Florida Power
CORPORATION

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U.S. NUCLEAR REGULATORY COMMISSION

Mr. John F. Stolz, Chief
Operating Reactors Branch #4
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Crystal River Unit 3
Docket No. 50-302
Operating License No. DPR-72
NUREG-0737 Item II.E.1.2
Emergency Feedwater System Upgrade

Dear Mr. Stolz:

By our letters dated March 3, 1981, and April 1, 1981, Florida Power Corporation committed to provide a final system description for our planned upgrade to the emergency feedwater (EFW) system and a qualitative assessment of the reliability enhancement from the addition of a third EFW pump, respectively. Pursuant to our commitments, we hereby provide the following response.

The basic features of our upgraded EFW system were presented in a meeting to members of the NRC on September 4, 1980, documented in our letter dated December 19, 1980, and conceptually approved by your letter dated January 27, 1981. The system design and analysis phase of the project is now complete. Based upon the results of this phase, a design review was performed, and the system description has been revised. The revised EFW System Description (attached) includes the following additions:

. A design description for main feedwater overfill protection,

Drawings
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. A refinement of the steam generator level tap locations for level control within allowable limits,

. A section on operations, casualty instructions, and maintenance, and

. A section on Balance of Plant Criteria for the EFW Initiation and Control System.

Florida Power Corporation is now proceeding with hardware procurement to implement the design described in the attached description. A vendor has been selected, and hardware design and manufacturing will begin on approximately September 1, 1981. Hardware delivery is currently scheduled for late 1982 with plans to install the new system during the early 1983 refueling outage.

Also, a reliability study has been performed to compare the increased reliability from the addition of a third EFW pump as compared to the reliability of the upgraded system being implemented. The study considered the addition of a motor-driven pump and the addition of a turbine-driven pump with various permutations for each.

As expected, the addition of a third EFW pump does show an increase in the reliability of the EFW system. The motor-driven third pump powered from a dedicated diesel generator results in an improved system reliability over that of a turbine-driven third pump.

Florida Power Corporation will evaluate each of these alternatives and perform a cost-benefit analysis on each option. You will be advised of the results of our analysis and our plans, if any, to proceed with the addition of a third EFW pump b December 1, 1981.

Very truly yours,

William A. Cross

William A. Cross
Manager, Nuclear Licensing

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Attachment

REVISED SYSTEM DESCRIPTION

EMERGENCY FEEDWATER SYSTEM

FOR

FLORIDA POWER CORPORATION

CRYSTAL RIVER UNIT 3

INDEX

1.0 SCOPE

This document contains the system description for emergency feedwater (EFW). The requirements for this system come from three sources - first, the functional requirements needed to properly interface the EFW system with the nuclear steam supply system (NSSS); second, NUREG-0578, Short Term Lessons Learned Report; third, Draft NUREG-0667, Transient Response of B&W Designed Reactors. This document contains the criteria necessary to upgrade the EFW 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 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 EFW unless otherwise stated.

2.0 SYSTEM REQUIREMENTS

The EFW system requirements are listed below.

2.1 NSS Interface Requirements

2.1.1 Maximum Feedwater Flow

The maximum allowable FW flow is 1175 gpm per steam generator (SG). This maximum FW flow limit is based on a tube vibration crossflow velocity limit of 5 ft/s. This limit shall not be exceeded at any steam pressure.

2.1.2 Minimum Available Feedwater Flow

The EFW system shall be sized so that a minimum of 740 gpm (total) can be delivered to either one or both SGs at a SG pressure of 1050 psig. This flow shall 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 EFW flow is established within 50 seconds after an initiation signal is reached. This initiation time is based on the requirement to:

A. Maintaining 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 following a loss of main FW event and reactor trip;

And The Desirability Of:

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

NOTE: The 50 second delay includes instrumentation time delay, diesel startup, diesel sequencing, pump acceleration time, and valve stroke time.

2.1.4 Initiation and Control Requirements

2.1.4.1 General Requirements

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

A. The system shall provide automatic actuation of EFW, 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 (IE) 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 EFW when required nor spuriously actuate the system. This criterion shall apply to the EFW 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 EFW shall be considered;

F. Indication of EFW status, flowrate and OTSG level shall be available to the operator;

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;

H. The capability for manual initiation of EFW shall be provided;

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

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

K. Provisions shall be made to initiate the EFW to mitigate the consequences of a LOFW transient by a flux-feedwater ratio trip signal; and

L. 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.

2.1.4.2 Actuation Requirements

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

A. Loss of all main FW as a minimum, as indicated by the loss of both main FW pumps.

B. Low level in either SG.

C. Loss of all 4 RCPs.

D. Low pressure in either SG if main FW is isolation on this parameter.

E. ESFAS HP Actuation (High RB Pressure or Low R.C. Pressure)

NOTE: NUREG-0667 recommends that additional EFW initiation signals be evaluated. The purpose of this evaluation is to permit automatic initiation of EFW in a more timely manner to preclude SG dryout. The required signals will detect a trip of the MFW pumps or a low SG level. Failures that stop main FW without tripping the MFW pumps (e.g., control system failures) may not be detected in time to prevent a SG dryout. The following signals, as a minimum, should be evaluated as possible actuation signals:

Power/MFW flow
Power/SG level

2.1.4.3 Level* Requirements

Three adjustable level setpoints are required.

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

B. Following EFW actuation, the level setpoint shall be automatically selected to approximately 20 feet if all 4 RCPs are tripped.

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.

*For the purpose of EFW design, "LEVEL" refers to the equivalent height of a saturated liquid column (1065 psia) referenced from the top of the lower tube sheet.

2.1.4.4 Flowrate Requirement

The objective of flowrate control is to minimize overcooling for low DH conditions. The EFW flowrate is controlled by the rate level increase (see Section 2.1.4.3 for level definition). A level rate of 2 inches/minute to 4 inches/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 transient conditions which require EFW.

The level rate limit shall be adjustable under administrative control.

In operation, the EFW flowrate is modulated to hold the level rate at the setpoint.

2.1.4.5 Steamline Break/Feedwater Line Break Requirements

A steamline break of FW line break that depressurizes a SG shall cause the isolation of the main steamlines and main FW lines on the depressurized SG. If isolation of the SG does not isolate the break, EFW shall be provided only to the intact SG. No single active failure in the system shall prevent EFW from being supplied to the intact SG nor allow EFW to be supplied to the broken SG.

To meet these requirements, the following design shall be implemented:

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

B. SG Selection -

(1.) If both SGs are above 600 psig, supply EFW to both SGs,

(2.) If one SG is below 600 psig, supply EFW to the other SG, (3.) If both SGs are below 600 psig but the pressure difference between the two SGs exceeds a fixed setpoint (approximately 100 psig) supply EFW only to the SG with the higher pressure, and

(4.) If both SGs are below 600 psig and the pressure difference is less than the fixed setpoint, supply EFW to both SGs).

2.1.4.6 Steam Generator Overfill Requirements

Provisions shall be made in the design to terminate a main FW or EFW overfill condition. Provisions shall also be made to manually bypass the EFW overfill setpoint following a LOCA to permit establishing an OTSG level which will support steam condensation natural circulation in the RCS.

2.2 Fluid System Requirements

2.2.1 Branch Technical Position ASB10-1

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

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

B. Other powered components of the emergency 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 emergency 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;

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;

D. The emergency 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; and

E. When considering a high energy line break, the system should be so arranged as to assure the capability to supply necessary emergency 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 EFW system is not used (and therefore not pressurized) during startup, hot standby and shutdown conditions, then a high energy line break in the EFW 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 hours and to subsequently cooldown the plant to the decay heat removal (DHR) system pressure.

2.2.3 EFW Pump Protection

The system design shall protect the EFW 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 EFW or (b) be designed as a Class IE. system.

2.2.4 EFW Support Systems

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

A. Electrical power to support systems,

B. Compressed Air,

2.2.5 Cross Connects

The EFW system shall be designed to allow each 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:

A. High SG level (For SG A and SG B),

B. Low SG level (For SG A and SG B),

C. Low source water level,

D. Low EFW pump discharge pressure (For Pump EFP-1 and Pump EFP-2),

E. Steam line valves MSV-55 and MSV-56 not open,

F. EFW/MFW cross connect valves FWV-34 and FWV-35 not closed, and

G. All motor operated valves in EFW system not in proper position.

2.2.7 Indication

As a minimum, the following indication shall be provided to the operator:

A. EFW flow to each SG,

B. Startup range SG level (For SG A and SG B),

C. Operate range SG level (For SG A and SG B),

D. Wide range SG level (For SG A and SG B),

E. Key valve positions*,

F. Water source inventory,

G. Control system status (level setpoint selected),

H. Steam pressure of each SG,

I. EFW pump status indication,

J. Indications needed to check the status of EFW support systems,

K. Additional primary system indication as required to monitor system functions and operations, and

L. Status of the EFIC system (bypass, test, tripped, etc.).

*Direct position indication (e.g., valve stem position) 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. Strict administrative control should be exercised over the use of these valves.

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.

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 inlet piping during normal plant operation or during upset or accident conditions.

2.2.10 Operational Testing

Provisions shall be made to allow periodic operational 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.

2.3 Codes and Standards

The EFW system shall consider the requirements of the following codes and standards:

A. General Design Criteria 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 Based, 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 associated with pipe breaks;

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;

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 assume:

(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.), and

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

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; and

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.

H. <u>Regulatory Guides</u>

(1.) 1.22, Feb 1972	Periodic Testing of Protection System Actuation Functions
(2.) 1.26, Rev. 3, Sept. 1978	Quality Group Classifications and Standards for Water, Steam and Radioactive Waste containing Components.
(3.) 1.29, Rev. 3, Sept. 1978	Seismic Design Classification
(4.) 1.47, May 1973	Bypassed and Inoperable Status Indication
(5.) 1.53, June 1973	Application of the Single Failure Criterion
(6.) 1.62, Oct 1973	Manual Initiation of Protective Actions
(7.) 1.75, Rev. 2, Sept. 1978	Physical Independence of Electrical Systems
(8.) 1.97, Rev.1, Aug. 1977	Instrumentation to Assess Plant Conditions During and Following an Accident)
(9.) 1.102, Rev. 1, Sept. 1976	Flood Protection for Nuclear Power Plants

I. IEEE Standards

(1.) 279-1971 Criteria for Protection Systems for Nuclear Power Generating Stations (for initiation portions of EFW System)

(2.) 323-1971 General Guide for Qualifying Class I Electrical Equipment

(3.) 338-1971 Trial Use Criteria for Periodic Testing of Protection System

(4.) 344-1971 Seismic Qualification of Class 1E Electrical Equipment

(5.) 379-1972 Trial Use Guide for the Application of the Single Faiure Criterion

(6.) 384-1974 Separation of Class 1E Equipment and Circuits

TABLE 2-1

OTSG Emergency Feedwater Chemistry Requirements

pH at 77F	Same as normal requirement[a]
Dissolved oxygen (O_2)	
OTSG at <250F	No requirement (see hydrazine)
OTSG at >250F	
Normal	7 ppb max
Upset	100 ppb max for a period not to exceed 1 week
Total iron	100 ppb max
Hydrazine Catalyzed hydrazine	
OTSG at <250F	Added to at least 300% of Stoichiometric oxygen concentration
OTSG at >250F	1.0 μmho/cm, max for a period not to exceed 24 hours

(a) 8.5-9.3 at 77F - with 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 EFW system consists of two interconnected trains, capable of supplying emergency feedwater (EFW) to either or both SGs from either of two water sources under automatic or manual initiation and control. A piping and instrumentation diagram is included as Figure 3.1-1 of this report.

The system pumps (EFW pumps) take suction from either the condensate storage tank or from the condenser hotwell and discharge to the SGs. In the flow path between the EFW pumps and the SGs there are isolation valves, check valves, control valves, flow instrumentation, and pressure instrumentation to control the flow of EFW to the SGs. The fluid system design is described in Section 3.2. The instrumentation system design is described in Section 3.4.

3.2 Fluid System Design

The EFW system is designed to provide a minimum of 740 gpm of EFW to the SGs at 1050 psig within 50 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 with a single failure. Figure 3.1-1 depicts the piping and instrumentation diagram.

3.2.1 Suction

The primary water source for both EFW trains is the Seismic Category I condensate storage tank, CDT-1. Water is supplied from this tank through an 8-inch line with locked open manual valve CDV-103 to separate 6-inch lines containing normally open, motor-operated valves EFV-3 and EFV-4.

A reserve of 150,000 gallons is maintained within the tank and is verified by redundant, safety grade level indication in the control room. This volume of water will remove Decay Heat (plus RC pump heat for 2 pumps) for approximately 15 hours. This volume will also be sufficient to remove DH plus cooldown to the DHR system in approximately 11 hours. In addition, safety grade low level alarms are provided to alert the operator to perform a suction transfer.

The main condenser hotwell is the main alternative water source available for the EFW system. Separate 8-inch lines with normally closed, DC-powered valves EFV-1 and EFV-2 draw suction through an 8-inch line with locked open manual valve EFV-36. The DC-powered valves are interlocked such that they can be opened only if at least one of two DC-powered vacuum breaker valves is open.

For extended periods of EFW system operation with a loss of offsite power, an additional water source can be made available via the Fire Service System.

3.2.2 Pumps and Discharge Cross-Connect

EFW Train B pump, EFP-2, is a turbine-driven pump with a rated capacity of 740 gpm at 1300 psig with a design recirculation flowrate of 200 gpm with the pump discharge closed. EFW Train A pump, EFP-1, is a motor-driven pump which has the same rated capacity and recirculation flow as the Train B pump.

The Train A and B pumps discharge through check valves and motor operated, stop-check valves into 6-inch cross-connected discharge lines. The separate cross-connects contain normally open motor operated valves EFV-14 and EFV-32. These cross-connects permit either pump to feed either or both steam generators.

3.2.3 Emergency Feedwater Flow Control Valves

The flow of EFW to each steam generator is controlled by normally closed, control valves (EFV-55, EFV-56, EFV-57, and EFV-58) in parallel paths. These control valves are designed to fail "open" on loss of air. Initiation and control instrumentation for these valves is described in Section 3.4 of this report.

3.2.4 Steam Generator EFW Isolation Valves

Each steam generator can be isolated from EFW flow by normally open, motor-operated valves (FWV-11, FWV-14, FWV-32, FWV-33). These valves are located in the parallel lines upstream of the EFW control valves. Initiation and control instrumentation for these valves is described in Section 3.4 of this report.

3.2.5 Recirculation and Test Lines

Recirculation lines are connected to the discharge piping of the EFW pumps. Recirculation for pump protection is accomplished with normally open flow paths to the condensate storage tank consisting of small lines with check valves and locked-open manual valves.

EFW pumps can be operability tested using the normal recirculation flow paths to confirm the pump and pump drive capability to operate and produce the required discharge pressure. No change to the normal EFW system valve lineup is required to perform this testing.

3.2.6 Steam Supply for the EFW Turbine Driven Pump

Steam supply for the EFW pump EFP-2 turbine is obtained from both steam generators through six-inch lines containing check valves MSV-186 and MSV-187, and normally-open, DC motor operated stop-check valves MSV-55 and MSV-56. 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 normally-closed, DC motor operated valve ASV-5. A description of the controls for this valve is contained in Section 3.4. An alternate steam source is provided from the auxiliary steam system which is tied to fossil fired Crystal River Units 1 and 2. This backup steam source is manually valved into service when required.

Turbine exhaust is vented to the atmosphere.

3.2.7 Key Valve Positions

Direct position indication (e.g., valve stem position) is required on all automatically operated and remote manual, power operated valves. To comply with this requirement, the following valves require position indication:

EFV-3	EFV-11	FWV-35
EFV-4	EFV-33	EFV-14
EFV-1	EFV-32	MSV-55
EFV-2	EFV-58	MSV-56
EFV-57	ASV-5	EFV-7
EFV-55	EFV-8	EFV-56
FWV-34		

3.3 Supporting Systems

The EFW turbine-driven pump and turbine are self-contained entities without dependencies on secondary support systems. The bearings on the turbine and pump are lubricated by slinging oil from reservoirs near the bearings. Lube oil cooling is accomplished by heat transfer to the pumped fluid.

The EFW motor-driven pump and pump motor bearings are lubricated by slinging oil from reservoirs near the bearings. Lube oil cooling is provided by the nuclear service closed cycle cooling system. Two of the three cooling water pumps receive diesel-backed power.

3.3.1 Power

The two EFW trains are powered from diverse power sources. EFW pump EFP-2 is turbine-driven and EFW pump EFP-1 is AC power motor-driven with back-up power from the diesel generator.

To ensure EFW flow in the event of a loss of all AC power, the turbine driven pump train derives its power from the steam generators for the pump and from a battery-backed DC bus for its steam supply valves. The following valves are battery backed DC power: EFV-1, EFV-2, EFV-11, EFV-33, EFV-14, EFV-32, MSV-55, MSV-56, and ASV-5.

3.3.2 Service Air

EFW flow control valves EFW-56, EFW-57, EFW-55, and EFW-56 are connected to the qualified redundant air supply system with redundant valves in the same train being connected to a different air supply system.

3.4 EFIC Instrumentation Description

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

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

A. Initiation of emergency feedwater (EFW),

B. Control of EFW at appropriate setpoints (approx. 3, 20 and 31.5 feet),

C. Level rate control when required to minimize overcooling,

D. Isolation of the main steam and main feedwater lines of a depressurized steam generator,

E. The selection of the appropriate steam generator(s) under conditions of steamline break or main feedwater or emergency feedwater line break downstream of the last check valve,

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

G. Termination of EFW to a steam generator on approach to overfill conditions,

H. Control of atmospheric dump valve to a predetermined setpoint, and

I. Signals for isolation of the main steam and MFW lines of a depressurized steam generator.

The emergency feed initiation and control system (EFIC) is illustrated in Figures 3.4-1 through 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.

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

3.4.1 Input Logic

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

A. receives the analog channel input signals,

B. provides input buffering as required,

C. compares analog signals to appropriate setpoirts to develop digital signals based on analog values,

D. provides for the injection of test stimuli,

E. provides buffered Class IE signals and isolated non-IE signals, and

F. provides signals to remaining channel logic.

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 provides signals which result in the issuance of trip signals via the trip logics in Channels A and B.

The initiate logic issues a call for EFW trip (to the trip logic) when:

A. all four RC pumps are tripped,

B. both main feedwater pumps are tripped,

C. the level of either steam generator is low,

D. either steam generator pressure is low, or

E. flux to MFW flow ratio is present.

Other functions of the initiate logic are:

(1.) issue a call for SG A main feedwater and main steamline isolation when SG B pressure is low,

(2.) issue a call for SG B main feedwater and main steamline isolation when SG A pressure is low,

(3.) signal approach to SG A overfill when SG A level exceeds a high level setpoint,

(4.) signal approach to SG B overfill when SG B level exceeds a high level setpoint, and

(5.) provide for manually initiated individual shutdown bypassing of RC pumps, and SG pressure initiation of EFW as a function of permissive conditions. The bypass(es) are automatically removed when the permissive condition terminates, and

(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 relay racks. A characteristic of coincidence logic systems is that a test stimuli 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 relay racks, test stimuli inserted at the input logic will be propagated to each relay rack. EFIC testing philosophy is discussed in Section 3.4.9.

The trip logic is provided with five 2 (1-out-of-2) trip networks. These networks monitor the appropriate outputs of the initiate logics in each of the channels and output signals for tripping:

A. emergency feedwater,

B. SG A main steamline isolation,

C. SG B main steamline isolation,

D. SG A main feedwater isolation, and

E. SG B main feedwater isolation.

It should be noted, for the later discussion of the vector logic, that the trip logic outputs a signal when a 2 (1-out-of-2) trip of EFW occurs. Also, note the presence of the vector enable switch.

It should also be noted that the EFW trip logics are input by the Emergency Safety Features Actuation System (ESFAS) HPI trip signals to assure that EFW is initiated coincident with emergency core cooling activation.

Refer to Figure 3.4-1 - trip logics are contained in Channels A and B only per the two train EFW system.

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

Once a trip of the trip bus occurs, the trip is latched. A manual reset switch is provided for breakdown of the latch. Once a trip occurs, the trip can only be removed by manual reset action following return of the initiating parameter to an untrip value except as described in the next paragraph.

So that the operator may resume manual control of EFIC initiated devices following a trip, each trip logic is provided with a manual pushbutton. Operation of the manual pushbutton:

(1.) will have no effect on the trip logic so long as a trip condition does not exist.

(2.) will remove the trip from the trip bus only so long as the switch is depressed in the case of a one half trip (either bus but not both tripped). This allows for testing the manual function.

(3.) will remove the trip from both busses so long as a full trip (both busses are tripped) exists. This is accomplished by means of latching logic. Institution of the manual function also breaks the trip latches so that, if the initiating stimuli clears, the trip logic will revert to the automatic trip mode in preparation for tripping if a parameter returns to the trip region.

Trip signals are transmitted out of the EFIC by activating a relay thereby gating power onto trip busses. In this manner, the EFIC provides power to energize the control relays whose contacts form the AND gates in the controllers.

3.4.4 Vector Logics

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

A. SG pressure signals,

B. SG (A and B) overfill signals, and

C. EFW trip signals (vector enable) originating in Channel A and B trip logics.

The vector logic develops signals for open/close control of steam generator A and B emergency feedwater valves.

The vector logic outputs are in neutral state (neither open nor close) until enabled by trip signals (vector enable) from the channel A or B trip logics. Once enabled, the vector logic will issue close commands to the valves associated with an SG for which an overfill signal exists.

Note the EFW overfill limit may be manually bypassed. Manual bypass can only be initiated under permissive conditions of EFW trips in Channel A and/or B.

When enabled and with no overfill signals present, the valve open/close commands are determined by the relative values of steam generator pressures as follows:

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	Open	Open
SG A 100 psi > SG B	Open	Close
SG B 100 psi > SGA	Close	Open

3.4.5 Control Logic

The control logic is depicted in Figure 3.4-2.

For each SG (A and B) there are two controls which are selectable by transfers T1 and T5, respectively. The three foot level setpoint control is automatically selected when an EFW trip occurs with one or more reactor coolant pumps operating. A level rate control with a twenty foot setpoint is selected when an EFW trip occurs with no reactor coolant pumps operating. The three foot level control requires no explanation. However, the rate control is more involved.

The characteristics of the level rate limited follower are important in the following discussions. As the level signal changes, the rate output of the follower will follow it exactly so long as the rate of change does not exceed the predetermined rate limit values. The rate limit values given (4 inches per minute for increasing level rates and 200 inches per minute for decreasing level rates) are approximate for purposes of illustration. If level rate is increasing at greater than four inches per minute, the output of the rate limited follower will increase at four inches per minute. Once the rate of increase decreases to four inches per minute or less the output rate of increase will follow the input rate of increase. The function is similar for decreasing level except that the rate limit is approximately 200 inches per minute. A side benefit of the rate limited follower is attentuation of noise whose effective rate is in excess of four inches per minute or 200 inches per minute, respectively.

Reference Figure 3.4-2b. With no RC pumps operating, the twenty foot setpoint will be selected and applied to one input of the low selector. As SG level falls, the output of the rate limited follower will lag actual level by twelve inches (twelve inch bias added to the level signal in the summer). When the rate limited signal (level plus twelve inches) becomes less than twenty feet, the rate limiter signal will appear at the subtractor (delta). The output of the subcontractor will be approximately a negative one foot level error signal which will start opening the control valve ever wider through the proportional plus integral. The increasing flow should halt the drop in level and ultimately start the level to increase toward the setpoint.

If the level increase is more rapid than four inches per minute, the error signal out of the subtractor will decrease. This is due to the fact that the direct level input to the subtractor is not rate limited while the rate limited signal is. This action will control the control valve so that the rate of approach to the setpoint does not exceed four inches per minute.

When level exceeds nineteen feet, the low selector will lock the twenty foot setpoint into the subtractor. During the last foot of level increase the error output of the subtractor will gradually reduce.

Transfer T4 is provided for future use by the user. It allows for selection of hand control from either the Main Control Room or Auxiliary Shutdown Panel.

See Figure 3.4-2. Transfer logics T3 and T7 allow for selection of a manually inserted setpoint (illustrated as a twenty eight foot setpoint). The logic is arranged so that manual may be selected before and after an EFW trip. However, the twenty foot setpoint will automatically be selected on the occurrence of an EFW trip.

See Figure 3.4-2b. Transfer logics T2 and T6 allow for selection of hand control of emergency feedwater control valves before and after an EFW trip. However, automatic operation will automatically be selected on the occurrence of an EFW trip.

In addition, EFIC channel A is provided with a pressure control loop for the steam generator A atmospheric dump valve. EFIC channel B is provided with a pressure control loop for the steam generator B atmospheric dump valve. Transfer T8 describes provision for future transfer of ADV control to a location outside the main control room.

The steam generator atmospheric dump valve control logic requires no explanation.

3.4.6 Output Signals

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

A. The channel A EFW trip signal starts the electric emergency feedwater pump. The channel B trip logic admits steam to the turbine powered emergency feedwater pump. With this arrangement, at least one pump will be started with a single failure of the A or B trip logics.

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

B. If the cause of the EFW trip is low SG pressure in SG A, EFW will be tripped as in A above. In addition, the trip logics in channels A and B will issue SG A main steamline and 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 FW to that generator will be terminated in the presence of a single failure;

C. Isolation of SG B main steam and 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 and main steamline trip logics are employed;

D. Given the condition where both SG pressures are low, the events described in both 2 and 3 above will occur; and

E. The emergency 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.

3.4.7 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 signal is removed, the controller design shall be such that valves (other than the EFW control valve) will not change position and pumps will not change state without a specific manual command. When the vector logic close command to the EFW control valve is removed, the control valve shall be positioned as required by the EFW control system or the manual control, as selected.

3.4.8 Input Signals

3.4.8.1 OTSG Level Sensing

Figure 3.4-8 contains the proposed arrangement for OTSG level sensing. The acceptability of this design will depend on the accuracy of the measurement. Allowable instrument error requirements to render this design acceptable are given in Appendix B.

To provide for low level control and initiation signals for the emergency feedwater, four differential pressure transmitters (dP transmitters) will be added. The sensing lines for these transmitters will be connected between the unused existing level sensing connection located 277 inches above the top face of the lower tube sheet and manifolded to the existing low levels tops at six inches above the top face of the lower tube sheet.

To provide high level control and overfill protection signals, four dP transmitters will be added. The upper sensing connections will be manifolded with the upper sensing line of the existing operating range level transmitters. The lower sensor connections will be manifolded with the lower sensing line of the existing operating range level transmitter.

There are four drain line connection (located approximately five inches below the face of the tube sheet) which can be used for the lower sensing lines of all added transmitters. These will be manifolded as necessary to best serve the redundancy requirements.

3.4.8.2 Main Steam Header Pressure

To provide for steam generator pressure input, four transmitters will be provided on each steam generator.

3.4.8.3 Trip of Main Feedwater Pumps

To input, pump trip indication signals will be provided parallel from pressure switches used for anticipatory reactor trip input through the NI/RPS.

3.4.8.4 Trip of Reactor Coolant Pumps

To input pump trip indication, signals will be provided from NI/RPS. These inputs are from power pump monitor units.

3.4.9 EFIC Trip Testing

Figure 3.4-7 illustrates the trip philosophy of the EFIC in simplified form for one EFIC trip function (e.g., EFW 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.

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

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

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

C. 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,

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

E. 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,

F. The trip logic reset switches can now be depressed to reset the half trip. The confirm lamp should go out,

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

H. The foregoing tests may be conducted for all trip functions from all channels for complete trip testing, and

I. 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 the foregoing test philosophy while minimizing the probability of inadvertent initiation.

4.0 SYSTEM LIMITS, PRECAUTIONS AND SETPOINTS

4.1 Limits and Precautions

4.1.1 EFW Flow Limits

Maximum allowable flow -	1175 gpm/SG
Minimum allowable flow -	740 gpm

4.1.2 EFW Pump Suction Pressure

EFP-1 minimum NPSH -	21 feet
EFP-2 minimum NPSH -	23 feet

4.1.3 System Limits (Design)

Pressure -	1600 psig
Temperature -	465 ^{o}F

4.2 Setpoints

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 (1065 psia) referenced from the top of the lower tube sheet.

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 shown in Appendix C. 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 EFW.

4.2.1 Low SG Level EFW Initiate Setpoint

This is a protective setpoint designed to initiate EFW 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.

4.2.2 EFW Control Level (3 Foot Level) Setpoint

This is a level control setpoint designed to be automatically selected following initiation of EFW 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.

4.2.3 Natural Circulation Control Level (20 Foot Level) Setpoint

This is a level control setpoint designed to be automatically selected following initiation of EFW 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 full range level instrumentation is used to monitor steam generator level at his point and to provide signals to the EFIC control system. For setpoints, see Table 4.2-1.

4.2.4 Steam Generator Overfill Setpoint

This is a protective setpoint designed to automatically terminate EFW or main feedwater flow to a steam generator. This setpoint is required to prevent steam generator level from increasing to a level at which feedwater would flow into the main steam lines. This setpoint can be manually bypassed to allow the setpoint described in Section 4.2.5 to be reached. The high range level instrumentation is used to monitor steam generator level at this point. For setpoints, see Table 4.2-1.

4.2.5 ECCS Fill Limit Setpoint (31.5 Feet Level)

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. To preclude terminating feedwater flow before this setpoint is reach, the steam generator overfill setpoint described in, Section 4.2.4 must be manually bypassed. The full range level instrumentation is used to monitor steam generator level in this region. For setpoints, see Table 4.2-1.

4.2.6 Low Steam Generator Pressure Setpoint

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

4.2.7 Steam Generator Differential Pressure Setpoint

This is a pressure setpoint designed to 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. Pressure instrumentation string requirements are given in Appendix B. For setpoints, see Table 4.2-1.

4.2.8 Automatic Dump Valve Operating Setpoint

This is a pressure setpoint designed to automatically open the atmospheric dump valves to relieve steam generator pressure. This setpoint is lower than the steam generator 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

The EFW 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.

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 with the exception of the low OTSG level initiate of EFW and the high OTSG level overfill termination. The power/main FW flow trip will 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.

When the first RC pump is started, the "Loss of 4 RC Pumps" initiate signal may be manually bypassed. This is accomplished by depressing the "Bypass Reset" button located in each of the EFIC cabinets. If the bypass is not manually reset, it will be automatically reset when the plant reaches 10% power. As the plant begins heating up, the bypass of the low OTSG pressure signal will be reset. This bypass reset will automatically occur for both OTSG's when the first steam generator reaches 750 psig. The operator should ensure that both steam generators are above 600 psig before the bypass reset occurs.

5.2 Hot Standby to Full Power

At hot standby conditions, all trip functions should be active except the MFW pump trip. (The power/MFW flow trip is still effectively bypassed since this trip will allow power to be increased to approximately 20% with no main feedwater flow). As power is increased, the MFW pump trip will automatically become active at about 20% power. The logic for this function is located in the NI/RPS. No operator actions are required.

When reducing power from full power to hot standby, no operator actions are required. The power/MFW pump trip will be automatically bypassed in the NI/RPS when power is reduced below approximately 20%. The operator should confirm that this action has been taken.

5.3 Cooldown from Hot Standby to Cold Shutdown

During the cooldown, two shutdown bypasses must be implemented. The first is the low steam pressure shutdown bypass. When both steam generators are below 750 psig, this bypass may be implemented by depressing the low steam pressure shutdown bypass buttons located in the EFIC cabinets. One button in each of the four channels must be depressed. This action must be taken before either OTSG pressure reaches 600 psig.

The second shutdown bypass is for the "Loss of 4 RC Pumps" trip. This shutdown bypass may be implemented at any time after power has been reduced below 10%. However, for most operating conditions, it is recommended that this trip function remain active until after the Decay Heat Removal System has been initiated and the system is ready for the last RC pumps to be tripped. As with the low steam pressure shutdown bypass, this action must be taken by depressing the Loss of 4 RC Pumps Shutdown bypass buttons on the EFIC cabinets.

5.4 Wet Layup

Wet layup of a steam generator requires a level above the overfill setpoint. One method of achieving wet layup is to fill the OTSG until the overfill setpoint is reached and flow through the MFW lines is terminated. The operator may then take manual control by depressing the MFW Isolation "Manual" buttons (one for each train) in the control room. This overrides the MFW isolation signal and allows the operator to continue to fill the OTSG. Filling in this manner allows a complete test of the MFW isolation functions each time the OTSG's are taken to a wet layup condition.

6.0 CASUALTY EVENTS AND RECOVERY PROCEDURES

6.1 Casualty Events

As part of the design of the EFW 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 steam line isolation valve closure,

G. Main feedline break,

H. Main steam line break/auxiliary feedwater line break,

I. Small break LOCA, and

J. OTSG overfill.

6.2 Design Features to Mitigate Effects of Casualty Events

6.2.1 Loss of Main Feedwater (LMFW) - Upon loss of all feedwater, both EFW pumps are automatically initiated by the EFIC system. A minimum flow rate of 740 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 operator actions are to confirm that EFW flow has been initated 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 EFW system is used to establisn natural circulation. Both EFW pumps are automatically initiated by the EFIC system. The level rate control system will automatically raise the level in the OTSG's to about 20 ft. at a rate of about 4"/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 event, the level should increase to 20 ft. at 4"/minute without requiring any operation action. For lower decay heat event, the excess EFW 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 EFW 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 900 psig. This feature should minimize the potential for overcooling. For very low decay heats, the operator may have to make manual control of the EFW system and further reduce EFW flow to keep from loosing 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 - This event is not a design basis for the plant, but the EFW system is designed to supply 740 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 EFW should start and raise the level to 20 ft. as described in Section 6.2.2.

6.2.4 Plant Cooldown - The EFW 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 EFW pump can be used with the atmospheric dump valves to cool the plant down to the Decay Heat Removal System cut-in temperature. Since this is not a design basis requirement for this system, specific calculation of time to cooldown the plant using atmospheric dump valves have not been made.

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

6.2.6 Main Steam Line Isolation Valve Closure - Again this event does not affect the EFW system unless MFW fails.

6.2.7 Main Feed Line Break - This break is a more abrupt case of LOFW and has approximately the same requirements for EFW flow. If the break is upstream of the last feedwater line check valve, the accident should proceed as the loss of main feedwater event described in Section 6.2.1. If the break is downstream of the last check valve, the steam generator will blow down to the containment. When the steam generator has depressurized below approximately 600 psi, the steam generator isolation logic will isolate the main feedwater and main steam lines to the affected steam generator. After isolation, the Vector Logic will supply EFW only to the intact steam generator. The only required operator actions are to confirm that the proper automatic actions were taken.

6.2.8 Main Steam Line Break/Emergency 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, the depressurized steam generator will be automatically isolated. Some brake sizes and locations may cause both steam generators to depressurize below 600 psig and both will be isolated. If the brake is downstream of the isolation valve, both steam generators should repressurize. EFW will then be fed to both steam generators. If the break is upstream of the isolation valve, only one steam generator will repressurize. The Vector Logic will direct EFW only to the intact steam generator. The only required operator actions are to confirm that the proper automatic actions were taken.

6.2.9 Small Break LOCA - For a small break LOCA (SBLOCA) event, the EFW system will be automatically initiated by an ESFAS 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 about 4"/minute in the steam generators to the natural circulation setpoint of approximately 20 ft. This fill process is expected to require approximately 50 minutes, unless the operator has further throttled the EFW system to avoid exceeding the 100° F OTSG cooldown rate. During this time, current procedures required that the operator diagnose the event to determine that it is a SBLOCA. When this determination has been made, the operator is instructed to raise the OTSG level to approximately 31 feet. The purpose of raising the level is to assist in establishing steam condensation natural circulation if part of the primary system is voided. The action to raise the level should be taken while the OTSG is filling to 20 ft. During this time, there will be substantial EFW flows high in the OTSG. These flows will provide good heat transfer high in the OTSG.

In order to raise the level to 31 ft., the operator must select the "High-High Level EFW Control" setpoint on the EFW control station. Selection of this setpoint will continue the filling of the OTSG at about 4"/minute to the 31 ft. level. A second action the operator should take is to bypass the EFW overfill protection. The setpoints for overfill termination will probably prevent filling the OTSG to the desired level if they are not bypassed. Bypassing these setpoints requires that the operator go the EFW cabinets and press the bypass button in each channel. This action cannot be taken from the EFW control station.

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 EFW control valves. EFW can then be manually controlled as required for a given situation.

6.2.10 OTSG Overfill - A main feedwater (MFW) overfill event is detected by a high range ΔP signal. This signal essentially detects the level in the OTSG downcomer. When an excessive level is detected (~31 ft.) 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.

An EFW overfill event is detected in the same manner as the MFW overfill. The action taken is to close the EFW isolation and control valves to the affected OTSG. For an EFW overfill event, however, the overfill protection circuit will automatically return control to the EFIC when OTSG level has dropped to a reset setpoint of about 28 ft. No operator action is required for an EFW overfill. The operator should determine the cause of the overfill and correct it. Otherwise, the level will probably cycle between the overfill setpoint and the reset setpoint.

7.0 TESTING AND MAINTENANCE

The EFW System is designed to allow periodic testing during power operation. Routine maintenance activities, however, should be performed during plant outages. The technical specifications will allow one train of the EFW 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 EFW system during power operation. The pumps can be tested by manually starting them and operating for at least 5 minutes with recirculation flow. The EFW control valves are closed in the absence of an automatic initiation signal. Therefore, no system realignment or bypassing is required to perform this test.

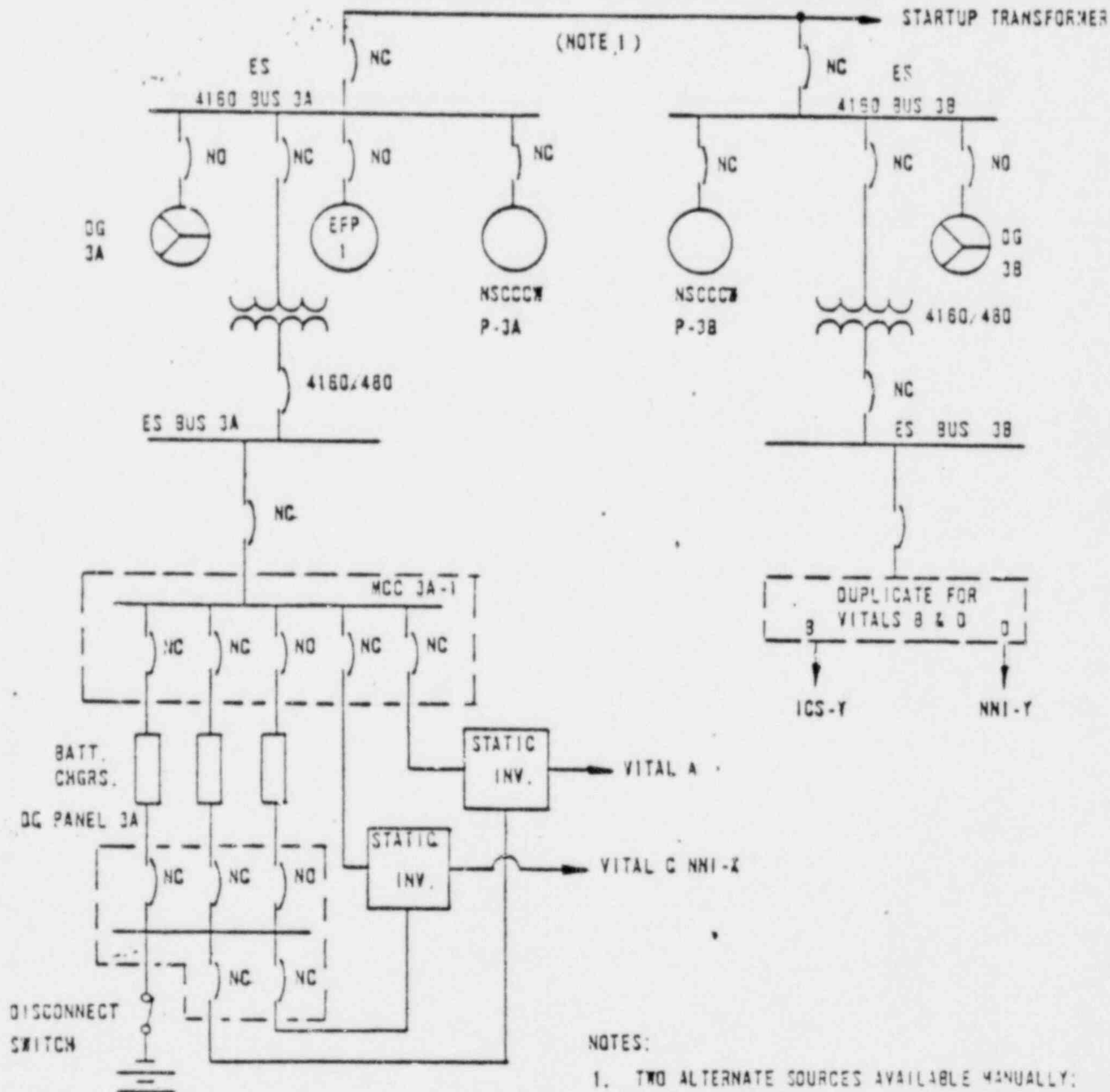
All automatic valves in the EFW system can be full stroke exercised during power operation. No system realignment is required to perform these valve tests.

7.2 Periodic Testing of the EFIC

The EFIC is designed to allow testing during power operation. One channel should be placed in "maintenance bypass" prior to testing. This will bypass only one channel of EFW initiate logic. An interlock feature prevents bypassing more than one channel at a time. In addition, since the EFIC receives signals from the NI/RPS, the maintenance bypass from the NI/RPS is interlocked with the EFIC. If one channel of the NI/RPS is in maintenance bypass, only the corresponding channel of the EFIC may be bypassed (e.g., channel A NI/RPS and channel A EFIC). Administrative procedures should be written to ensure that only corresponding channels of the EFIC and NI/RPS are placed in maintenance bypass at the same time.

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 toactuate 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.

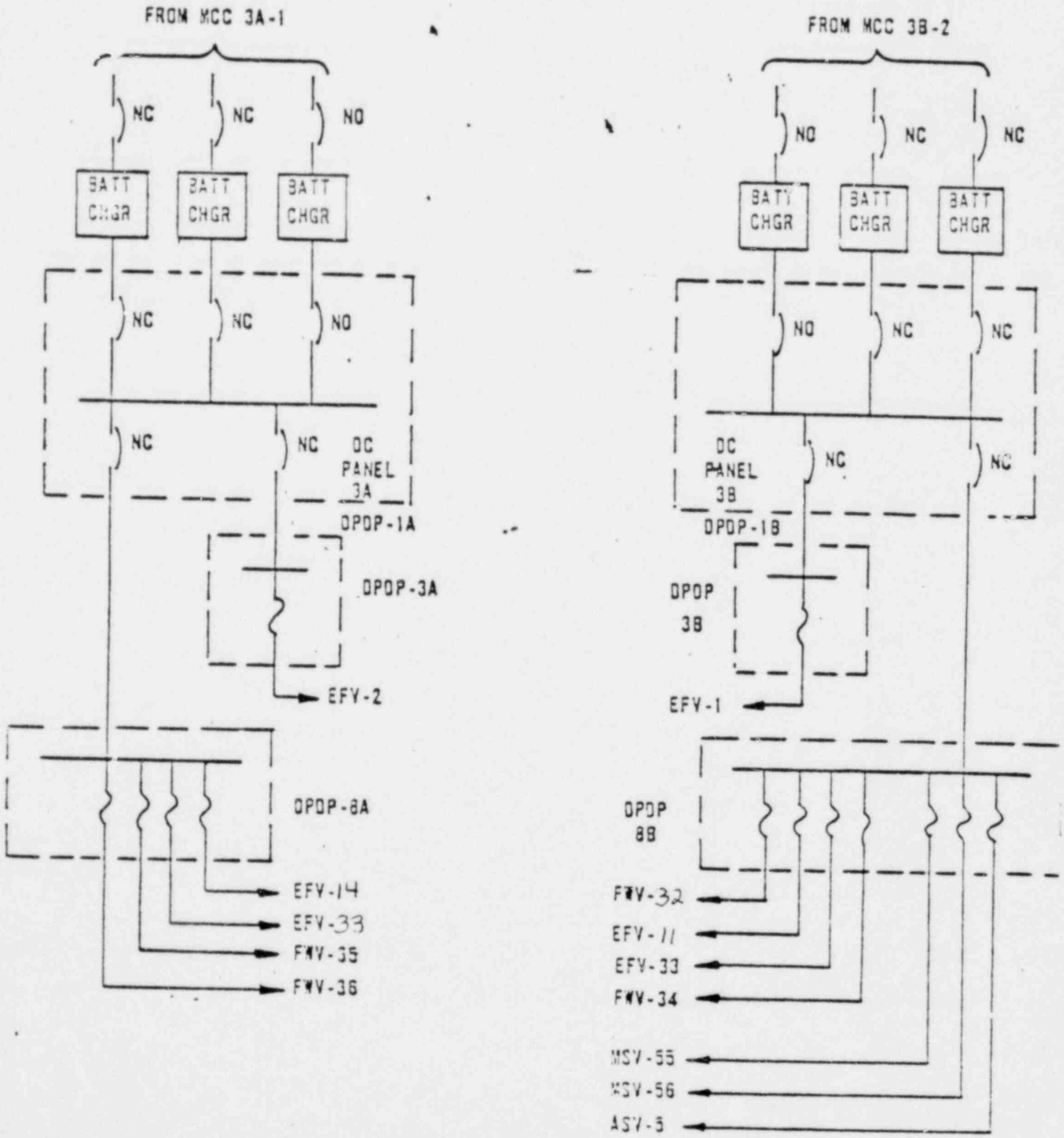
Figure 3.3-1
CRYSTAL RIVER UNIT
SIMPLIFIED POWER SOURCE DIAGRAM



NOTES:

1. TWO ALTERNATE SOURCES AVAILABLE MANUALLY: UNIT 1/2 STARTUP XFMR WITHIN MINUTES AND UNIT 3 AUX. XFMR WITHIN EIGHT HOURS.

Figure 3.3-2
CRYSTAL RIVER UNIT 3
SIMPLIFIED POWER SOURCE DIAGRAM
DC LOADS



CRYSTAL RIVER UNIT 3
SIMPLIFIED POWER SOURCE DIAGRAM
AC VALVES

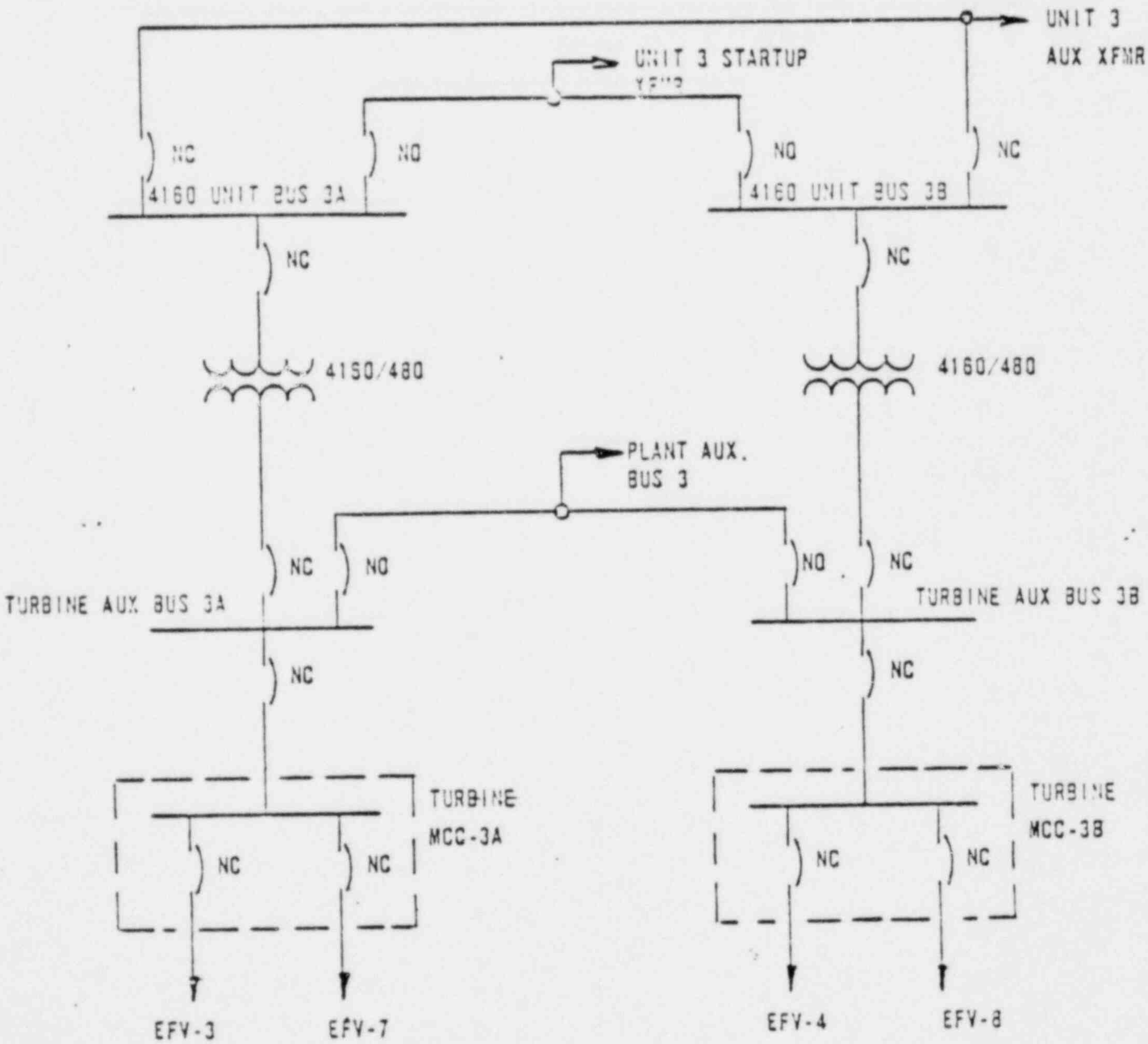


FIGURE 3.3-3

FIGURE 4.2-1
CRYSTAL RIVER UNIT 3
FLUX TO FEEDWATER SETPOINT

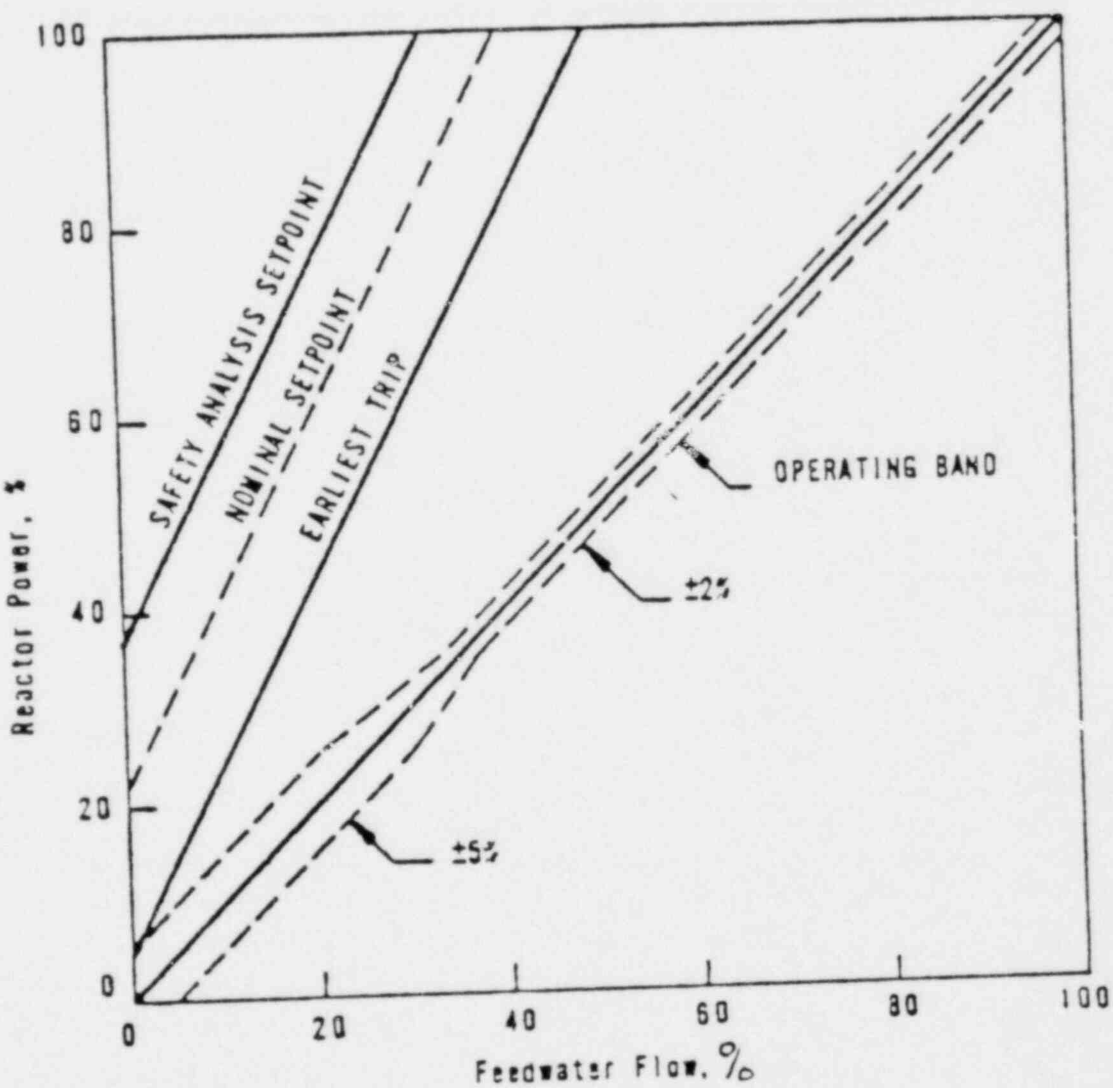


Table 4.2-1

EFW SYSTEM SETPOINTS

SETPOINT	NORMAL SETPOINT	MAXIMUM SETPOINT		MINIMUM SETPOINT	
		NORMAL	ACCIDENT	NORMAL	ACCIDENT
Low SG Level Initiate	12"	15"	N/A	9"	N/A
EFW Control Level **	36"	39"	N/A	33"	N/A
Natural Circulation Control Level	240"	246"	263"	234"	192"
Steam Generator Overfill	*374"	380"	N/A	368"	N/A
ECCS Fill Limit	379"	N/A	394"	N/A	343"
Low Steam Generator Pressure	600 psig	625 psig	***N/A	575 psig	***N/A
Steam Generator Differential Pressure	100 psig	150 psig	***N/A	50 psig	***N/A
ADV Opening SetPoint	1020 psig	1045 psig	***N/A	995 psig	***N/A

* It is recommended that this setpoint be established at 15% above the normal operating range of the steam generator. This setpoint was used in the analyses establishing setpoints for this document.

** Accident environments were not considered for this measurement since current procedures require the RC Pumps to be tripped on a low pressure ESFAS. If this procedure is changed, these setpoints should be reevaluated.

*** It is assumed that the steam generator pressure measurements will be located outside the reactor building and therefore accident environment errors do not apply.

All level setpoints refer to the equivalent height of a saturated water column (1064 psia) 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.

APPENDIX A

TABULATION OF DRAWING NUMBERS VS. FIGURE NUMBERS

FOR

CRYSTAL RIVER-3 EFW SYSTEM

FIGURE NUMBER	B&W DRAWING NUMBER
3.1-1	1121232D
3.4-1	1122969F
3.4-2	1122968E
3.4-3a	1122972C
3.4-3b	1122973C
3.4-3c	1122974C
3.4-4	1122967D
3.4-5	1122971E
3.4-6	1122970C
3.4-7	1122966C
3.4-8	1121441C
3.4-9	1122965B

APPENDIX B

INSTRUMENTATION REQUIREMENTS

1. <u>Low Range Level Instrument String</u>

   a. Tap Elevations ______ 6" & 277"
   b. Scale ______ 0-150"
   c. Pressure ______ 1200 psig
   d. Temperature ______ 600 F
   e. Instrument String Errors:

   * e.1 Normal Operating Environment ______ ±3"
   ** e.2 Small LOCA Environment ______ ±15
   Reference Leg Heatup ______ -20

   See Note 1.

2. <u>High Range Level Instrument String</u>

   a. Tap Elevations ______ 102" & 394"
   b. Scale ______ 100" - 400"
   c. Pressure ______ 1200 psig
   d. Temperature ______ 600 F
   e. Instrument String Errors:

   * e.1 Normal Operating Environment ______ ±6
   ** e.2 Small LOCA Environment ______ ±15
   Reference Leg Heatup ______ -21"
   *** e.3 Design Break Environment ______ ±23"
   Reference Leg Heatup ______ -25

   See Note 1.

3. <u>Full Range Level Instrument String</u>

   a. Tap Elevations ______ 6" & 394"
   b. Scale ______ 0-400"
   c. Pressure ______ 1200 psig
   d. Temperature ______ 600 F
   e. Instrument String Errors:

   * e.1 Normal Operating Environment ______ ±6"
   ** e.2 Small LOCA Environment ______ ±15"
   Reference Leg Heatup ______ -21"
   *** e.3 Design Break Environment ______ ±23"
   Reference Leg Heatup ______ -25"

   See Note 1.

4. Pressure Instrument Strings

   a. Span ______________ 0-1200 psig
   b. Response Time ______ 1 second
   c. Instrument String Errors:

   * c-1 Normal Operating Environment ______ $\pm$25psi

   * Normal Operating Environment - 30F to 140F/100%RH
   ** Small LOCA Environment - 80F to 240F/100%RH
   Radiation Dose Air (TID Rads) - 2 Hours = 8.6×10^3
   36 Hours = 5.0×10^4
   30 Days = 8.2×10^4
   Peak Building Pressure ________ 43 psia @ 2500 seconds after accident
   *** Design Break Environment - 80^oF to 280^oF/100% RH
   Radiation Dose Air (TID Rads) - 1000 hrs - 3.3×10^3
   Peak Building Pressure ________ 55 psig @ 20 seconds
   Spray pH ______________________ 7.5 to 10.0

Since no SLB analysis has been performed for the 177-FA plants the design break LOCA environment conditions were considered conservative and used for temperature, RH, Peak Building Pressure, and spray pH. The radiation dose used is the requirement for the 205 FA plants and is therefore considered conservative since the 205-FA plant power level is higher than the 177-FA plant power level.

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.

APPENDIX C

FLUX/FEEDWATER SETPOINT

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

$$\phi = 1.9 \text{ WFW} + 21$$

Where: WFW = Feedwater flowrate in % secondary 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 seconds.

APPENDIX D

BALANCE OF PLANT CRITERIA FOR EFIC

This Appendix provides data for use in planning for installation of the Emergency Feedwater Initiation and Control System (EFIC). The data is of a general nature with exact values, counts, etc provided in the EFIC data. Since the data addresses no specific plant, the user must utilize the data and adapt it to this plant and mode of construction.

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 associated 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 EFW 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 EFW 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 (e.g., remote switches, hand/auto stations, transmitters, indicators, etc) which are:

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.

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 must be powered by the same vital power source as the NI/RPS and ESFAS channels which provide input signals.

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 presently two level sensors per channel per steam generator. Total of eight conductors per channel exclusive of safety grounds, etc.

6.3 Pressure Sensors

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

6.4 EFAS ECC Actuation

Presently there are two actuation signals from ESFAS actuation channel. Total of four conductors. This same format is repeated for channel B.

6.5 NI/RPS Signal

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

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

Signal	Conductors
RC Pump 2B Trip	2
MFW Pump A & B Trip and	2
MFW/Power Ration 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.

Channel	No. of Signals
A	28
B	2[illegible]
C	8
D	8

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 of actuated devices.

6.10 Vector Signals

Each EFIC channel originates an open and close signal to SGA EFW valves as well as an open and close signal to SGB EFW valves. Total of eight conductors per EFIC channel.

6.11 EFW Control Valve Signals

Channel A provides one control signal for SGA EFW control valves. Channel A also provides one control signal for SGB EFW control valves. Each signal involves two conductors. The total is four conductors for channel A. This format is repeated for channel B.

6.12 ADV Control Signals

Channel A utilizes two conductors to transmit control signals to the SGA ADV. Channel B also utilizes two conductors to transmit control signals to the SGV ADV.

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 & Backlighting	80
2) Post Accident Monitoring	12
3) Hand Control SGA Level	6
4) Hand Control SGB Level	6
5) Hand Control SG ADV	6
6) Set Point Selection	8
7) 20'/31.5' SGA Selection	4
8) 20'/31.5" SGB Selection	4

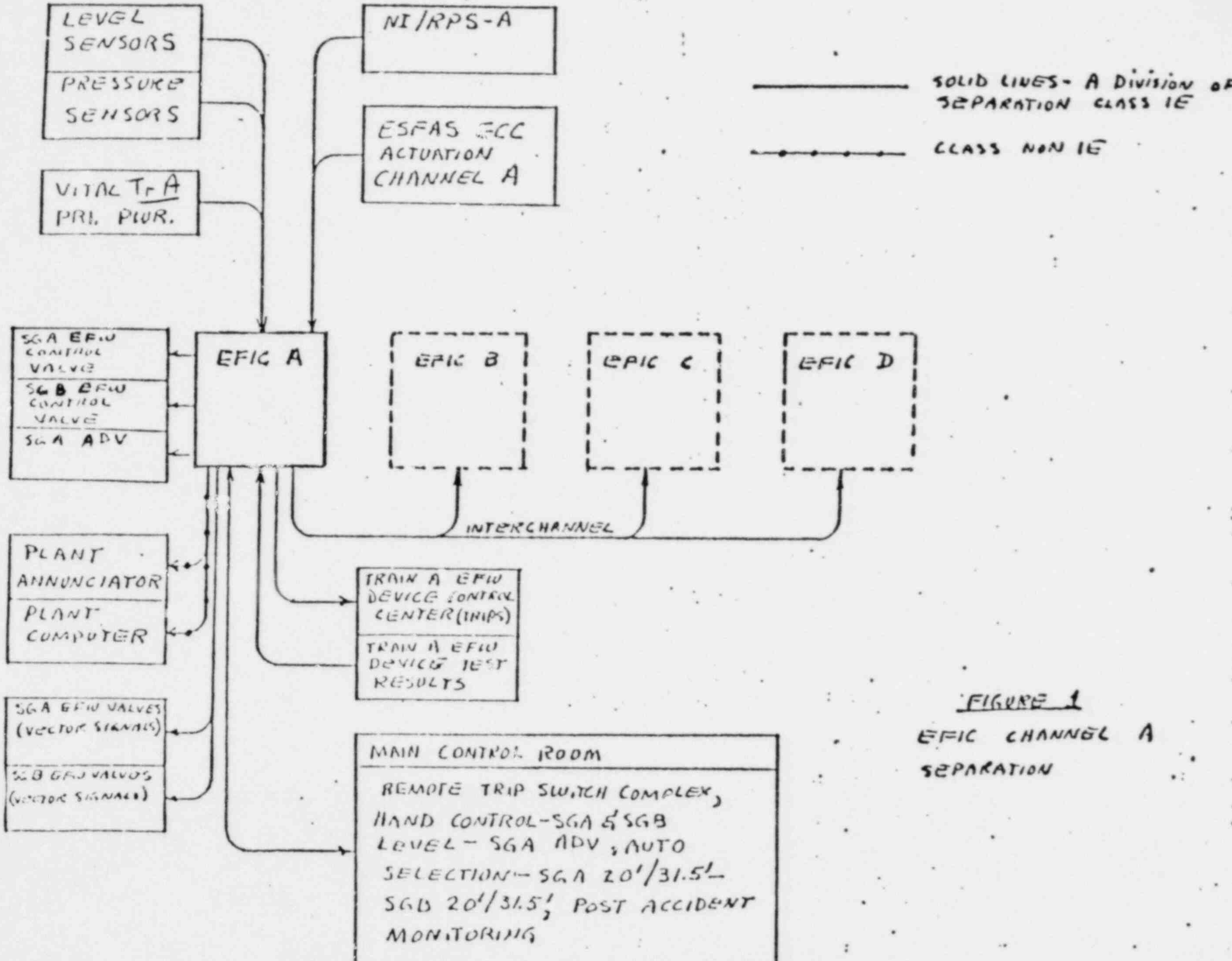


FIGURE 1
EFIC CHANNEL A SEPARATION

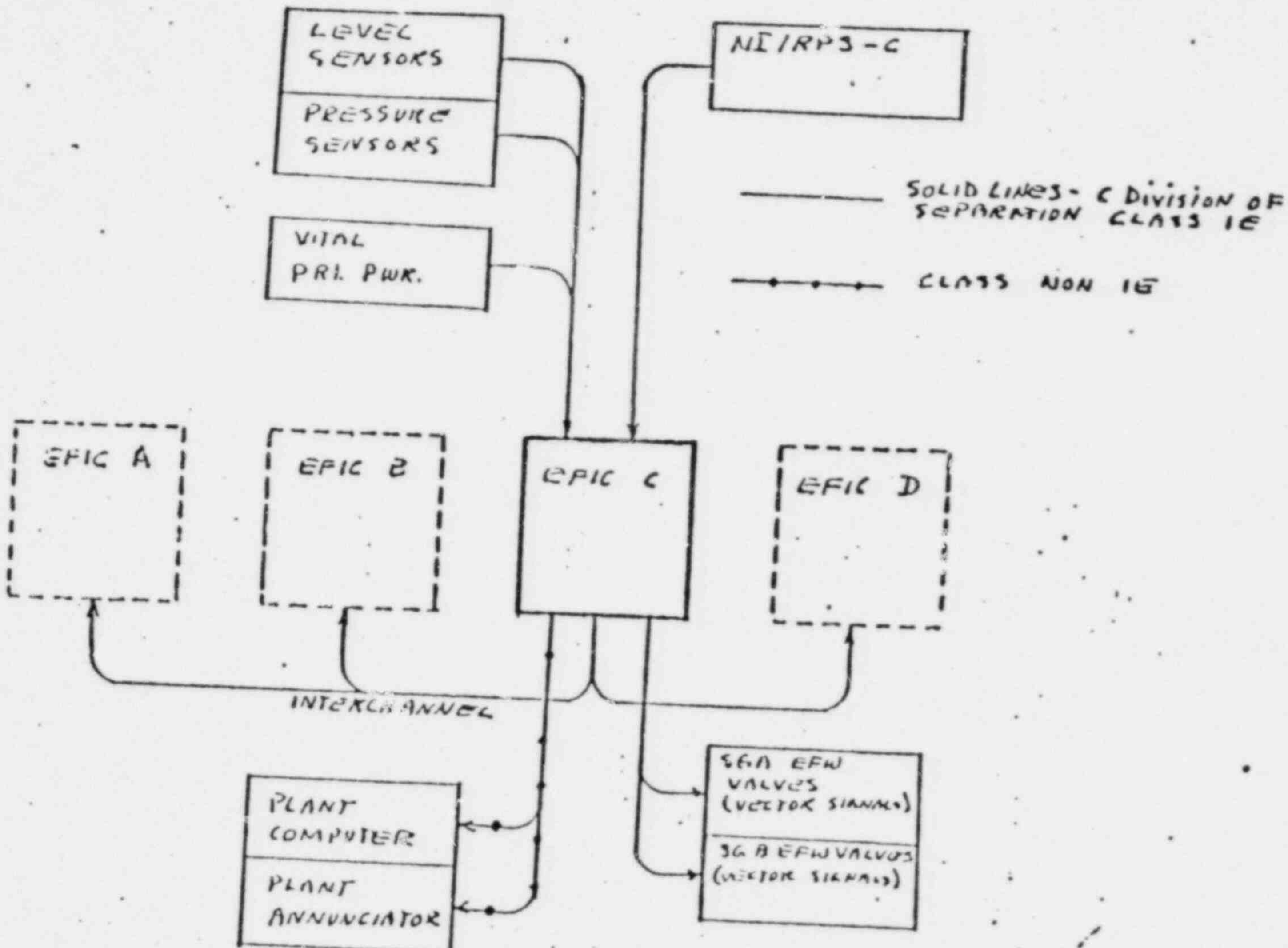


FIGURE 3
EFIC CHANNEL C
SEPARATION

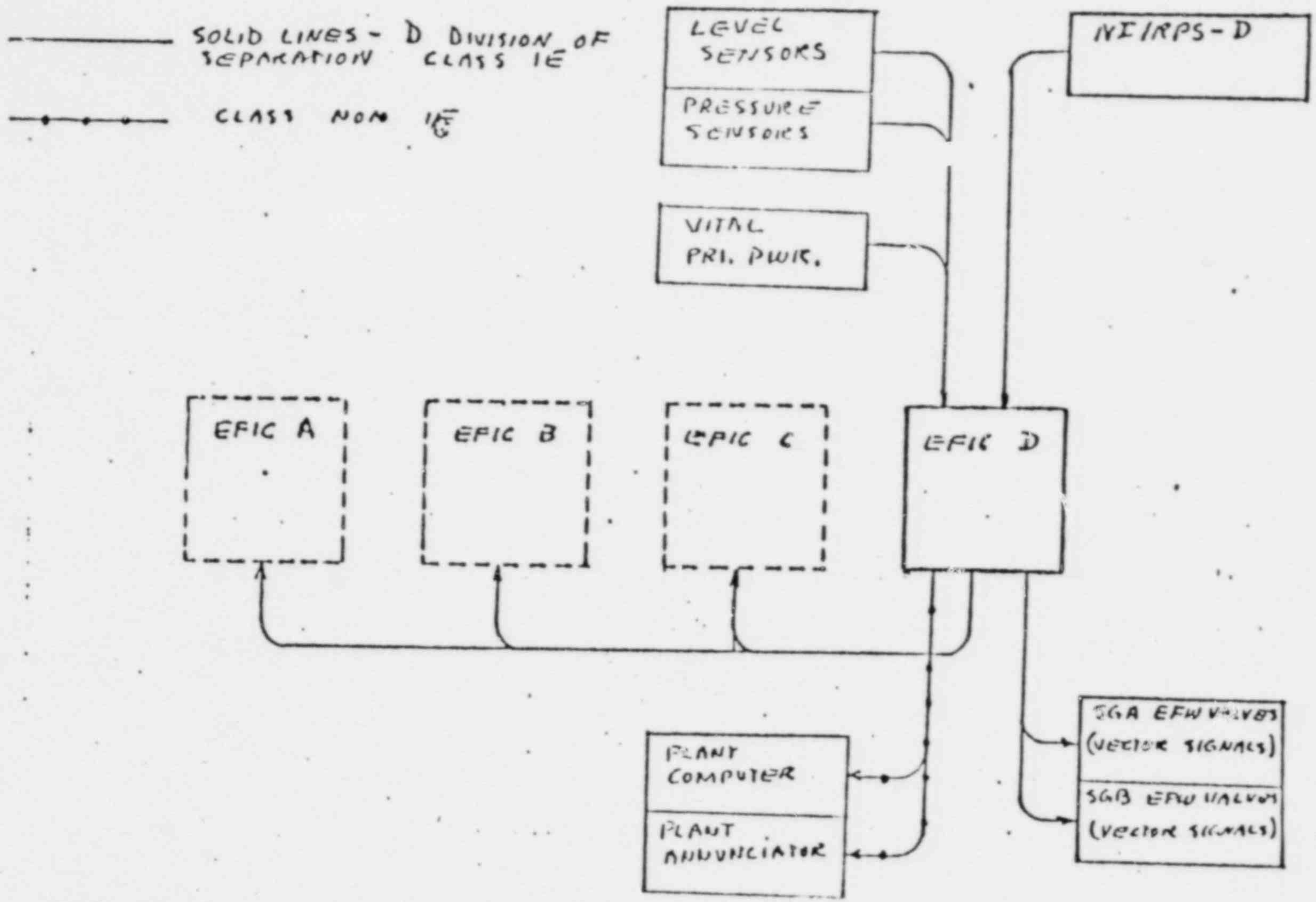


FIGURE 4
EFIC CHANNEL D SEPARATION