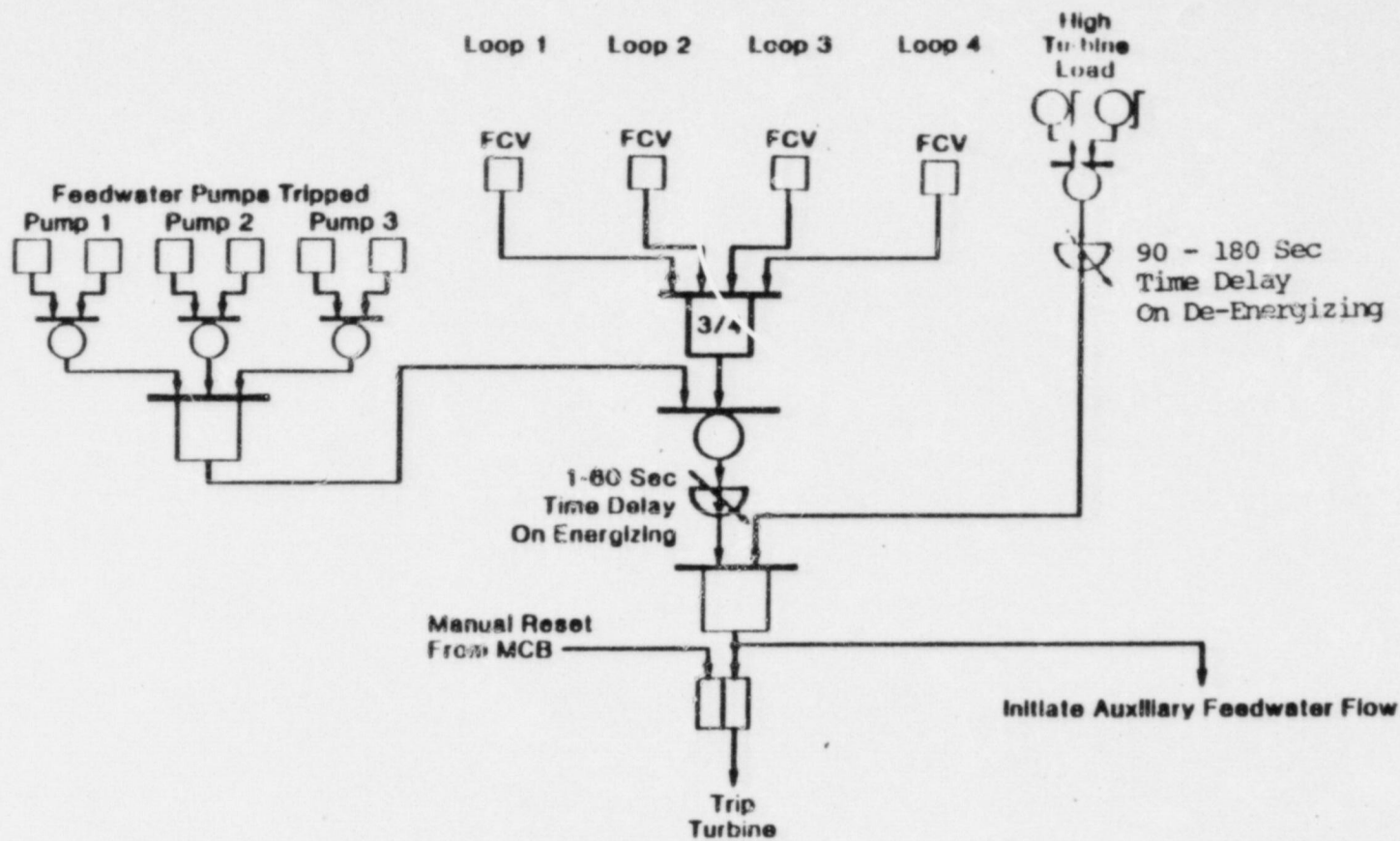
LOGIC DIAGRAM-FEEDWATER PUMP AND VALVE STATUS

FIGURE 3 - 6



LOGIC DIAGRAM-FEEDWATER PUMP AND VALVE STATUS

FIGURE 3 - 7



LOGIC DIAGRAM-FEEDWATER PUMP AND VALVE STATUS