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BABCOCK & WILCOX
NUCLEAR POWER GENERATION DIVISION

TECHNICAL DOCUMENT

SYSTEM DESCRIPTION

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for

AUXILIARY FEEDWATER SYSTEM

FOR

SACRAMENTO MUNICIPAL UTILITY DISTRICT

RANCHO SECO

BABCOCK & WILCOX
NUCLEAR POWER GENERATION DIVISION

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1.0 SCOPE

This document contains the system description for auxiliary feedwater (AFW). The requirements for this system come from three sources - first, the functional requirements needed to properly interface the AFW system with the nuclear steam supply system (NSSS); second, NUREG-0578, Short Term Lessons Learned Report; third, NUREG-0667, Transient Response of B&W Designed Reactors. This document contains the criteria necessary to upgrade the AFW system to comply with the Standard Review Plan Section 10.4.9, Branch Technical Position ASB10-1 and other standards generally applied to new designs. In (03) implementing these requirements, some exceptions may be taken where the improvement in system reliability is so small that the required modification is not justified for an operating plant. Note that "feedwater", as used in this document, refers to AFW unless otherwise stated.

2.0 SYSTEM REQUIREMENTS

The AFW system requirements are listed below. (01)

2.1 NSS Interface Requirements

2.1.1 Maximum Feedwater Flow

The maximum allowable FW flow is 1800 gpm per steam generator (SG). (03) This maximum FW flow limit is required to minimize flow induced vibration of the steam generator tubes. This limit must not be exceeded at any steam pressure.

2.1.2 Minimum Available Feedwater Flow

The AFW system must be sized so that a minimum of 760 gpm (total) (02) can be delivered to either one or both SGs at a SG pressure of 1050 psig. This flow must be available for all accident conditions considered in the design basis for the plant even with a single active failure in the system.

2.1.3 Maximum Automatic Initiation Time

The system shall be designed so that the minimum AFW flow is established within 70 seconds after an initiation signal is (03) reached. This initiation time is based on the requirements to:

A. Maintain continuity in reactor coolant system (RCS) flow in the transition from forced to natural circulation when the RC pumps (RCPs) are tripped.

B. Provide margin to prevent overpressurization of the RCS fol- (02) lowing a loss of main FW event and reactor trip.

And the desirability of: (02)

C. Reducing the probability of boil off of the entire inventory of water immediately following a loss of main FW occurrence. (03)

2.1.4 Initiation and Control Requirements

2.1.4.1 General Requirements

The requirements to which the AFW control system shall be designed are:

A. The system shall provide automatic actuation of AFW, for the conditions specified in Section 2.1.4.2. The capability for bypassing certain initiations shall be provided for unit startup or shutdown in accordance with the IEEE-279 provisions for shutdown bypasses.

B. The system shall be designed to minimize overcooling following a loss of main FW event. This feature of the system is not required to meet the single failure criterion.

C The system, including control valve positioners, sensors, control and actuation signals and their auxiliary supporting systems, shall be designed as a safety grade (1E) system to the extent possible. As such, it shall be independent of the ICS, NNI, and other non-safety systems.

D. Redundancy and testability shall be provided to enhance the reliability demanded of a safety grade system.

E. A single failure shall neither prevent actuation of AFW when required nor spuriously actuate the system. This criterion shall apply to the AFW system and its auxiliary supporting features. In addition to this single failure, all failures which can be predicted as a condition or a result of the initiating event requiring AFW shall be considered. (03)

F. Indication of AFW operational availability, flowrate and OTSG level shall be available to the operator. (03)

G. The capability for a manual override of the automatic functioning of the system shall be provided. This condition shall be annunciated in the control room. (03)

H. The capability for manual initiation of AFW shall be provided. (03)

I. The capability for manual initiation and control of AFW shall be provided in the main control room. The capability for future installation of control from a remote shutdown panel shall be provided in the initiation and control system. (03)

J. The system shall be designed to prevent or minimize cycling of the AFW control valves during normal plant operation when the AFW system is not in operation. (03)

K. The system shall provide the capability to control the atmospheric dump valves to a single, predetermined setpoint and in addition shall have manual override capability.

L. Deleted. (03)

2.1.4.2 Actuation Requirements

AFW shall be automatically initiated after the occurrence of any of the following conditions:

- o Loss of main feedwater flow as indicated by the reactor power/MFW flow reactor trip. (03)
- o Low level in either steam generator. (03)
- o Loss of all 4 reactor coolant pumps. (03)
- o Low pressure in either SG if main FW is isolated on this parameter. (03)
- o SFAS ECCS actuation (high RB pressure or low RC pressure). (03)

2.1.4.3 OTSG Level* Control Requirements (03)

Three level setpoints are required.

A. Following AFW actuation, the level setpoint shall be automatically selected to control OTSG level to approximately 3 feet if one or more RCPs are running.

B. Following AFW actuation, if all four reactor coolant pumps are not running, the level setpoint shall be automatically selected to a level sufficiently high to assure natural circulation within the RCS. This setpoint shall be at least 20 feet.

C. Provision for manual selection of a high level setpoint of approximately 31.5 feet shall be provided. This setpoint will be selected by the operator in accordance with operating guidelines and is intended for use during small break loss of coolant accidents.

*For the purpose of AFW design, "LEVEL" refers to the equivalent height of a saturated liquid column referenced from the top of the lower tube sheet.

2.1.4.4 Fillrate Requirement (03)

The objective of the fillrate control is to minimize overcooling for low DH conditions. The AFW flow rate is controlled by the rate of level increase. A level of 2 to 8 inches per minute has been estimated to provide adequate RCS cooling. This fill rate is varied as a function of steam generator pressure in the range of 800 to 1050 psig for the transient conditions which require AFW. Fillrate control is not necessary for the RC pumps running level setpoint.

The level rate limit shall have the capability to be adjusted locally under administrative control.

In operation, the AFW flowrate is modulated to hold the level fill rate or level at the desired value.

2.1.5 Steamline Break/Feedwater Line Break (03)

A steamline break or feedwater line break that depressurizes a SG shall cause the isolation of the main FW line on the depressurized SG. AFW shall be automatically supplied in accordance with the following SG selection logic.

To meet these requirements the following design shall be implemented: (03)

A. Isolation - Low steam pressure (below approximately 600 psig) in either SG will isolate the main feedwater line to the affected SG(s).

B. SG Selection Logic -

- If both SGs are above 600 psig, supply AFW to both SGs.
- If one SG is below 600 psig, supply AFW to the other SG.
- If both SGs are below 600 psig but the pressure difference between the two SGs exceeds a fixed setpoint (approximately 100 psig) supply AFW only to the SG with the higher pressure.
- If both SGs are below 600 psig and the pressure difference is less than the fixed setpoint, supply AFW to both SGs. (01)

2.1.6 Steam Generator Overfill

Provisions must be made in the design to terminate a main feedwater overfill condition. The steam generator overfill setpoint should be high enough to prevent spurious tripping of this function (and subsequent MFW isolation) during normal operation, however, it must also be low enough to minimize the effects of the overfill. (03)

2.2 Fluid System Requirements

2.2.1 Branch Technical Position ASB10-1 (03)

BTP ASB10-1 places the following requirements on the AFW system:

A. The auxiliary FW system should consist of at least two full capacity, independent systems that include diverse power sources.

B. Other powered components of the auxiliary FW system should also use the concept of separate and multiple sources of motive energy. An example of the required diversity would be two separate auxiliary FW trains, each capable of removing the afterheat load of the reactor system, having one separate train powered from either of two AC sources and the other train wholly powered by steam and DC electric power. (03)

C. The piping arrangement, both intake and discharge, for each train should be designed to permit the pumps to supply FW to any combination of SGs. This arrangement should take into account pipe failure, active component failure, power supply failure, or control system failure that could prevent system function. One arrangement that would be acceptable is crossover piping containing valves that can be operated by remote manual control from the control room, using the power diversity principle for the valve operators and actuation systems. (03)

D. The auxiliary FW system should be designed with suitable redundancy to offset the consequences of any single active component failure; however, each train need not contain redundant active components.

E. When considering a high energy line break, the system should be so arranged as to assure the capability to supply necessary auxiliary FW to the SG despite the postulated rupture of any high energy section of the system, assuming a concurrent single active failure.

NOTE: If the AFW system is not used (and therefore not pressurized) during startup, hot standby and shutdown conditions, then a high energy line break in the AFW system only needs to be considered between the SG and the first check valve upstream of the SG.

2.2.2 Water Sources

Seismic Category I water sources shall be provided of sufficient volume to remove decay heat for four hours and to subsequently cooldown the plant to the decay heat removal (DHR) system pressure.

2.2.3 AFW Pump Protection

The system design shall protect the AFW pump from runout and cavitation due to high energy line breaks or single failures in the system. Any automatic pump trip features must (a) not override automatic initiation of AFW, or (b) be designed as a Class 1E system. (03)

2.2.4 AFW Support Systems

The requirements for diverse power sources and operation with a single failure also apply to the AFW support systems. These systems include:

- Electrical power to support systems.
- Compressed air for AFW control valves. (03)
- HVAC as applicable. (03)

2.2.5 Cross Connects (01)

AFW system shall be designed to allow either pump to feed either steam generator. Cross connects provided for this purpose shall include normally open remotely operated isolation valves.

2.2.6 Alarms

As a minimum, the following alarm outputs are required:

- High SG level. (For SG A and SG B) (02)
- Low SG level. (For SG A and SG B) (02)
- Low condensate storage tank level (03)
- Low AFW pump discharge pressure. (For Pump P-318 and Pump P-319) (02)
- Low AFW pump suction pressure. (For Pump P-318 and Pump P-319) (02)
- Steam line valves HV-20569 and/or HV-20596 not open. (03)
- AFW cross connect valves HV-31826 and HV-31827 not open.
- High flow through full flow test line (as indicated on flow indicator FI-31850). (03)

2.2.7 Indication

As a minimum, the following indication shall be available to the operator. (03)

- o AFW flow to each SG.
- o Low range SG level, 4 channels (For SG A and SG B) (03)
- o Wide range SG level, 4 channels (For SG A and SG B) (03)
- o Key valve positions.**
- o Condensate storage tank level. (03)
- o Control system status (level setpoint selected).
- o Steam pressure of each SG. (03)
- o AFW pump status indication.*** (02)
- o Indications needed to check the status of AFW support systems.
- o Status of the EFIC system. (03)

**Direct position indication shall be provided for all automatically operated valves and all remote manual power operated valves. Local manual valves in the flow path shall be locked open and alarmed if not open. Strict administrative control should be exercised over the use of these valves. (03)

***A specific measurable parameter of AFW pump status shall be used (e.g., pump speed, current draw (amps), pump differential head, etc). (02) (03)

2.2.8 Physical Separation

System components and piping shall have sufficient physical separation or shielding to protect the essential portions of the system from the effects of internally and externally generated missiles. (03)

Functional capability of the system shall also be assured for fires and the maximum probable flood.

2.2.9 Fluid Flow Instabilities

The system design shall preclude the occurrence of fluid flow instabilities; e.g., water hammer in system piping during normal plant operation or during upset or accident conditions. (03)

2.2.10 Operational Testing

Provisions shall be made to allow periodic operations testing.

2.2.11 Water Chemistry

The requirements of the B&W Water Chemistry Manual, BAW-1385, shall be met. The normal water source shall meet the requirements in Table 2-1. (02) (03)

2.3 Codes and Standards

The AFW system shall consider the requirements of the following: (03)

A. General Design Criterion 2*, Design Bases for Protection Against Natural Phenomena, as related to structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods.

B. General Design Criterion 4*, Environmental and Missile Design Bases, with respect to structures housing the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces assocated with pipe breaks. (03)

C. General Design Criterion 5*, Sharing of Structures, Systems and Components, as related to the capability of shared systems and components important to safety to perform required safety functions. (03)

D. General Design Criterion 19*, Control Room, as related to the design capability of system instrumentation and controls for prompt hot shutdown of the reactor and potential capability for subsequent cold shutdown.

E. General Design Criterion 44*, Cooling Water, to assure:

  (1) The capability to transfer heat loads from the reactor system to a heat sink under both normal operating and accident conditions.

  (2) Redundancy of components so that under accident conditions the safety function can be performed assuming a single active component failure. (This may be coincident with the loss of offsite power for certain events).

  (3) The capability to isolate components, subsystems, or piping if required so that the system safety function will be maintained. (03)

F. General Design Criterion 45*, Inspection of Cooling Water System, as related to design provisions made to permit periodic inservice inspection of system components and equipment.

G. General Design Criterion 46*, Testing of Cooling Water System, as related to design provisions made to permit appropriate functional testing of the system and components to assure structural integrity and leak-tightness, operability and performance of active components, and capability of the integrated system to function as intended during normal, shutdown, and accident conditions. (03)

H. NRC Documents (03)

NUREG-0800	Standard Review Plan
NUREG-0578	Short Term Lessons Learned Report
NUREG-0667	Transient Response of B&W Designed Reactors

I. IEEE Standards

279-1971	Criteria for Protection Systems for Nuclear Power Generating Stations (for initiation portions of AFW System)	(03)
323-1971	General Guide for Qualifying Class I Electrical Equipment	(03)
344-1971	Seismic Qualification of Class 1E Electrical Equipment	(03)

TABLE 2-1

OTSG Emergency Feedwater Chemistry Requirements

pH at 77F	Same as normal requirement[a]	
Dissolved oxygen (O_2)		(03)
OTSG at < 250F	No requirement (see hydrazine)	
OTSG at > 250F		
Upset	100 ppb max for a period not to exceed 1 week	(03)
Total iron	100 ppb max	
Hydrazine Catalyzed hydrazine		
OTSG at < 250F	Added to at least 300% of stoichometric oxygen concentration	
OTSG at > 250F	20-100 ppb residual	
Cation Conductivity	1.0 mho/cm, max for a period not to exceed 24 hours	

[a] 8.5-9.3 at 77F - Austenitic stainless steel feedwater heater tubes and stainless steel or copper-nickel reheater tubes.

9.3-9.5 at 77F - Carbon steel feedwater heater tubes or combinations of carbon steel and stainless steel feedwater and/or reheater tubes.

3.0 DESIGN DESCRIPTION

3.1 Summary Description

The AFW system consists of two interconnected trains capable of supplying auxiliary feedwater (AFW) to either or both SG's by automatic or manual initiation and control. The normal source of water is the condensate storage tank, however the Folsom South Canal and the on-site reservoir are also available as secondary sources. A piping and instrumentation diagram is included as Figure 3.1-1 of this report. (03)

In the flow path between the AFW pumps and the SGs there are isolation valves, check valves, control valves, flow instrumentation, and pressure instrumentation to control and monitor the flow of AFW to the SGs. The fluid system design is described in Section 3.2. The instrumentation system design is described in Section 3.4. (03)

3.2 Fluid System Design

The AFW system is designed to provide a minimum of 760 gpm of AFW to the SGs at 1050 psig within 70 seconds of system initiation signal. The system is designed as two interconnected trains with redundant components to insure that the system will meet these requirements even with a single failure. Figure 3.1-1 depicts the piping and instrumentation diagram. (01) (03)

3.2.1 Suction

The primary water source for both AFW trains is the Seismic Category I condensate storage tank, T-358. Although there are other connections to this tank, they draw through an internal stand-pipe which assures that a minimum of 250,000 gallons is held in reserve exclusively for the AFW system. This volume of water will remove decay heat (plus RC pump heat for 2 pumps) for approximately 13 hours. This volume will also be sufficient to remove DH plus cooldown to the DHR System in approximately 10.5 hours. Water is supplied from this tank to the AFW pumps by separate 8-inch lines containing locked open manual valves MCM-057, MCM-058, FWS-045, FWS-046, and check valves MCM-059 and MCM-060. (03)

Alternative AFW system suction sources are available from the on-site reservoir and the Folsom South Canal. These alternate sources enter the cross connect in the suction piping between locked closed manual valves PWC-076 and PWC-079. Suction must be manually transferred from the condensate storage tank to the reservoir or the Folsom South Canal by opening the locked closed manual valves PWC-076 and PWC-079, closing the locked open manual valves MCM-057 and MCM-058, and either:

(1) operating the Folsom South Canal transfer pumps and valves or (2) opening motor operated valve HV-43011 to obtain gravity flow from the on-site reservoir. The suction cross connect also includes pressure relief valves PSV-31800 and PSV-31900. The operators are alerted to perform this suction transfer by redundant, safety-grade low level alarm from the condensate storage tank. In addition, tank level is redundantly indicated in the control room. (03)

3.2.2 Pumps and Discharge Cross-Connect

AFW Train A pump, P-318, is a combination turbine-driven motor-driven pump with both the turbine and electric motor on a common shaft. Either motive source can drive the pump at its rated capacity of 840 gpm at 1150 psig with a normal minimum flow of 60 gpm. The turbine drive is used as the primary motive source for this pump. The motor drive can be manually initiated. (03)

AFW Train B pump, P-319, is a motor-driven pump which has the same rated capacity and minimum flow as the Train A pump. (03)

The pumps discharge through check valves and locked open manual valves into 6-inch cross-connected discharge lines. The cross-connection line contains two normally-open motor-operated valves (HV-31826 and HV-31827). This cross-connect permits either pump to feed either or both steam generators.

3.2.3 Auxiliary Feedwater Flow Control Valves

The flow of AFW to steam generator A is controlled by a normally open pneumatically operated control valve, FV-20527A, in parallel with a normally open modulating solenoid motor operated control valve, FV-20527B. Flow to steam generator B is controlled in a similar manner using valves FV-20528A (pneumatic) and FV-20528B (solenoid). The pneumatic operated valves are equipped with Seismic Class I air accumulators which enable the valves to be operated for up to 2 hours following a loss of the plant air supply to the valves. The solenoid operated valves are DC battery backed. Initiation and control instrumentation is described in Section 3.4 of this report. (03)

3.2.4 Auxiliary Feedwater Isolation Valves

Each steam generator can be isolated from AFW flow by normally-closed motor-operated valves (FV-20577A, FV-20578A, FV-20577B and FV-20578B). These valves are located in the parallel lines downstream of the AFW control valves. Initiation and control instrumentation for these valves is described in Section 3.4 of this report. (03)

3.2.5 Pump Minimum Flow and Test Lines (03)

Minimum flow and test lines are connected to the discharge piping of both pumps. The minimum flow required for pump protection is maintained with normally open flow paths to the condenser. The manual valves FWS-051 and FWS-052 located in the minimum flow lines shall be locked open whenever the secondary coolant system is the primary cooling medium for the RC system.

Full flow test capability is provided through a 6-inch line which intersects the AFW system cross-connect between the two normally open motor-operated valves HV-31826 and HV-31827. This full flow test path is isolated from the cross-connect during normal operation by a normally closed pneumatically operated control valve (FV-31855). Either AFW train can be full-flow tested by opening valve FV-31855 and starting the appropriate AFW pump. The full capability of both AFW trains to supply AFW on demand is maintained during the test since either a channel A or B AFW initiation signal will result in automatic closure of valve FV-31855. The AFW system is, therefore, automatically restored to its normal configuration.

3.2.6 Steam Supply for the AFW Turbine (K-308) (03)

Steam supply for the AFW pump P-318 turbine is obtained from both steam generators through six-inch lines containing check valves MSS-051 and MSS-052, locked-open manual valves MSS-049 and MSS-050, and normally-open motor operated valves HV-20569 and HV-20596. The check valve and motor operated valve provide redundant isolation capability to preclude blowing down the good steam generator in the event of steam line or feed line break. Downstream of these valves the lines join to form a common supply to the pump turbine. Upstream of the turbine is a normally closed DC motor operated valve FV-30801. A description of the controls for this valve is contained in Section 3.4.

Turbine exhaust is vented to the atmosphere.

3.2.7 Key Valve Positions

Direct position indication is provided on the following valves. (03)

FV-20527A	FV-31855	FWS-053	FV-20528A	FV-30801	FWS-054
FV-20577A	HV-20569	FWS-119	FV-20578A	HV-20596	FWS-120
FV-20527B	HV-31826	FWS-063	FV-20528B	HV-31827	FWS-064
FV-20595	HV-20560	MCM-057	FV-20575	HV-20565	MCM-058
FV-20529	FV-20515	FV-20526	FV-20516	FV-20576	FWS-046
FV-20530	FWS-045	FV-20577B	FV-20578B		

3.3 Supporting Systems

The AFW system valves and pumps, including pump motors and turbine are self-contained entities without dependencies on secondary support systems. (03)

3.3.1 Electrical Power (03)

The two AFW trains are powered from diverse power sources. AFW pump P-318 is turbine driven with an AC powered back-up motor, and AFW pump P-319 is AC motor driven. Each of the pump motors are powered from a diesel generator backed emergency bus. The following valves required to operate the AFW system are also on AC power with back-up power from a diesel generator: FV-20527A, FV-20528A, FV-20577A, FV-20578A, HV-20569, HV-20596, HV-31826, HV-31827, and FV-31855.

In the highly unlikely event of a loss of all AC power, the turbine driven AFW pump train derives its power from the steam generators for the pump and from a battery backed DC bus for its steam supply valve. Valves FV-20527B, FV-20528B, FV-30801, FV-20577B, FV-20578B and flow transmitters FT-31802, FT-31803, FT-31902, and FT-31903 require battery backed DC power. Power distribution and separation is shown in Figures 3.3-1 and 3.3-2.

3.3.2 Service Air

The normal air supply to the AFW flow control valves, FV-20527A and FV-20528A, is provided by the plant air system. In the event that the air supply to these valves is interrupted or lost, an accumulator tank will provide air to the valve operator so that valve operation will continue for at least 2 hours. (03)

3.4 AFW Initiation and Control System Description (03)

It should be noted that all setpoints and values used in the following discussion are approximate and are given for purposes of illustration. (01)

The emergency feed water initiation and control system (EFIC) is an instrumentation system designed to provide the following: (03)

1. Initiation of auxiliary feedwater (AFW),

2. Control of AFW flow to maintain steam generator level at appropriate setpoints. (03)

3. Level rate control when required to minimize overcooling,

4. Isolation of the main feedwater lines of a depressurized steam generator, (03)

5. The selection of AFW flow to the appropriate steam generator(s) under conditions of steamline break or main feedwater or emergency feedwater line break downstream of the last check valve. (03)

6. Termination of main feedwater to a steam generator on approach to overfill conditions,

7. Control of atmospheric dump valves to minimize challenges to the main steam safety valves and to allow a cooldown controlled from the main control room. (03)

The emergency feed initiation and control system (EFIC) is illustrated in Figures 3.4-1 thru 3.4-9. Figure 3.4-1 illustrates the EFIC organization while the remaining figures illustrate the individual logics that comprise the system. The interface of the EFIC with the secondary plant is illustrated in Figure 3.1-1. (01)

The EFIC - see Figure 3.4-1 - consists of four channels (A,B,C, & D). Each of the four channels are provided with input, initiate, and vector logics. Channels A and B also contain trip logics and control logics.

Each channel monitors inputs by means of the input logic, ascertains whether action should be initiated by means of the initiate logic and determines which SGs should be fed by means of the vector logic.

Channels A and B monitor initiate signals from each of the four initiate logics by means of the trip logics to transmit trip signals when required. Channels A and B also exercise control of emergency feedwater flow to the SG by means of control logics to maintain SG level at prescribed values once AFW has been initiated. In addition, Channels A and B also monitor SG A and B overfill signals originating in the Channel A, B, C and D initiate logics. By means of trip logics, Channels A and B terminate main feedwater to a steam generator that is approaching overfill. Channel A controls the ADV's on the A main steam line. Channel B controls the ADV's on the B main steam line. (03)

3.4.1 Input Logic

The input logic, depicted in Figures 3.4-3a, 3.4-3b, and 3.4-3c is located in each of the channels. The input logic: (01)

1. Receives analog input signals, (01)

2. Provides input buffering as required,

3. Compares analog signals to appropriate setpoints to develop digital signals based on analog values,

4. Provides for the injection of test stimuli,

5. Provides buffered Class 1E signals and isolated non-1E signals, and

6. Provide signals to the remaining channel logic. (02)

3.4.2 Initiate Logic

The initiate logic, depicted in Figure 3.4-4 is located in each channel. The initiate logic derives its inputs from the input logic and provide signals which result in the issuance of trip signals via the trip logics in Channels A and B. (03)

The initiate logic issues a call (to the trip logic) for AFW initiation when: (03)

1. All four RC pumps are tripped.

2. Reactor flux to MFW flow ratio reactor trip is present. (03)

3. The level of either steam generator is low.

4. Either steam generator pressure is low.

5. Deleted. (01)

Other functions of the initiate logic are:

1. Issue a call for SG A main feedwater isolation when SG A pressure is low. (03)

2. Issue a call for SG B main feedwater isolation when SG B pressure is low. (03)

3. Issue a call for MFW isolation of SG A when SG A level exceeds a high level setpoint. (03)

4. Issue a call for MFW isolation of SG B when SG B level exceeds a high level setpoint. (03)

5. Provide for manually initiated shutdown bypassing when permissive conditions exist of "loss of 4 RC pumps", "low SG level", and "low SG pressure" initiation of AFW and "SG overfill terminate". The bypass(es) are automatically removed when the permissive condition terminates. (03)

6. Provide for maintenance bypassing of an EFIC initiate logic.

3.4.3 Trip Logic

The trip logic is illustrated in Figure 3.4-5. The trip logic of the EFIC employs a 2(1-out-of-2) format. This format provides for easy one step testing from input logic test switches to the initiated controllers. Testing is facilitated by locating the AND portion of the 2(1-out-of-2) logic in the controller. A characteristic of coincidence logic systems is that a test stimulus inserted at the input propagates to the first AND element of the system and no further. Since the first AND element of the EFIC is in the controller, test stimuli inserted at the input logic will be propagated to each controller. EFIC testing philosophy is discussed in Section 3.4.6. (03)

The trip logic is provided with five trip networks. These networks monitor the appropriate outputs of the initiate logics in each of the channels. They output a full trip when a [2(1-out-of-2)] network exists in the initiate logic. The trip module outputs signals for: (03)

1. Auxiliary feedwater initiate
2. SG A isolate
3. SG A main feedwater isolate
4. SG B isolate
5. SG B main feedwater isolate

The trip module trip signals are output to the Trip Interface Equipment (TIE) cabinets. The trip interface equipment actuates AFW system components as a result of these signals. The AFW trip module also activates a control/vector enable signal. The actuated components are summarized in Table 3.4-1. (03)

The AFW trip logics are input by Safety Features Actuation System (SFAS) Emergency Core Cooling trip signals to assure that AFW is initiated coincident with Emergency Core Cooling actuation. As shown in Figure 3.4-1, the trip logics are contained in Channels A and B only. (03)

For each trip function, the trip logic is provided with two manual "trip" switches. This affords the operator a means of manually tripping a selected function by depressing both switches. The use of two "trip" switches allows for testing the trip busses and also reduces the possibility of accidental manual initiation. (03)

Once a trip of the trip bus occurs, the trip condition will remain until it is manually reset. A "reset" switch and a "manual" switch are provided for each of the five trips in both channel A and channel B. The "reset" switch is a momentary contact button which allows the operator to clear a trip signal from the trip bus <u>after</u> the initiating conditions have cleared. The "manual" switch is a momentary contact button which allows the operator to clear a full trip signal from the trip busses after the trip has occurred but <u>before</u> the initiating conditions have cleared. This allows the operator to take manual control of EFIC actuated equipment to optimize response to the initiating condition. (03)

Whether cleared by the "reset" or the "manual" switches, the trip signal will be re-established if initiating conditions re-initialize; i.e., if the conditions which caused the trip return to acceptable values and then those conditions (or any others) re-enter a trip region. (03)

Both the "manual" and the "reset" switches are also used in conjunction with the "trip" buttons to test the trip circuits. Each of these buttons are located in the main control room. (03)

Trip signals are transmitted out of the EFIC by activating a solid state relay, thereby gating power onto the trip busses. In this manner, the EFIC provides power to energize the control relays in the trip interface equipment (TIE) whose contacts form the AND gates in the controllers. The TIE also provides signals to the EFIC in response to half trip conditions for test purposes. (03)

3.4.4 Vector Logic

The vector logic - Figure 3.4-6 - appears in each of the EFIC channels - Figure 3.4-1. The vector logic monitors:

1. SG pressure signals,
2. SG (A and B) overfill signals, and
3. AFW control/vector enable originating in Channel A and B trip logics. (03)

The vector logic develops signals for open/close control of steam generator A and B auxiliary feedwater valves. (03)

The vector logic outputs are in a neutral state until enabled by the control/vector enable from the channel A or B trip logics. When enabled, the channel A vector logic can issue close commands to valves FV-20527A and FV-20528A. Channel B can issue close commands to FV-20527B and FV-20528B. Channel C can issue open or close commands to FV-20577A and FV-20578A. Channel D can issue open or close commands to FV-20577B and FV-20578B. (03)

The valve open/close commands are determined by the relative values of steam generator pressures as follows: (03)

Pressure Status	SG A Valve Command	SG B Valve Command	
SG A & B > Setpoint	Open	Open	
SG A > Setpoint & SG B < Setpoint	Open	Close	
SG A < Setpoint & SG B > Setpoint	Close	Open	
SG A < Setpoint & SG B < Setpoint and SG A & B within 100 psid	Open	Open	(03)
SG A 100 psid > SG B	Open	Close	(03)
SG B 100 psid > SG A	Close	Open	(03)

3.4.5 Control Logic

The control logic is shown in Figure 3.4-2. (03)

Control logic is located in EFIC channels A and B only. The control logic in channel A controls pressure to steam generator A and level in steam generators A and B. Likewise, the control logic in channel B controls pressure in steam generator B and level in steam generators A and B. (03)

3.4.5.1 Steam Generator Pressure Control (03)

The control logic in EFIC channel A receives steam generator A pressure from pressure transmitter PT-20544A. If this pressure exceeds approximately 1020 psig, EFIC A channel sends a control signal to open the three atmospheric dump valves connected to the A main steam line (PV-20571A, PV-20571B, PV-20571C). This setpoint is higher than the ICS controlled turbine bypass valve setpoint, but lower than the set-pressure of the main steam safety valves. Thus, it allows the ICS to control pressure if possible, but minimizes challenges to the MSSV's. It would also remain fully functional even if the ICS were not available to control pressure.

Provision is available in the control room to manually control the ADV's. This allows their use in cooling the RCS without the aid of the ICS. (03)

EFIC channel B control logic controls pressure in steam generator B in a similar fashion. However, it receives steam generator B pressure from pressure transmitter PT-20545B and controls the three atmospheric dump valves connected to the B main steam line (PV-20562A, PV-20562B, PV-20562C). (03)

Channel A and Channel B pressure control logic is functional at all times, regardless of the initiate state of EFIC. (03)

3.4.5.2 Steam Generator Level Control (03)

If the AFW system is initiated with one or more Reactor Coolant Pumps running, the level control logic in EFIC channel A will be "enabled" by a signal from the A and/or B channel trip logic and will send control signals to AFW flow control valves FV-20527A and FV-20528A (feeding steam generators A and B respectively) to maintain a level of approximately 3 feet.

If all four of the Reactor Coolant Pumps are not running, the control logic in channel A will automatically select a level setpoint high enough to assure good natural circulation characteristics in the RCS. The natural circulation setpoint is greater than 20 feet. To minimize overcooling effects on the RCS while filling to this higher level, the level control employs a level "rate of increase" control which uses steam generator pressure as a feedback parameter. In this way, the rate of level increase is controlled such that it will not rise faster than approximately 8 inches per minute if the steam pressure maintains 1050 psig or greater. This rate of increase would decrease linearly with decreasing steam pressure to a value not to exceed approximately 2 inches per minute at a steam pressure of 800 psig or below.

Regardless of which level setpoint has been automatically selected by EFIC, after initiation of AFW the operator can select a high level setpoint of approximately 31.5 feet by pushing a single button in the Control Room. This option is intended for use during some LOCAs, and utilizes the same rate of fill limits as the natural circulation setpoint.

Level control logic in EFIC channel B, controls level in both steam generator A and B in a similar fashion. Channel B controls AFW flow control valves FV-20527B and FV-20528B.

Manual control of AFW flow control valves from the Control Room is also possible. However, initiation or re-initiation of AFW will automatically revert control to EFIC.

3.4.6 EFIC Trip Testing

Figure 3.4-7 illustrates the trip philosophy of the EFIC in simplified form for one EFIC trip function (e.g., AFW initiate trip). For purposes of the following discussion, the test pushbuttons associated with each bistable are capable of forcing the bistable input into the trip region. The bistables employ a low dead band so the bistable will reset once the pushbutton is released. (03)

Complete trip testing (input to controllers) may be initiated from the input logic bistable module in each of the channels. Depressing the pushbutton in Channel A will trip the Channel A bistable and: (03)

1. The Channel A initiate logic will transmit initiate signals to both the Channel A and B trip logics.

2. The Channel A and B trip logics will half trip (trip one of the two trip busses).

3. The Channel A and B trip logics will latch in the half trip. The half trip will be retained after reset of the bistable. This tests the latching circuit.

4. Each controller receiving the half trip will acknowledge the half trip by transmitting a test confirmation signal assuming all controllers are functioning properly.

5. A full complement of test confirm signals will satisfy the AND gate in both Channel A and B. The result is that the confirm lamps will indicate test success.

6. The trip logic reset switches can now be depressed to reset the half trip. The confirm lamp should go out. (03)

7. If some, but not all, controllers were to respond due to a malfunction, the confirm lamp will flash. (03)

8. The foregoing tests may be conducted from each channel in turn to test the ability to transmit trips from all channels.

9. The foregoing tests may be conducted for all trip functions from all channels for complete trip testing.

10. Tests as described above may also be conducted by use of the local and remote manual trip and reset switches.

NOTE: The utilization of one out-of-two taken twice logic allows for for foregoing test philosophy while minimizing the probability of inadvertent initiation. (02)

3.4.7 EFIC Signal Application

Figure 3.1-1 illustrates the application of EFIC signals to a simplified auxiliary feedwater system. Salient features of the arrangement are:

1. The channel B AFW trip signal starts the electric emergency feedwater pump, P-319. The Channel A trip signal admits steam to the turbine powered auxiliary feedwater pump, P-318. With this arrangement, at least one pump will be started even with a single failure of the A or B trip logics. (03) (02)

   Also, given a failure of channel A, B, C, or D initiate logics, both pumps will be started due to the 2(1-out-of-2) character of the trip logic. The cross-connect between the discharges of the two auxiliary feedwater pumps allows either pump to supply feedwater to both SGs.

2. If the initiating event is low SG pressure in SG A, AFW will be initiated as in 1 above. In addition, the trip logics in channels A and B will issue SG A main feedwater isolation trip signals. The channel A and B trip logics will redundantly isolate SG A main feedwater. With the occurrence of low pressure in SG A, main feedwater to that generator will be terminated even in the presence of a single failure. (03)

3. Isolation of SG B main feedwater lines occurs in the same way as described in 2 above for SG A except that the channel A and B SG B main feedwater trip logics are employed.

4. Given the condition where both SG pressures are low, MFW to both SG's is terminated. (03)

5. The auxiliary feedwater path to each SG consists of parallel control valves and parallel isolation valves. This allows feeding when required in the presence of a single valve failure. It also allows closure of the flow path when required in the presence of a single failure. Since each of the four valves receives vector close signals from different channels, the path will be closed when required by the vector logics in the presence of the failure of a single vector logic.

   In the open direction, the isolation valves receive open vector commands, from channels C and D, when feeding of the SG is required. The control valves, under these conditions will open as dictated by the control logics in channels A and B. In this way, a generator will be fed when required in the presence of a failure of channel A, B, C, or D.

3.4.8 OTSG Level Sensing

Figure 3.4-8 contains the arrangement for OTSG level sensing. Allowable instrument error requirements are given in Appendix B. (03)

To provide for low level control and low level initiation signals for the auxiliary feedwater, four level transmitters (dP transmitters) are used. The sensing lines for these transmitters will be connected between level taps located 156 inches above the top face of the lower tube sheet and to level taps at 6 inches above the top face of the lower tube sheet. (03)

To provide high level control and overfill protection signals, four level transmitters will be used. The upper sensing connections will be taps at 619 inches above the top face of the lower tube sheet. The lower sensor connections will be at 6 inches above the top face of the lower tube sheet. (03)

3.4.9 Interface with Valve and Pump Controllers

All valve and pump controllers shall be designed such that signals from the EFIC system will override any other control signals. Also, when an EFIC trip signal is placed in manual or is reset, the controller design shall be such that valves will not change position and pumps will not change state without a specific manual command. When the vector logic close command to the AFW control valve is removed, the control valve shall be positioned as required by the AFW control system or the manual control as selected. (03)

3.5 Main Feedwater Overfill Termination (02)

The EFIC System, as described in Section 3.4, is designed to provide signals for termination of main feedwater to a steam generator on approach to an overfill condition. Implementation of main feedwater overfill termination is accomplished by actuation of components in the main feedwater system. Upon approach of an overfill condition in either steam generator, the EFIC channel B "main feedwater isolation" trip signal will be used to stop main feedwater by closing FV-20515 for isolation of steam generator "A", or closing FV-20516 for isolation of steam generator "B". The EFIC Channel A "main feedwater isolation" trip signal will also be used to stop main feedwater by closing the main feedwater control valve (FV-20595), the startup feedwater valve (FV-20575), and the main feedwater block valve (FV-20529) for isolation of steam generator "A" or main feedwater control valve (FV-20526), the startup feedwater valve (FV-20576), and the main feedwater block valve (FV-20530) for isolation of steam generator "B". The steam generator overfill setpoint, as described in Section 4.2.5, is given in Table 4.2-1. (03)

4.0 SYSTEM LIMITS, PRECAUTIONS AND SETPOINTS

4.1 Limits and Precautions

4.1.1 AFW Flow Limits

Maximum allowable flow -	1800 gpm/SG	(03)
Minimum required flow -	760 gpm	(03)

4.1.2 Deleted. (01)

4.1.3 AFW Pump Suction Pressure

P-318 minimum required NPSH -	18 feet at 840 gpm, 28 feet at 1200 gpm	(03)
P-319 minimum required NPSH -	18 feet at 840 gpm, 28 feet at 1200 gpm	(03)

4.1.4 System Limits (Design)

Pressure -	1310 psig	(03)
Temperature -	115 F	(03)

4.1.5 Minimum Required Pump Flow (03)

P-318 -	60 gpm*
P-319 -	60 gpm*

*Actual pump minimum flow is 88 gpm at 1235 psid across orifice.

4.2 Setpoints (01)

All setpoints given in this section and defined as "nominal" are instrument calibration points. Instrument string errors as defined in Appendix B were used in the analyses to determine the conservative maximum and minimum setpoint values. The maximum and minimum setpoints represent the earliest and latest assumed actuation point for use in analysis.

For the purpose of this discussion, "Level" refers to the equivalent height of a saturated water column referenced from the top of the lower tube sheet. (03)

4.2.1 Flux to Feedwater Ratio Setpoint (03)

The flux to feedwater ratio setpoint is shown on Figure 4.2-1. This setpoint was developed as an anticipatory trip for loss of feedwater events. The equation used for this setpoint and the errors and delay times are also shown on Figure 4.2-1. This trip function is located in the RPS and is used to trip the reactor. An output from the RPS will feed the EFIC to initiate AFW.

4.2.2 Low SG Level AFW Initiate Setpoint (03)

This is a protective setpoint designed to initiate AFW flow to a steam generator following loss of main feedwater flow. The low range level instrumentation is used to monitor low level in the steam generators. For setpoints see Table 4.2-1.

4.2.3 AFW Control Level Setpoint (03)

This is a level control setpoint designed to be automatically selected following initiation of AFW if one or more reactor coolant pumps are providing forced circulation. The low range level instrumentation is used to monitor steam generator level at this point and to provide signals to the EFIC control system. For setpoints see Table 4.2-1.

4.2.4 Natural Circulation Control Level Setpoint (03)

This is a level control setpoint designed to be automatically selected following initiation of AFW if all four reactor coolant pumps are tripped. For 177 FA plants, 20 feet of steam generator level provides a thermal center in the steam generator at a higher elevation than that of the reactor. Controlling steam generator level at a minimum level of 20 feet insures natural circulation of the reactor coolant system fluid. The wide range level instrumentation is used to monitor steam generator level at this point and to provide signals to the EFIC control system. For setpoints see Table 4.2-1.

4.2.5 Steam Generator Overfill Setpoint (03)

This is a protective setpoint designed to automatically terminate main feedwater flow to a steam generator. This setpoint is provided to minimize the effects of overcooling and/or moisture carryover following an unacceptable increase in SG level. The wide range level instrumentation is used to monitor SG level at this point. For setpoints see Table 4.2-1.

4.2.6 ECCS Fill Limit Setpoint (03)

This is a level control setpoint designed to be manually selected following a LOCA. This setpoint will establish a steam generator feedwater level which will support steam condensation natural circulation. The wide range level instrumentation is used to monitor steam generator level in this region. For setpoints see Table 4.2-1.

4.2.7 Low Steam Generator Pressure Setpoint (03)

This is a pressure setpoint designed to initiate AFW and to automatically isolate the main feedwater lines to the affected steam generator. This setpoint will isolate main feedwater to the steam generator only if one steam generator is affected. Feedwater to the other steam generator will not be isolated. If both steam generators are below this setpoint the EFIC system will initiate AFW and terminate MFW to both SGs. Pressure instrumentation string requirements are given in Appendix B. For setpoints see Table 4.2-1.

4.2.8 Steam Generator Differential Pressure Setpoint (03)

If both SGs are below the low SG pressure setpoint, the differential pressure setpoint will automatically determine, by comparing the difference in steam generator pressures, which steam generator is to be isolated and which steam generator is to be fed with AFW. Pressure instrumentation string requirements are given in Appendix B. For setpoints see Table 4.2-1.

4.2.9 Atmospheric Dump Valve Operating Setpoint (03)

This is a pressure setpoint designed to automatically open the atmospheric dump valves to relieve steam generator pressure. This setpoint is higher than the ICS setpoint for TBV's but is lower than the lowest main steam relief valve lift point and will therefore decrease the frequency of challenges to the relief valves. The control system provides the operator with the capability to manually override this setpoint. Pressure instrumentation string requirements are given in Appendix B. For setpoints see Table 4.2-1.

5.0 OPERATION (03)

The AFW is in a standby mode during normal power operation. Manual action will be required to remove and initiate bypass features of the EFIC system during various modes of operation. The system design will permit bypassing of four EFIC functions when steam generator A and B pressures are both below a single permissive setpoint of 750 psig. Those functions are steam generator low pressure AFW initiate, all four RC pumps tripped AFW initiate, steam generator low level AFW initiate, and steam generator overfill terminate. All four functions will be capable of being bypassed via a single "EFIC Shutdown Bypass" switch in each channel. Automatic reset of all four trip functions will occur if they are in bypass and either steam generator A or B pressure exceeds 750 psig.

5.1 Heatup from Cold Shutdown to Hot Standby

Before heating up from cold shutdown, the operator should verify the status of the EFIC. All signals should be bypassed. The reactor power/MFW flow trip does not have an explicit bypass. However, this trip will allow the plant to go to approximately 20% power with no MFW flow and, therefore, this trip is effectively bypassed. As heatup progresses the four functions of SG low pressure AFW initiate, all four RCP's tripped AFW initiate, SG low level AFW initiate, and SG overfill terminate will automatically reset when either steam generator A or B pressure exceeds 750 psig. (03)

5.2 Hot Standby to Full Power

At hot standby conditions, all trip functions should be active except the reactor power/MFW flow AFW initiate. As power is increased, the reactor power/MFW flow trip will automatically become active at about 20% power. The logic for this function is lcoated in the NI/RPS. No operator actions are required.

Conversely, when reducing power from full power to hot standby, no operator actions are required. The reactor power/MFW flow reactor trip will be effectively bypassed when power is reduced below approximately 20%.

5.3 Cooldown from Hot Standby to Cold Shutdown

During the cooldown, four EFIC functions must be manually bypassed. These functions are SG low pressure AFW initiate, all four RC pumps tripped AFW initiate, SG low level AFW initiate, and SG overfill terminate. When both steam generators are below 750 psig these functions may be bypassed via a single "EFIC Shutdown Bypass" in each of the four channels. The bypass switches are located in the main control room. Action to bypass these functions must be taken before either steam generator pressure reaches 600 psig.

6.0 Casualty Events and Recovery Procedures (02)

6.1 Casualty Events

As part of the design of the AFW system, consideration was given to handling the following casualties:

a) Loss of main feedwater (LMFW)
b) LMFW w/loss of offsite AC power
c) LMFW w/loss of onsite and offsite AC power
d) Plant cooldown
e) Turbine trip with and without bypass
f) Main feedline break (03)
g) Main steam line break/auxiliary feedwater line break (03)
h) Small break LOCA (03)
i) OTSG overfill (03)

6.2 Design Features to Mitigate Effects of Casualty Events (03)

6.2.1 Loss of Main Feedwater (LMFW) - Upon loss of all feedwater both AFW pumps are automatically initiated by the EFIC system. A minimum flow rate of 760 gpm with a single failure is sufficient to mitigate the effects of a LMFW. After initiation, the level will be automatically controlled to about 3 ft. The only required operator actions con- (03) cerning AFW are to confirm that AFW flow has been initiated and that a level has been established in both OTSG's.

6.2.2 Loss of Main Feedwater with Loss of Offsite AC Power - Upon loss of offsite AC power (which causes a loss of the RC pumps), the AFW system is used to establish natural circulation. Both AFW pumps are auto- (03) matically initiated by the EFIC system. The level rate control system will automatically raise the level in the OTSG's to the natural circulation setpoint at a rate of between 2"/minute and 8"/minute. The high auxiliary feedwater injection point in the steam generators provides a high thermal center which will establish natural circulation even with a low steam generator level. For a high decay heat rate event, the level should increase to the natural circulation setpoint at 8"/minute without requiring any operator action. For lower decay heat rate events, the excess AFW injection will begin to quench the steam and steam pressure in the OTSG will drop. This decrease in OTSG steam pressure (and saturation temperature) will continue to overcool the primary system. The EFIC is designed to automatically throttle back AFW flow as steam pressure drops. The flow will be throttled to a minimum of about 2"/minute level increase when steam pressure drops to about 800 psig or below. This feature will minimize the potential for overcooling. For very low decay heat rates, the operator may have to take manual control of the AFW system and further reduce AFW flow to keep from losing pressurizer level. The design basis for the EFIC is to allow a minimum of 10 minutes with no operator action for all cases. It is anticipated that either no operator action will be required, or a time well in excess of 10 minutes will be available for operator action.

6.2.3 Loss of Main Feedwater with Loss of Onsite and Offsite AC Power - (03) This event is not a design basis for the plant, but the AFW system is designed to supply 760 gpm flow with the loss of both onsite and offsite AC power. All EFIC controls are powered by battery-backed vital AC power. All valves required to supply flow are powered from DC busses. The turbine train of AFW should start and supply sufficient flow as described in Section 6.2.2.

6.2.4 Plant Cooldown - The AFW system is capable of being used to assist in a plant cooldown. The plant, however, was not designed for a cooldown with only safety grade systems. The motor-driven AFW pumps can be used with the atmospheric dump valves to cool the plant down to the Decay Heat Removal System cut-in temperature.

6.2.5 Turbine Trip With and Without Bypass - This event does not affect the AFW system unless MFW fails. In which case, the loss of MFW event in Section 6.2.1 describes the behavior of the AFW system. (03)

6.2.6 Main Feed Line Break - This break is a more abrupt case of LOFW and has approximately the same requirements for AFW flow. If the break is upstream of the last feedwater line check valve, the accident should proceed as the loss of main feedwter event described in 6.2.1. If the break is downstream of the last check valve, the steam generator will blow down to the containment and AFW will be initiated through EFIC by either a low SG level or low SG pressure. When the SG has depressurized below approximately 600 psig, the steam generator isolation logic will isolate main feedwater to the affected steam generator. Upon reactor trip the turbine control commands the turbine throttle valves to close, thus allowing the unaffected steam generator to repressurize. After isolation of the affected steam generator the EFIC vector logic will supply AFW only to the intact steam generator. (03)

6.2.7 Main Steam Line Break/Auxiliary Feedwater Line Break - The effect on the system from both of these transients is essentially the same. For smaller break sizes, the steam generator will not depressurize or will require a very long time to depressurize. No automatic action is taken for these cases. The operator must diagnose the problem and take appropriate manual actions. For break sizes that will depressurize the steam generator down to approximately 600 psig, EFIC will automatically terminate main feedwater to the depressurized steam generator(s). Some break sizes and locations may cause both steam generators to depressurize below 600 psig without a 100 psid differential between the two steam generator pressures. In this case main feedwater will be terminated automatically to both steam generators. A reactor/turbine trip signals (via the turbine control) the turbine stop valves to close. If the break is downstream of the turbine stop valves, both steam generators should repressurize. AFW will then be fed to both steam generators. If the break is upstream of the turbine stop valves, only one steam generator will repressurize. The EFIC vector logic will direct AFW only to the intact steam generator. (03)

For a steam line break with a concurrent failure of one turbine stop valve in the unbroken line, the back pressure in the unbroken steam line can prevent the turbine stop valves in the broken lines from seating. Both steam generators will blow dry after the rupture. Since main feedwater has been isolated, the accident is terminated, and the core does not return to criticality. An equilibrium reactor system cooldown and depressurization is achieved by operator control of the auxiliary feedwater flow with steam relief out of the steam line break. Refer to Abnormal Transient Operating Guidelines (ATOG) for operator actions required.

6.2.8 Small Break LOCA - For A Small Break LOCA (SBLOCA) event, the AFW system will be automatically initiated by an SFAS signal. Current procedure also requires that the RC pumps be tripped for a Small Break LOCA. Under these conditions, the EFIC system should automatically raise level at a controlled rate in the steam generators to the natural circulation setpoint. The time for the controlled rate fill process to the natural circulation setpoint will vary depending on SG inventory. During this time, current procedures require that the operator diagnose the event to determine that it is a SBLOCA. When this determination has been made, the operator is instructed to select the ECC level setpoint. The purpose of raising the level is to assist in establishing steam condensation natural circulation if part of the primary system is voided. Prior to reaching the required ECC level setpoint there will be substantial AFW flows high in the OTSG. These flows will provide good heat transfer high in the OTSG. (03)

Selection of the ECC level setpoint will continue the filling of the OTSG at a controlled rate.

If filling the OTSG at some rate other than the one used in the EFIC system is required, the operator may take manual control of the AFW control valves. AFW can then be manually controlled as required for a given situation.

6.2.9 OTSG Overfill - A main Feedwater (MFW) overfill event is detected by a high range ΔP signal. When an excessive level is detected, main feedwater to the affected steam generator is terminated. Termination of MFW will, in most instances, lead to a reactor trip. Recovery from this condition requires operator action to determine the cause and restore MFW. (03)

7.0 Testing and Maintenance (02)

The AFW System is designed to allow periodic testing during power operation. Routine maintenance activities, however, should be performed during plant outages. The technical specification will allow one train of the AFW system to be inoperable for only a short period of time during power operation (typically 24 to 72 hours). Therefore, most corrective maintenance must be performed with the plant shutdown.

7.1 Periodic Testing of the Fluid System

The system design allows testing of the pumps and valves in the AFW system during power operation. The pumps can be tested by manually starting them and operating for at least 5 minutes with minimum flow. (03)
The AFW isolation valves are closed in the absence of an automatic initiation signal. Therefore, no system realignment or bypassing is required to perform this test.

All automatic valves in the AFW system can be full stroke exercised during power operation. No system realignment is required to perform these valve tests.

7.2 Periodic Testing of the EFIC

The EFIC is designed to be tested from its input terminals to the actuated device controllers. A test of the EFIC trip logic will actuate one of two relays in the controllers. Activation of both relays is required in order to actuate the controllers. The two relays are tested individually to prevent automatic actuation of the component. Testing of the sensor inputs to the EFIC will normally be accomplished with the plant at cold shutdown. EFIC trip testing is discussed in Section 3.4.6. (03)

Figure 3.3-1 AC Power Distribution to Components in AFWS

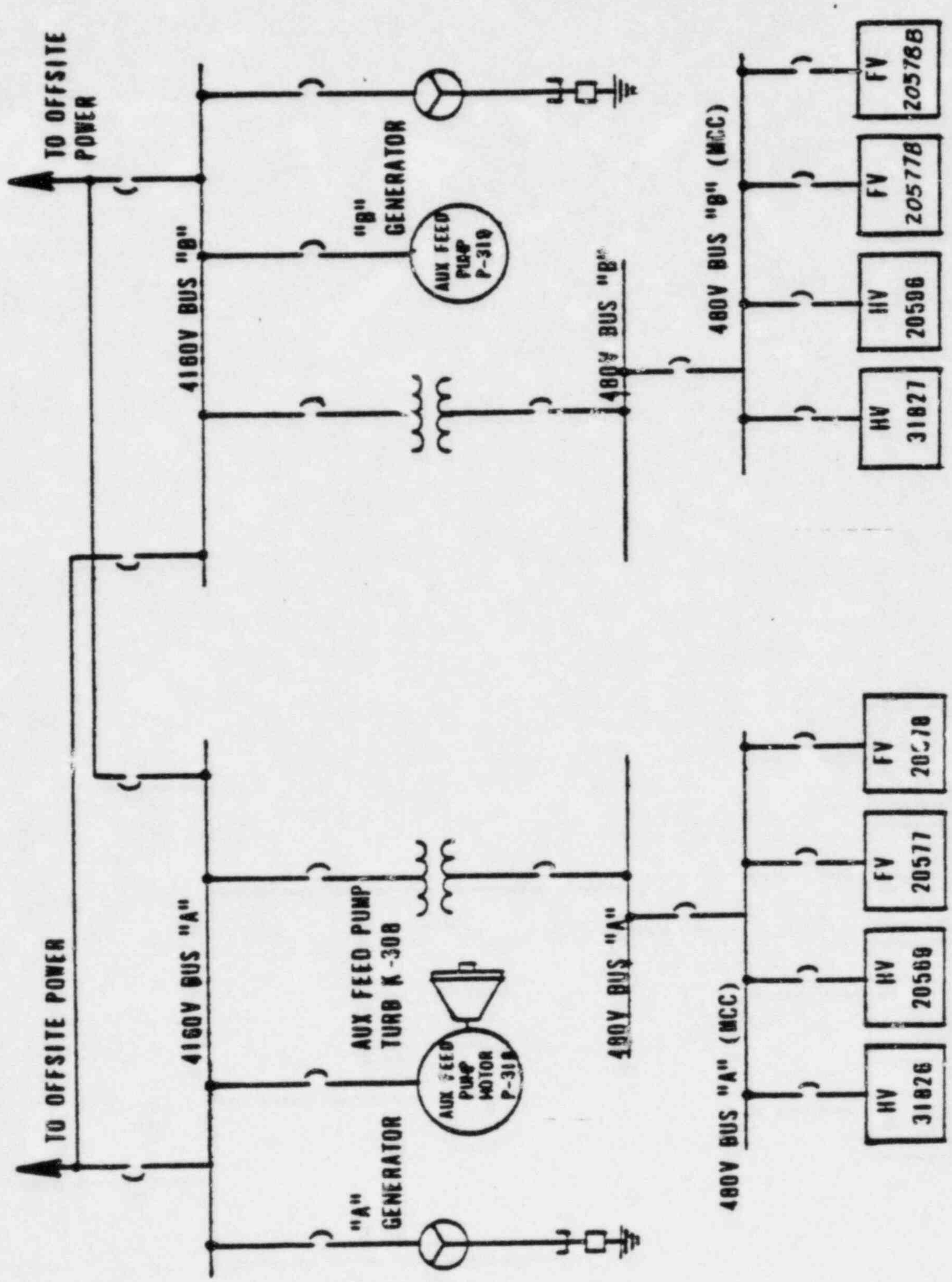


Figure 3.3-2 125V DC and Vital 120V AC Power Distribution

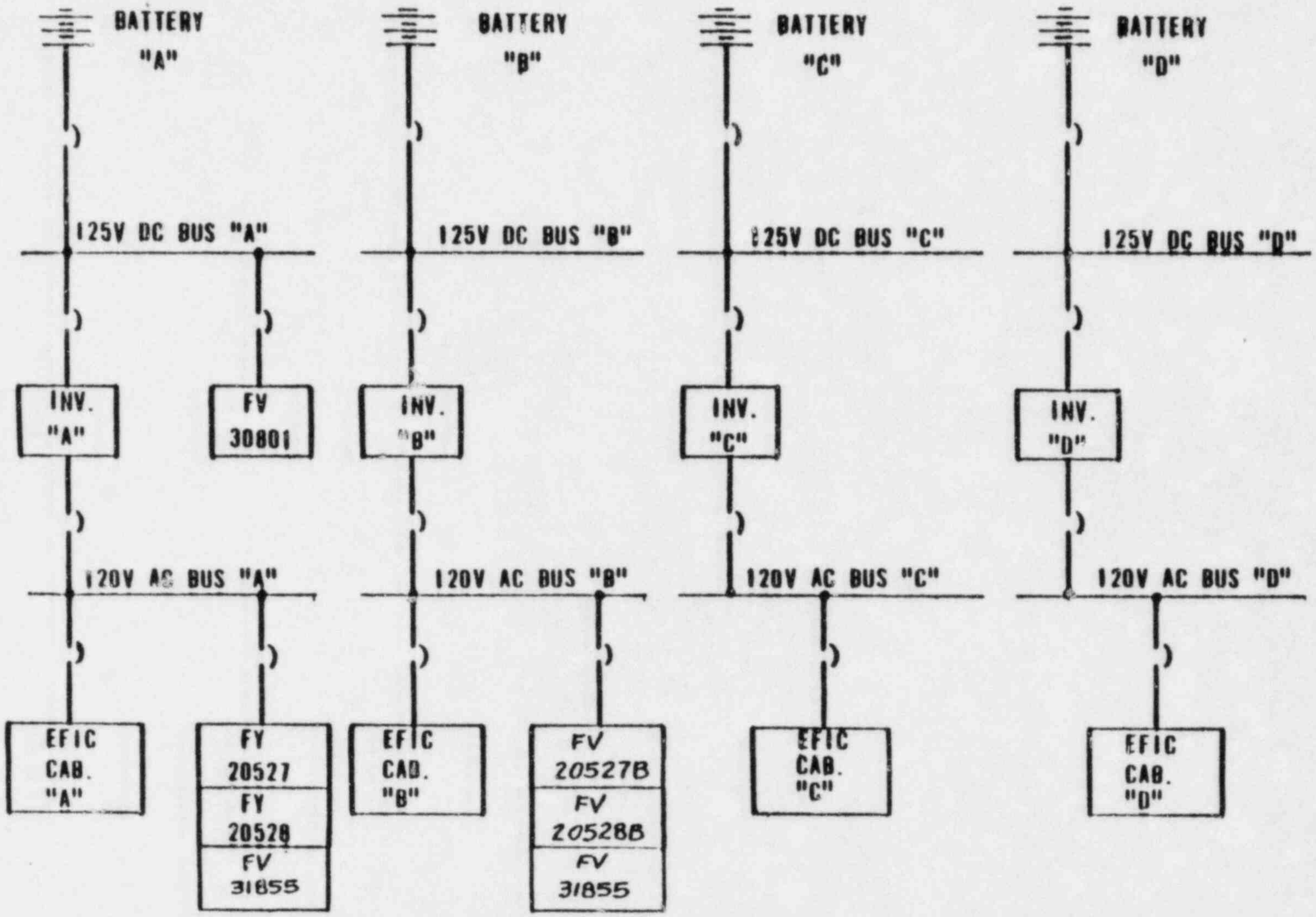


Figure 4.2-1 Flux to Feedwater Setpoint

The following is the equation for the nominal setpoint used in Figure 4.2-1.

$$\phi = 1.9\ WFW + 21$$

where: WFW = total main feedwater flowrate in % of total flow
ϕ = neutron flux measured in % full power

The errors and delay time used in developing this setpoint are:

Flow measurement error = 5.5%
Flux measurement error = 6%
Delay time = 2 sec.

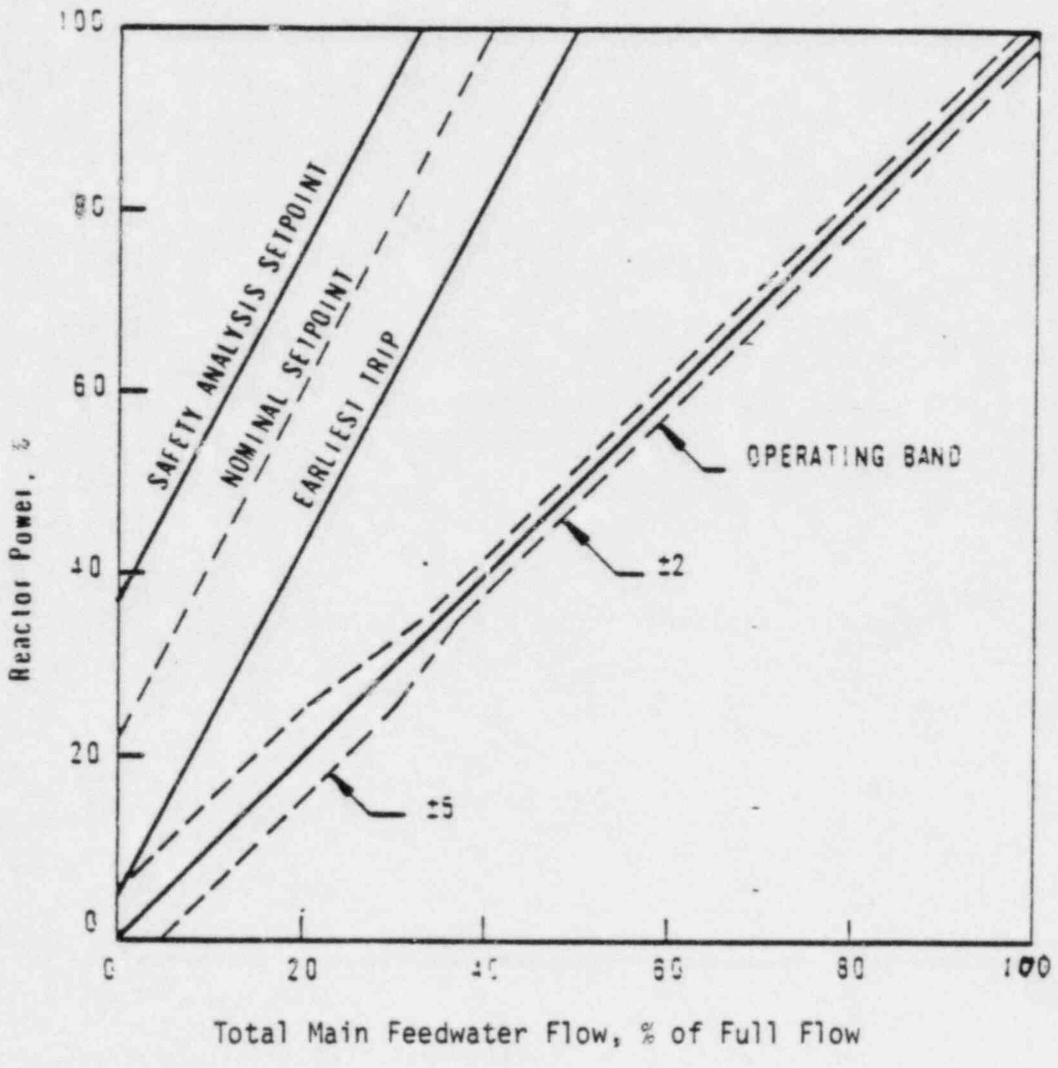


Table 4.2-1

EFW SYSTEM SETPOINTS

SETPOINT	NORMAL SETPOINT	MAXIMUM SETPOINT NORMAL	MAXIMUM SETPOINT ACCIDENT	MINIMUM SETPOINT NORMAL	MINIMUM SETPOINT ACCIDENT	
Low SG Level Initiate	12"	15"	N/A	9"	N/A	(02)
AFW Control Level	36"	40.5"	52"	31.5"	20"	(03)
Natural Circulation Control Level	316"	334"	392"	298"	240"	(03)
Steam Generator Overfill	360.5"	371"	N/A	350"	N/A	(03)
ECCS Fill Limit	379"	N/A	422"	N/A	336"	(03)
Low Steam Generator Pressure	600 psig	625 psig	N/A*	575 psig	N/A*	(03)
Steam Generator Differential Pressure	100 psig	150 psig	N/A*	50 psig	N/A*	(03)
ADV Opening Setpoint	1020 psig	1045 psig	N/A*	995 psig	N/A*	(03)

*The steam generator pressure measurements will be located outside the reactor building and therefore accident environment errors do not apply. (03)

All level setpoints refer to the equivalent height of a saturated water column referenced from the top of the lower tube sheet. It should be noted that the lowest low range instrument sensing tap is at an elevation of 6" above top of lower tube sheet. (02) (03)

Table 3.4-1 (03)

	EFIC Channel	1E or Non-1E Control Circuit
AFW Initiate		
1. AFW Pump, P-319 (start)	B	1E
2. AFW Flow Test Valve HV-31855 (close)	A&B	1E
3. AFW Pump Steam Inlet Valve FV-30801 (open)	A	1E
4. MFW Pump Turbine Steam Valve (From "A" OTSG), HV-20565 (close)	A&B	Non-1E
Main Steam Line Isolation "A" OTSG		
- None -		
Main Feedwater Isolation "A" OTSG		
1. MFW Control Valve ("A" OTSG) FV-20595, (close)	A	1E
2. MFW Start-up Control Valve ("A" OTSG), FV-20575, (close)	A	1E
3. Main FW Control Block Valve ("A" OTSG) FV-20529 (close)	A	1E
4. MFW Isolation Valve ("A" OTSG) FV-20515 (close)	B	1E
Main Steam Line Isolation "B" OTSG		
- None -		
Main Feedwater Isolation "B" OTSG		
1. MFW Control Valve ("B" OTSG) FV-20526, (close)	A	1E
2. MFW Start-up Control Valve ("B" OTSG), FV-20576 (close)	A	1E
3. MFW Control Block Valve ("B" OTSG) FV-20530 (close)	A	1E
4. MFW Isolate Valve ("B" OTSG) FV-20516 (close)	B	1E

Note: A Main Steam Line Isolate signal ("A" OTSG) will initiate AFW, and will initiate a Main Feedwater Isolate signal for that same OTSG. This logic is internal to EFIC.

TABULATION OF DRAWING NUMBER VS. FIGURE NUMBERS

FOR

RANCHO SECO AFW SYSTEM

FIGURE NUMBER	B&W DRAWING NUMBER	
3.1-1	1121327D	
3.4-1	1122924F	(01)
3.4-2	1122923E	(03)
3.4-3a	1122930C	(01)
3.4-3b	1122928C	(01)
3.4-3c	1122927C	(01)
3.4-4	1122922D	(01)
3.4-5	1122926E	(01)
3.4-6	1122925C	(01)
3.4-7	1122921C	(01)
3.4-8	1121322C	
3.4-9	1122920B	(01)

INSTRUMENTATION REQUIREMENTS (03)

1. Low Range Level Instrument String

   a. Tap Elevations ____ 6" & 156" (03)
   b. Scale ____ 0-150"
   c. Pressure ____ 1200 psig
   d. Temperature ____ 600 F
   e Instrument String Errors:

   * e.1 Normal Operating Environment ____ ±3" (trip)/±4.5" (control) (03)
   ** e.2 Design Break Environment ____ ±16" (03)

   See Note 1, 2.

2. Wide Range Level Instrument String (03)

   a. Tap Elevations ____ 6" & 619" (03)
   b. Scale ____ 0" - 600" (03)
   c. Pressure ____ 1200 psig
   d. Temperature ____ 600F
   e. Instrument String Errors:
   * e.1 Normal Operating Environment ____ ±10.5" (trip)/±18" (control) (03)
   ** e.2 Small LOCA Environment ____ ±43" (03)
   *** e.3 Design Break Environment ____ ±76" (03)

   See Note 1, 2.

3. Deleted. (03)

4. Pressure Instrument Strings
   a. Span ____ 0-1200 psig
   b. Response Time ____ 1 second
   c. Instrument String Errors:
   * c.1 Normal Operating Environment ____ ±25psi

*Normal Operating Environment 80F to 140F/100%RH (03)
**Small LOCA Environment 80F to 240F/100%RH (03)
Radiation Dose Air (TID Rads) - 2 Hours = 1.86×10^4 (03)
(includes 40 yr. service 36 Hours = 6.0×10^4 (03)
dose of 10^4 RADS) 30 Days = 9.2×10^4 (03)
Peak Building Pressure ____ 43 psia @ 2500 seconds after accident (02)
***Design Break Environment (03)
Temperature - 3 min. - 320°F
6 min. - 300°F
30 min. - 275°F
1 hr. - 200°F
1 week - 190°F
Building Pressure - 1 min. - 60 psia
2 min. - 60-69 psia
2 hrs. - 69-18 psia
2 weeks - 18 psia

Humidity - 100%
Radiation Dose Air (TID RADS) - 3.4×10^6
(includes 40 yr service dose
of 10^4 RADS)
Spray pH = 7.5 to 10

NOTES:

1. Level measurement to be density/pressure compensated over a pressure range of atmospheric to 1050 psig assuming a saturated volume of steam and water. Since the level measurement is density compensated, the unit "inches" refers to the actual level in the steam generator over the specified pressure range.
2. Assumes reference leg temperature compensation. (03)

MODULATING SOLENOID ACTUATED AFW SYSTEM CONTROL VALVE REQUIREMENTS (03)

Mark Numbers: FV-20527B
FV-20528B

1. Design Conditions

a. Pressure	1600 psig
b. Temperature	316F
c. Maximum dP @ shutoff	1600 psid
d. Stroke time	10 sec. max.

2. Function/System

Auxiliary Feedwater Control/AFWS

3. Operation Modes*

a. Flow 50 gpm; Inlet Press/Temp 1450 psig/100F; Outlet Press/Temp 50 psig/100F
b. Flow 50 gpm; Inlet Press/Temp 1150 psig/100F; Outlet Press/Temp 1050 psig/100F
c. Flow 850 gpm; Inlet Press/Temp 1150 psig/100F; Outlet Press/Temp 650 psig/100F
d. Flow 850 gpm; Inlet Press/Temp 1150 psig/100F; Outlet Press/Temp 1085 psig/100F

*NOTE: 1. Valve shall be capable of controlling at all points within the operating envelope.

4. Top Work and Accessories:

a. Actuator - Modulating Solenoid Motor
   1. Power: 125 VDC +15V -20V
   2. Increase in signal input closes valve
b. Failure mode - open

5. Valve Material

a. Body - stainless steel
b. End Prep - 4" ANSI 900# R.F.
   Weld Neck Flange
   SA - 182 - F304

6. Code Classification

a. Governing Code	ASME Section III
b. Code Class	3
c. Issue Date & Addenda: That in effect at time of order	

7. Design Life Cycles:

   Full cycle - 2000
   20% stroke - 4000
   20% - 80% stroke - 2000

8. Qualification

   a. Valve actuator and essential electrical appurtenances shall be qualified to the requirements of IEEE-382, 1980.
   b. The valve and actuator shall be designed and qualified to operate during and after a seismic event.
   c. Valve and actuator located in the plant yard.

c.1 Temperature (F)	40 to 115F
c.2 Pressure	Atmospheric
c.3 Humidity (%RH)	0 to 100%
c.4 Radiation Conditions (TID, 40 years)	1000 Rads (including accident)

APPENDIX D (02)

BALANCE OF PLANT CRITERIA FOR EFIC

This Appendix provides data for use in planning for installation of the Auxiliary Feedwater Initiation and Control system (EFIC). The data is of a general nature with exact values, counts, etc provided in the EFIC data. (03)

1.0 PHYSICAL SEPARATION

The EFIC design provides for physical separation of redundant elements to promote single failure tolerance. The user must extend physical separation outside the EFIC cabinets to preclude compromising single failure tolerance. Figures 1,2,3, and 4 depict the boundaries of separation of channels A, B, C, and D respectively. Outside the EFIC cabinets the installer must ensure that:

1.1 All class 1E wiring and signals attendant to a particular channel is maintained separate from like signals and wiring assocated with the other channels.

1.2 All sensors providing input parameters to a particular EFIC channel are diversely located and/or protected with respect to like sensors for other channels to the extent that a given event (e.g., pipe whip, jet impingement, missiles, etc) and its effects cannot impair the operation of more than one channel.

1.3 Reference 1.1 above - all class 1E wiring and signals are maintained separate from non 1E circuits and wiring.

1.4 A given EFIC channel is assigned to the same division of plant separation as the NI/RPS and ESFAS channels which provides that EFIC channel's inputs.

1.5 AFW devices actuated by EFIC channel A are class 1E train A devices located in the A division of plant separation. An exception is where the user provides qualified electrical isolation and separation between the class 1E EFIC signal lines and the actuated device.

1.6 AFW devices actuated by EFIC channel B are class 1E train B devices located in the B division of plant separation. An exception is where the user provides qualified electrical isolation between the class 1E EFIC signal lines and the actuated device.

1.7 All peripheral devices which form a part of, feed information to, or derive information from the EFIC (e.g., remote switches, hand/auto stations, transmitters, indicators, etc) are: (03)

1.7.1 Qualified as Class 1E devices

1.7.2 Maintained in the same division of plant separation as the EFIC channel to which they are connected.

1.7.3 Physically separated and/or provided with barriers to separate them from Class 1E equipment and wiring assigned to other divisions of separation. (03)

1.7.4 Physically separated and/or provided with barriers to separate them from non Class 1E equipment and wiring.

2.0 ELECTRICAL ISOLATION NON 1E

The EFIC is provided with electrical isolation devices which allow coupling of signals which originate in Class 1E EFIC circuits to equipment in the non 1E environment. These electrical isolators provide for decoupling the effects of fault potentials of 750V peak AC 60 HZ or 480 VDC in the non 1E environment from the EFIC proper. Typically these isolated signals are provided to the plant annunciator and plant computer. The installer must ensure that:

2.1 Only electrically isolated signals are wired out of the EFIC to non 1E devices and equipment.

2.2 Non 1E wiring is routed so that faulting to potentials in excess of those indicated in 2.0 above is not credible.

2.3 Non 1E wiring is maintained separate from Class 1E wiring - Section 1.3.

3.0 GROUNDING

Each EFIC channel will be provided with two ground terminals 1) safety and 2) instrument. The safety ground will provide for ground connection to the EFIC cabinet and structure. The instrument ground is the electrically floating (not wired to cabinet ground). It is recognized that the user has provided grounding systems in his plant and has standard methods and philosophies which he employs. We recommend observance of the following rules to minimize potential ground problems.

3.1 Avoid Formation of Ground Loops

Each EFIC channel is designed to be an "electrical island." Where signals are coupled between EFIC channels, it is not necessary to interconnect instrument commons. Formation of ground loops can in part be avoided by:

3.1.1 Ensuring that all sensors float (are not ground referenced).

3.1.2 Where shielded cable is employed, ensure that it is grounded at only one end and has outer insulation sufficient to assure that it will not be inadvertently grounded anywhere along its length.

3.1.3 Ensure that all peripheral devices float (are not ground referenced.)

3.2 Safety Ground

The safety grounds must be grounded in a manner that will ensure that, in the presence of hot shorts to the EFIC cabinet structure, the EFIC cabinet cannot be elevated to a potential, relative to surrounding structures, which represents a personnel safety hazard.

3.3 Instrument Ground

Each EFIC channel (A,B,C, and D) is provided with an instrument ground point. The instrument ground for each channel should be:

3.3.1 Individually wired to the station ground.

3.3.2 Wired to the station ground with insulated cable to ensure that no inadvertent grounds occur along its length.

3.3.3 Provided with a removable link or other means of isolating the instrument ground from station ground for periodic tests to ascertain the EFIC channel has not developed inadvertent grounds.

4.0 ELECTRICAL POWER REQUIREMENTS

Actual electrical power data such as consumption, inrush, etc will be provided as a part of the EFIC documentation. For planning and design purposes, the following requirements have been imposed on the EFIC vendor.

Primary Voltage:	120VAC ±5%
Primary Frequency:	60 Hz ±2%
Maximum Current Consumption per Channel	20 amperes

The EFIC must be powered by vital power sources. Each channel shall be powered so that failure of vital energy sources in a division (A, B, C, or D) of plant separation could cause loss of power to only the EFIC channel assigned to that division and/or to the NI/RPS and SFAS channels which provide it with input signals. (03)

5.0 ELECTRICAL CURRENT RATINGS

EFIC vector and trip busses transmit actuation signals into the field by applying vital input power to transmission lines. A trip bus can be loaded to a maximum of five amperes. A vector bus can be loaded to a maximum of two amperes.

It should be noted that a given channel A or B issues signals on ten trip busses (two for each of the five functions). For this reason - reference section 4.0 - the total of trip bus loads, vector bus loads and cabinet instrumentation loads cannot exceed twenty amperes. Of the twenty ampere rating - section 4.0 six amperes are reserved for instrumentation.

6.0 CABLE COUNT

This section provides estimates of the cable counts involved. Estimates are on the maximum side.

6.1 Vital Power

By user - typically three conductors per channel

6.2 Level Sensors

There are two level sensors per channel per steam generator. Total of four conductors per channel exclusive of safety grounds, etc. (03)

6.3 Pressure Sensors

There is one pressure sensor per steam generator per channel. Total of four conductors per channel exclusive of safety grounds, etc. (03)

6.4 SFAS ECC Actuation (03)

There are two actuation signals from each of two SFAS actuation channels. There are a total of eight conductors.

6.5 NI/RPS Signals

The following applies to the interface of each EFIC channel with the corresponding NI/RPS channel.

Signal	Conductors per Channel
RC Pump 1A Trip	2
RC Pump 2A Trip	2
RC Pump 1B Trip	2
RC Pump 2B Trip	2

(03)

Signal	Conductors per Channel	
		(03)
MFW/Power Ratio Trip	2	
NI/RPS Channel Bypass	2	

6.6 Plant Annunciator Signals

Presently the following number of signals are available to the plant annunciator from each EFIC channel. To what extent they are utilized is the users option. Each signal involves two conductors. (03)

Channel	No. of Signals	
A	32	(03)
B	32	(03)
C	11	(03)
D	11	(03)

6.7 Plant Computer

Each analog variable in each channel is available to the plant computer. Each signal is transmitted on one pair of conductors. Each signal pair should be shielded with the shield grounded at the computer. The input to the computer should float to avoid creating ground loops. There are six analog signals per EFIC channel.

6.8 Trip Busses

Channel A and B each originate ten trip busses for tripping actuated devices. Each trip bus is composed of two conductors.

6.9 Test Results Signals

The user provides one test results signal per each actuated device. Each signal is transmitted by a conductor pair. The user will determine the number actuated devices. (03)

6.10 Vector Signals

EFIC Channel A provides close vector signals to AFW control valves FV-20527A and FV-20528A. EFIC channel B provides close vector signals to AFW control valves FV-20527B and FV-20528B. Channel C provides both open and close vector signals to AFW isolation valves FV-20577A and FV-20578A. Channel D provides both open and close vector signals to AFW isolation valves FV-20577B and FV-20578B. These signals utilize a total of four conductors from channels A and B. They also utilize a total of eight conductors from both channels C and D. (03)

6.11 EFW Control Valve Signals

Channel A provides one control signal for SGA AFW control valve FV-20527A. Channel A also provides one control signal for SGB AFW control valve FV-20528A. Each signal involves two conductors. The total is four conductors for channel A. This format is repeated for channel B. (03)

6.12 ADV Control Signals

Channel A utilizes two conductors to transmit control signals to the SGA ADV's (PV-20571A, PV-20571B, and PV-20571C). Channel B also utilizes two conductors to transmit control signals to the SGB ADV's (PV-20562A, PV-20562B, and PV-20562C). (03)

6.13 Main Control Room

Refer to Figure 1 and 2. Channels A and B have an involved interface with the main control room. The following is a maximum estimate per channel.

Function	Conductors	
1) Trip, Reset, Manual Switches and Backlighting	50	(03)
2) Post Accident Monitoring	12	
3) Hand Control SGA AFW flow control valves	11	(03)
4) Hand Control SGB AFW flow control valves	11	(03)
5) Hand Control SGA ADV's	11	(03)
6) Hand Control SGB ADV's	11	(03)
7) Level setpoint selection	6	(03)
8) Shutdown bypass	(later)	(03)
9) Control/vector enable reset	(later)	(03)

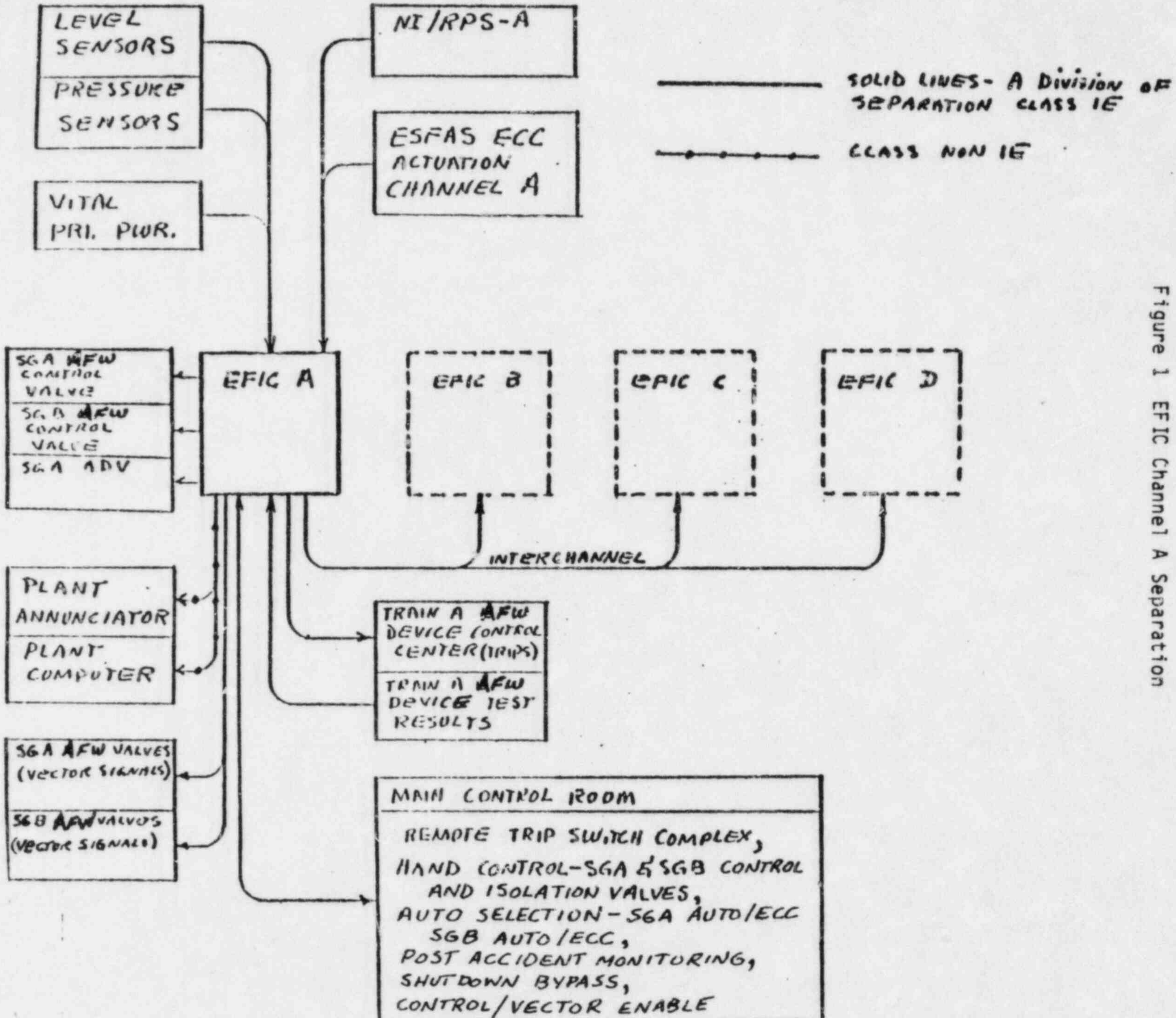


Figure 1 EFIC Channel A Separation

BWNP-20007 (6-76)
NUMBER
15-1120580-03

DATE: 3-30-83

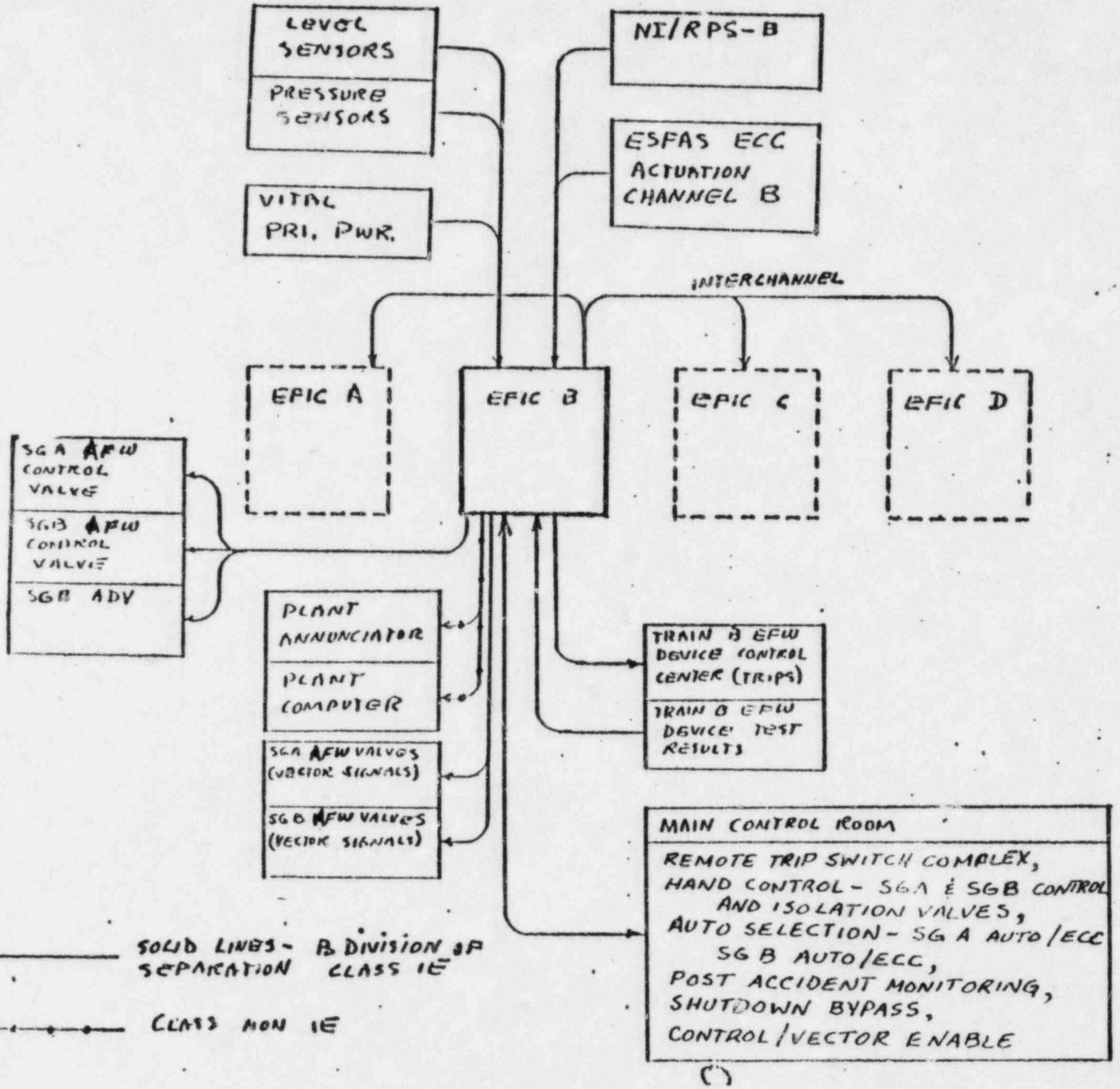


Figure 2 EFIC Channel B Separation

Figure 3 EFIC Channel C Separation

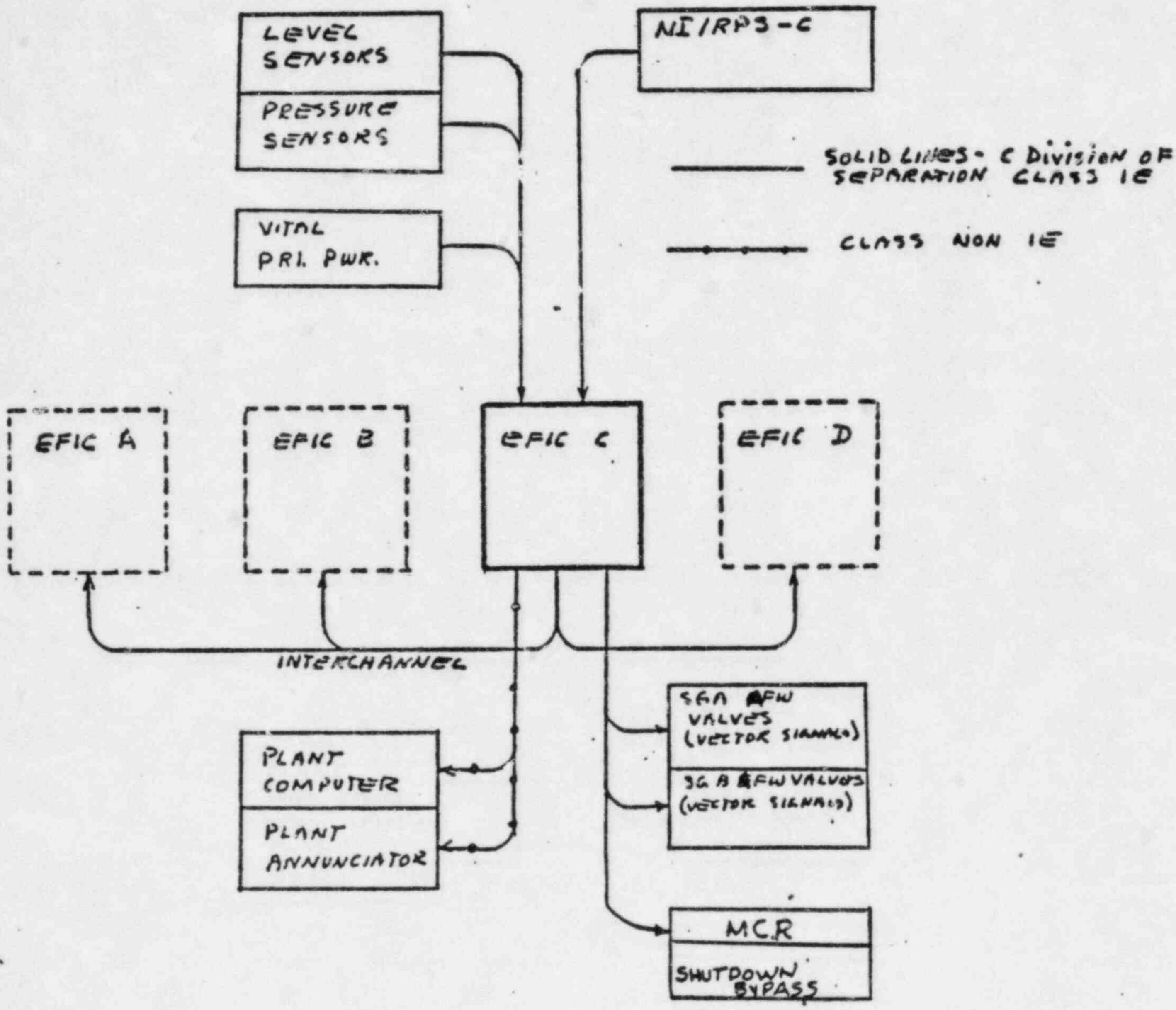
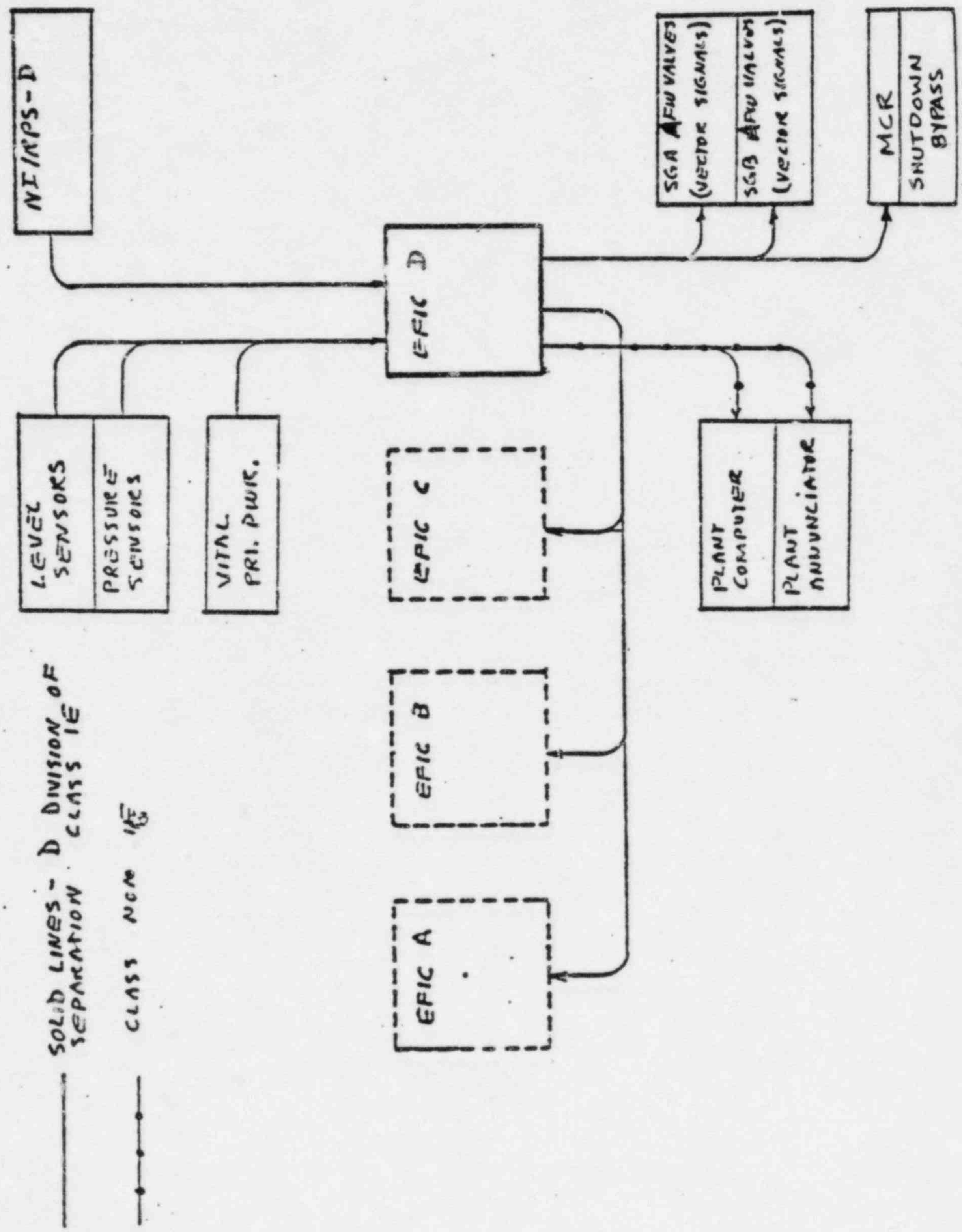


Figure 4 EFIC Channel D Separation



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