POINT BEACH NUCLEAR POWER PLANT

DBD-01

AUXILIARY FEEDWATER SYSTEM

DESIGN BASIS DOCUMENT

Revision 2

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A/193

TABLE OF CONTENTS

		Page
LIST OF TABLES		v
LIST OF FIGURES		vi
PREFACE		vii
1.0	FUNCTIONAL DESCRIPTION	1-1
1.1	Introduction	1-1
1.2	Configuration History	1-1
1.3	System Boundaries and Interfaces	1-3
1.3.1	Mechanical Boundaries	1-3
1.3.2	Electrical Boundaries	1-5
1.3.3	Instrument and Control Boundaries	1-6
1.3.4	Structural Boundaries	1-8
1.3.5	Boundary Differences Between Units	1-8
1.4	Unit Differences	1-8
1.5	System Support	1-8
1.5.1	Support Services Supplied by the AFW System	1-8
1.5.2	Support Services Supplied to the AFW System	1-8
2.0	SYSTEM DESIGN BASES	2-1
2.1	System Functions	2-2
2.1.1	Safety-Related Functions	2-2
2.1.2	Non-Safety-Related QA Functions (Augmented Quality)	2-2
2.1.3	Non-Safety-Related Non-QA Functions	2-3
2.2	System Parameters Summary	2-8
2.2.1	Minimum Flow Requirements at Operating Pressure	2-10
2.2.2	System Response Time	2-15
2.2.3	System Endurance ("Run-Time")	2-18
2.2.4	System Controls	2-21
2.2.5	Water Temperature Operating Limits	2-25
2.2.6	Power Requirements	2-26
2.2.7	System Hydraulic Requirements	2-29
2.2.8	System Design Pressure/Temperatures	2-31
2.2.9	Seismic and Other Environmental Hazards Design Requirements	2-34
2.2.10	Vibration and Reaction Force Design Requirements	2-35
2.2.11	Environmental Qualification Requirements	2-36
2.2.12	System Interlocks and Permissives	2-37
2.2.13	Redundancy, Diversity, Separation Requirements	2-38

TABLE OF CONTENTS (continued)

		Page
2.2.14	System Material Requirements	2-40
2.2.15	System Chemistry Requirements	2-41
2.2.16	Fire Protection Requirements	2-42
2.2.17	Containment Isolation Requirements	2-45
3.0	COMPONENT DESIGN BASIS	3-1
3.1	Auxiliary Feedwater Pumps	3-2
3.2	Condensate Storage Tanks	3-30
3.3	Piping	3-42
3.4	MDAFWP Discharge MOVs	3-46
3.5	TDAFWP Discharge MOVs	3-54
3.6	AFW Pump Suction Valves from Service Water	3-62
3.7	Steam Supply (Admission) Valves to AFW Pump Turbines	3-68
3.8	AFW Pump Recirc Flow Control Valves (AOVs)	3-76
3.9	MDAFW Pump Discharge Pressure Control Valves (AOVs)	3-85
3.10	AFW Pump Suction Check Valves	3-92
3.11	AFW Pump Discharge Check Valves	3-95
3.12	AFW Second-Off Check Valves	3-96
3.13	AFW First-Off Check Valves	3-97
3.14	AFW Pump Suction Relief Valves	3-98
3.15	AFW Pump Recirculation Line Relief Valve	3-102
3.16	AFW Pump Recirculation Line Orifices	3-106
3.17	AFW System Flow Transmitters	3-109
3.18	AFW System Pressure Transmitters	3-111
3.19	AFW System Level Transmitters	3-113
3.20	First-Off AFW Backup Nitrogen Accumulators Check Valves	3-115
3.21	TDAFW Pump Trip Throttle Valves	3-116
4.0	CODES, STANDARDS AND REGULATORY DOCUMENTS	4-1
4.1	General Design Criteria	4-1
4.2	Codes and Standards	4-4
4.3	Regulatory Documentation	4-5
5.0	SYSTEM OPERATION	5-1
6.0	INSPECTION AND TESTING	6-1
7.0	MODIFICATIONS AND SPEEDS	7-1
7.1	AFW Modifications	7-1
7.2	AFW System SPEEDs	7-13

TABLE OF CONTENTS (continued)

		Page
8.0	CALCULATION SUMMARIES	8-1
9.0	REFERENCES	9-1
9.1	Industry Codes, Standards and Regulations	9-1
9.2	Regulatory Correspondence and Documents	9-1
9.3	Technical Correspondence, Analyses, and Reports	9-6
9.4	Calculations	9-12
9.5	WE Drawings, Specifications, Modifications, and Other Documents	9-15
9.6	Vendor Reports, Specifications, and Drawings	9-25
9.7	Vendor Manuals	9-28
ATTACHMENT A - OPEN ITEMS		A-1
ATTACHMENT B - Descriptions of FSAR Chapter 14 Events Mitigated by AFW		B-1

LIST OF TABLES

		Page
Table 1-1	DBD/CHAMPS Scope Differences	1-10
Table 2-1	Deleted	N/A
Table 2-2	Alarm Circuits	2-24
Table 2-3	Safe Shutdown Components	2-44
Table 7-1	AFW Modifications	7-1
Table 7-2	AFW System SPEEDs	7-15

LIST OF FIGURES

		Page
Figure 1-1	AFW System - Major Flow Paths	1-2
Figure 2-1	AFW Logic Tree - Accident Mitigation Requiring Decay Heat Removal	2-4
Figure 2-2	AFW Logic Tree Accident Mitigation Requiring SG Level Maintenance	2-5
Figure 2-3	AFW Logic Tree Accident Mitigation Requiring Forced Cooldown for SGTR	2-6
Figure 2-4	AFW Logic Tree - AFW Isolation of a Faulted Steam Generator	2-7
Figure 3-1	Unit 1 Turbine-Driven AFW Pump (1P-29) Performance Curve (1969)	3-8
Figure 3-2	Unit 2 Turbine-Driven AFW Pump (2P-29) Performance Curve (1969)	3-9
Figure 3-3	Motor-Driven AFW Pump (P-38A) Performance Curve (1969)	3-10
Figure 3-4	Motor-Driven AFW Pump (P-38B) Performance Curve (1969)	3-11

PREFACE

This Design Basis Document (DBD) contains the design bases for the Auxiliary Feedwater System. Design bases, as defined by Wisconsin Electric, include:

- ✓ *Functions* performed by systems and components
- ✓ Values (or ranges of values) for *performance parameters* that bound the design
- ✓ Other *design requirements* imposed by:
    - Regulatory requirements and PBNP commitments
    - Codes and standards of record
    - Voluntary choice

Along with design bases, this DBD contains "supporting design information". Supporting design information attempts to explain the reasons (the WHYs) for a design basis, usually in an historical context.

A DBD is not a licensing basis document. Licensing basis information is included in the DBD if it involves regulatory requirements and PBNP commitments related to design. Other licensing bases, such as administrative or training commitments, are not addressed in the DBD.

Section 1 briefly describes the system's design history, boundaries, and interfaces with other systems. Sections 2 and 3 contain system-level and component-level design bases, respectively. Section 4 lists applicable codes and regulatory documents. Other sections discuss system operation, testing, modifications, and calculations related to the design basis. Open items identified during DBD preparation are listed in Attachment A.

DBDs are primarily an engineering tool. The typical user of this information is assumed to be an engineer who routinely needs design basis information to prepare and review plant modifications, conduct safety evaluations, perform operability reviews and engineering analyses, identify testing requirements, and locate design-related regulatory commitments.

This DBD is written assuming the reader already has a working familiarity with the system and plant design. It is not intended to be a system description document - that information is available elsewhere. Instead of describing the actual design, a DBD contains the limits of the design, and the reasons, when known, for those limits.

Except for unique terms defined in the DBD text, standard abbreviations and acronyms are taken from the CHAMPS Plant Nomenclature Manual. System and component designators are consistent with those found in CHAMPS (except for Figure 1-1).

This information has been researched, assembled, reviewed, and validated in accordance with the DBD Program Manual. This DBD will be maintained as a "living document" and revised, as necessary, when the design basis is further clarified or modified.

1.0 FUNCTIONAL DESCRIPTION

1.1 Introduction

The Auxiliary Feedwater (AFW) System provides a means of removing the energy from the Reactor Coolant System during periods when the main feedwater supply is unavailable. AFW System flow is sufficient to ensure adequate heat transfer through the steam generators (SG), with the reactor tripped, to prevent reactor coolant system (RCS) pressure and temperature increases beyond accident analysis limits.

During accident conditions, the AFW System is required to deliver flow to steam generators at pressures equal to the pressure setpoint of the first safety valve down to the steam generator pressure where the residual heat removal system can be operated (approximately 125 psia).

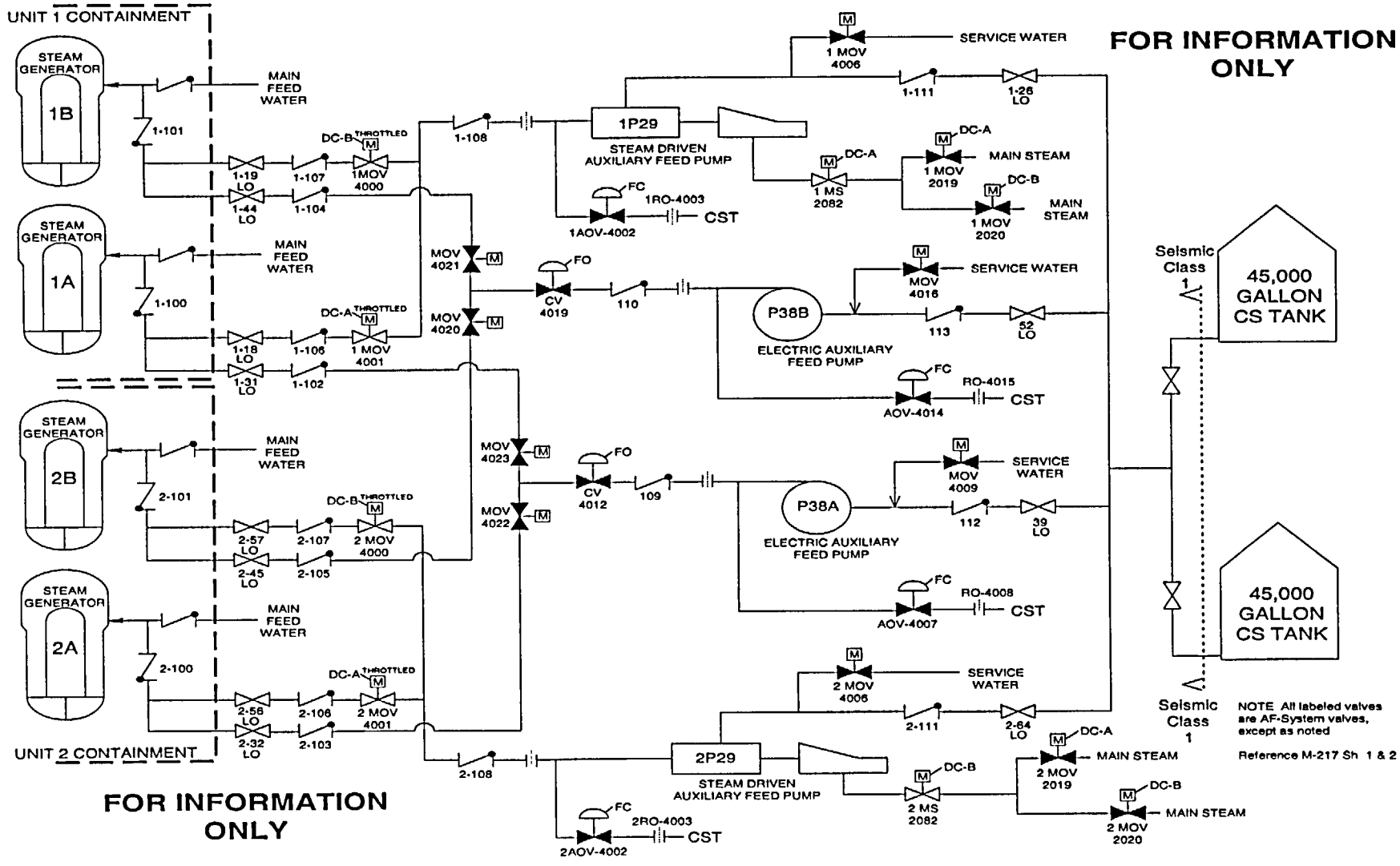
During non-accident conditions, the AFW System provides high pressure feedwater to the steam generators to remove thermal energy from the reactor coolant during shutdown conditions when operation of the main feedwater system is either unavailable or undesirable. The AFW System is also used to fill the steam generators for chemistry control or wet lay-up and support SG leak testing. A detailed description of AFW System functions is provided in DBD Section 2.

For illustrative purposes only, Figure 1-1 shows the major components and flow paths of the Auxiliary Feedwater System.

1.2 Configuration History

The Auxiliary Feedwater System (AFWS) was originally designed by Bechtel, Westinghouse, and Wisconsin Electric in late 1966 to early 1967. The system consists of two trains of independent pumps using a common line from the non-safety grade water source (CSTs) and four individual lines from the safety-grade water source, Service Water, to the suction of each pump. The two trains of pumps consist of a 200% capacity turbine-driven pump that is unit specific and capable of splitting flow between the two steam generators. The other train includes two 100% capacity motor driven pumps which are shared between units. One motor driven pump is capable of supplying flow to the 'A' generator for each unit. The other motor driven pump supplies the 'B' generator for each unit. In early design discussions the motor driven pump sizing was questioned in that a request was made to use motors with greater horsepower, but diesel loading restraints forced the decision to go with the current 250 HP motors. Also, the initial concept was for 1 MD pump with the same capacity as 1 TD pump. This evolved to 2 MD pumps with one-half TD pump capacity each. The final design became 1 MD pump = one-half capacity of one TD pump, which is why there are two extra bays in the AFW pump room **[REF 9.3.105, PBB-W-548]**. After Three Mile Island (TMI), a strong effort was made to upgrade AFW systems in the industry. Specific emphasis was placed on upgrading as much of the system as reasonably achievable to safety-related status with full implementation of single failure criteria. This resulted in the addition of a low suction pressure trip for each pump in 1985, so that the pumps would be protected during a seismic/tornado event to allow manual switchover to the Service Water System upon the incipient loss of the Condensate Storage Tank supply. Otherwise, the AFW system configuration is basically the same as original design in function and performance requirements.

Figure 1-1
AFW System - Major Flow Paths



1.3 System Boundaries and Interfaces

The scope of the AFW System includes the mechanical, electrical, instrument, and control components required for the system to perform its functions. The components that are within the system boundaries are identified in Section 3.0. Table 1-1 specifically identifies AFW System components that are scoped differently in this DBD than the system designation in CHAMPS.

1.3.1 Mechanical Boundaries

AFW System piping is connected to the following mechanical fluid systems:

- Main Steam
- Auxiliary Steam
- Main Feedwater
- Condensate
- Instrument Ai
- Service Water
- Water Treatment
- Blowdown Evaporator
- Secondary Sampling
- Fire Protection

In addition to mechanical piping connections, other AFW physical boundaries exist for instrument air, vents to atmosphere, drains, HVAC, and piping and equipment supports.

The mechanical scope of the AFW System includes the piping, valves, and components required to supply high pressure feedwater to the steam generators when the Main Feedwater System is not available. In general, this includes the AFW System components identified on the system P&ID [REF 9.6.21], as well as the steam supply valves and piping to the turbine-driven AFW pumps shown on the main steam system P&IDs [REF 9.6.22 and 9.6.23].

The bases for the boundary locations of each system interface are as follows:

1.3.1.1 Main Feedwater Boundaries

The boundaries between the AFW System and Main Feedwater System are located at the downstream side of the four steam generator inlet AFW header check valves (1AF-100, 1AF-101, 2AF-100, and 2AF-101 - these valves are also referred to as '1st off check valves').

1.3.1.2 Main Steam Boundaries

The boundaries between the AFW System and the Main Steam System are located at the upstream side of the four motor-operated steam supply isolation valves (1MS-2019, 1MS-2020, 2MS-2019, and 2MS-2020) for the turbine-driven AFW pumps. Although these valves are designated in CHAMPS as part of the Main Steam System, they are included within the AFW System boundary because the sole function of the associated equipment is to support turbine-driven AFW pump operation. Included in this boundary definition are the TDAFW pump trip throttle valves, 1MS-2082 and 2MS-2082, which perform the low suction pressure trip function for the respective TDAFW pump.

1.3.1.3 Service Water Boundaries

The boundaries between the AFW System and the Service Water System are located at the upstream side of the four motor-operated isolation valves (AF-4009, AF-4016, 1AF-4006, and 2AF-4006) between service water and the four individual AFW pump suction lines.

Four other AF-designated valves in the Service Water System are not included in the AFW DBD boundary. These are the automatic isolation valves (AF-4007A-S, AF-4014A-S, 1MS-2090-S, and 2MS-2090-S) that supply service water cooling to the AFW pumps. These valves are not included within the AFW System boundary because they are physically part of the Service Water System and do not supply water directly to the AFW System piping pressure boundary.

1.3.1.4 Secondary Sampling Boundaries

The boundaries between the AFW System and the Secondary Sampling System are located at the downstream side of the first manual valves (AF-22B, AF-35B, AF-48B, and AF-60B) in the sample lines.

1.3.1.5 Condensate Boundaries

The boundaries between the AFW System and the Condensate System are located at the upstream side of manual isolation valves 1CS-86, 1CS-93, 1CS-94, 2CS-86, 2CS-93, and 2CS-94, as well as at the downstream side of manual isolation valves 1CS-16, 1CS-111, 1CS-113, 2CS-16, 2CS-111, and 2CS-113. The boundary valves themselves are not included within the AFW System boundary. This is because the valves are associated with transferring water to and from the Condensate Storage Tanks, which is a Condensate System function.

1.3.1.6 Water Treatment Boundaries

The boundaries between the AFW System and the Water Treatment System are located at the downstream side of manual isolation valves WT-530B and WT-530C. The boundary valves themselves are not included within the AFW System boundary. This is because they are associated with transferring makeup water to the Condensate Storage Tanks, which is a Water Treatment System function.

1.3.1.7 Blowdown Evaporator Boundary

The boundary between the AFW System and the Blowdown Evaporator System is located at the downstream side of manual isolation valve BE-95. The boundary valve is not included within the AFW System boundary, because it allows waste distillate to be transferred to the Condensate Storage Tanks, which is a Blowdown Evaporator System function.

1.3.1.8 Auxiliary Steam Boundaries

The boundaries between the AFW System and the Auxiliary Steam System are located at the upstream side of manual isolation valves AF-69, HV-254, HV-739, and HV-4599 and at the downstream side of manual isolation valves HV-252, HV-253 and HV-255. The valves with an HV designator are not included within the AFW System boundary, because they are associated with lines whose function is associated with the Auxiliary Steam System.

1.3.1.9 Instrument and Service Air Boundaries

The boundaries between the AFW System and the Instrument and Service Air System are located immediately downstream of the filter-regulators which supply air-operated valves AF-4007, AF-4012, AF-4014, AF-4019, 1AF-4002, and 2AF-4002. Additional boundaries are associated with the backup nitrogen accumulators supplying AF-4012 and AF-4019 and are at the Instrument and Service Air side of isolation valves AF-130 and AF-150. These accumulators support the Instrument and Service Air System to supply a safety-related source of nitrogen to their respective valves.

1.3.1.10 Other Mechanical Boundaries

The AFW System boundaries are located at the end of the drain piping from drain traps, 1DT-2030, 1DT-2080, 1DT-2081, 2DT-2030, 2DT-2080, and 2DT-2081, at the downstream side of manual isolation valves 1MS-132A and 2MS-132A, and at the turbine-driven AFW pump exhausts to atmosphere.

1.3.2 Electrical Boundaries

AFW System electrical equipment is powered by the following electrical power systems:

- Vital Instrument Bus 120 VAC
- 120 VAC
- 125 VDC
- 480 VAC

AFW electrical boundaries with the above power systems are described generically, below. By convention, the boundary between an AFW electrical component and its power source is at the electrical terminals on the load. Overcurrent protection devices and the downstream power cable up to the load terminals are not included. The basis for the boundary locations are as follows:

1.3.2.1 480 VAC Boundaries

The 480 VAC Electrical System supplies power to the motor driven AFW pump motors, P-38A-M and P-38B-M, via 480 VAC safeguards load center breakers. The 480 VAC Electrical System also supplies operation and control power to the suction and discharge motor-operated valve (MOV) actuators associated with the motor driven AFW pumps, AF-4009-M, AF-4016-M, AF-4020-M, AF-4021-M, AF-4022-M, and AF-4023-M and to the suction MOV actuators associated with the turbine driven AFW pumps 1AF-4006-M and 2AF-4006-M via 480 VAC safeguards motor control center breakers.

1.3.2.2 125 VDC Boundaries

The 125 VDC Electrical System supplies power to the steam supply MOV actuators, the discharge MOV actuators, and the minimum recirculation control valve solenoids associated with the turbine driven AFW pumps 1AF-4000-M, 1AF-4001-M, 1AF-4002-S, 1MS-2019-M, 1MS-2020-M, 2AF-4000-M, 2AF-4001-M, 2AF-4002-S, 2MS-2019-M, 2MS-2020-M, 1MS-2082-S, 1MS-2082-M, 2MS-2082-S, and 2MS-2082-M via safety-related 125 VDC distribution panel breakers. In addition, the 125 VDC System supplies the minimum recirculation control valve and the discharge control valve solenoids associated with the motor driven AFW pumps, AF-4007-S, AF-4012-S, AF-4014-S, and AF-4019-S, are supplied by the 125 VDC Electrical System via circuit breakers. The 125 VDC system also supplies various circuits such as the AFW auto-initiation control and the normal and alternate breaker controls for the motor driven AFW pumps, via fuses or manually operated breakers (MOBs).

1.3.2.3 Vital 120 VAC Boundaries

Rack-mounted instruments and controls (such as Foxboro Spec 200 modules) generally receive power from power supplies which convert the 120 VAC to a low voltage DC. The low voltage power is normally isolated with fuses within each individual module.

1.3.2.4 120 VAC Boundaries

The 120 VAC System supplies power to the motor-driven AFW pump motor heaters via non-safety-related 120 VAC lighting panel breakers.

1.3.3 Instrument and Control Boundaries

The AFW System instrumentation and control (I&C) scope includes the major components listed in Section 3, which monitor and control AFW System operation. In addition, the AFW System receives I&C signals from, or supplies I&C signals to, the following systems:

- Engineered Safety Features Actuation System
- 4160 VAC
- Main Feedwater

- Service Water
- Plant Process Computer System (PPCS)
- Annunciators

The bases for the boundaries between the AFW system instrumentation and controls and other systems are as follows:

1.3.3.1 Engineered Safety Features (ESF) Actuation System Boundaries

The boundaries between the AFW system and the ESF Actuation System are at the AFW contact side of the signal relays. The ESF Actuation System provides signals for the auto-initiation of AFW flow.

1.3.3.2 Main Feedwater Boundaries

The boundaries between the AFW system and the Main Feedwater System are at the AFW contact side of the steam generator Low-Low level isolator modules, the feedwater pump control switches, and the feedwater pump breaker position devices. The Main Feedwater System provides control signals to the AFW system.

1.3.3.3 4160 VAC Boundaries

The boundaries between the AFW system and the 4160 VAC Electrical System are at the AFW contact side of the 4 KV bus undervoltage relays. The 4160 VAC Electrical System provides control signals to the AFW system.

1.3.3.4 Service Water Boundaries

The boundaries between the AFW system and the Service Water System are at the coil side of the AFW pump control circuit relays. The Service Water System receives control signals from the AFW system.

1.3.3.5 Steam Generator Blowdown Boundaries

The boundaries between the AFW system and the Steam Generator Blowdown System are at the coil side of the AFW pump control circuit relays. The Steam Generator Blowdown System receives control signals from the AFW system.

1.3.3.6 PPCS Boundaries

The boundaries between the AFW system and the PPCS are located at the multiplexer terminal strips. The Condensate Storage Tank level and AFW suction pressure instrumentation loops provide signals to the PPCS.

1.3.3.7 Annunciator Boundaries

The boundaries between the AFW System and the annunciators are located at the status contacts. Various off-normal AFW system conditions are annunciated in the main control room.

1.3.3.8 Instrument Recorder Boundaries

The boundaries between the AFW System and the instrument recorders are located at the thermocouple wire input terminals of the recorders. AFW pump and turbine bearing temperatures are sensed by thermocouples and read out on temperature recorders. The recorders are not included in the AFW System.

1.3.4 Structural Boundaries

The AFW System is located primarily in the Control Building (8 foot elevation), but extends to the Turbine Building (i.e., the CSTs), and into the Auxiliary Building (i.e., discharge pipe) and containment (i.e., first off check valves and discharge pipe). Boundaries with AFW components and the surrounding structures are taken at the point of attachment to the structure.

1.3.5 Boundary Differences Between Units

A significant portion of the AFW System is common to both units (motor-driven pumps and their associated equipment). Only the turbine-driven pumps and their associated equipment are dedicated to a single unit. For those portions that are unit-specific, there are no boundary differences.

1.4 Unit Differences

There are no significant differences in the design basis of the AFW System between Unit 1 and Unit 2. With the exception of component numbers and minor configuration differences, the Unit 1 and Unit 2 portions of the system are identical.

1.5 System Support

1.5.1 Support Services Supplied by the AFW System

The AFW System provides support services to the steam generators, and ultimately to the Reactor Coolant System for reactor heat removal. Under accident conditions, and when the Main Feedwater System is not operating, the AFW System provides feedwater flow to the steam generators via the 16-inch feedwater lines inside containment. In addition, the AFW System provides feedwater during plant start-up and shutdown conditions to maintain steam generator level. The AFW System supports the hydro testing of the steam generator(s). The AFW System is also used to inject chemicals into the secondary side of the steam generators (such as hydrazine or ethanolamine). These support services are the same as the system functions addressed in Section 2.1.

1.5.2 Support Services Supplied to the AFW System

The AFW System requires support from the following systems to perform its functions:

1.5.2.1 Main Steam System

The AFW System requires support from the Main Steam System to provide steam on demand to drive the turbines for AFW pumps 1P-29 and 2P-29.

1.5.2.2 Service Water System

The AFW System requires support from the Service Water System to automatically provide cooling water to the AFW pumps when the pumps start. In addition, the Service Water System is required to provide a manually-aligned, safety-grade, feedwater source to each AFW pump suction.

1.5.2.3 Fire Protection System

The AFW System requires support from the Fire Protection System to provide an automatic backup cooling water supply to the turbine-driven AFW pump bearing coolers, when they are required to operate, in the event that the Service Water System is inoperable (such as during the initial one-hour phase of Station Blackout). Also, the Fire Protection System provides the necessary fire detection and suppression to ensure that physical separation between adjacent AFW equipment is adequate to achieve and maintain safe shutdown [REF 9.2.59].

1.5.2.4 Instrument Air System

The AFW System requires support from the Instrument Air System to provide clean dry air to operate valves. In addition, the Instrument Air System is required to automatically provide a safety-grade nitrogen source to each air-operated discharge throttle valve for the MDAFW pumps, in case of a loss of Instrument Air to these valves [REF 9.5.182].

1.5.2.5 Secondary Sampling System

The AFW System requires support from the Secondary Sampling System to analyze AFW samples.

1.5.2.6 480 VAC Electrical System

The AFW System requires support from the 480 VAC Electrical System to provide power for AFW pump (P-38A and P-38B) and motor-operated valve (AF-4009, AF-4022, AF-4023, AF-4016, AF-4020 and AF-4021) motor operation. The 480 VAC Electrical System also provides power to the service water suction valves for 1P-29 (1AF-4006) and 2P-29 (2AF-4006). The requirements for the 480 VAC Electrical System, as related to AFW, are discussed in Section 2.7.

1.5.2.7 125 VDC Electrical System

The AFW System requires support from the 125 VDC Electrical System to operate the discharge, steam supply, trip throttle, and recirculation valves for pumps 1P-29 and 2P-29. In addition, the 125 VDC Electrical System powers the recirculation and discharge control valves for pumps P-38A and P-38B. Various AFW control circuits are also powered by the 125 VDC Electrical System. CHAMPS can be used to determine the power source for each circuit. The requirements for the 125 VDC Electrical System are discussed in Section 2.7.

1.5.2.8 120/240 VAC Electrical System

The AFW System requires support from the 120/240 VAC Electrical System to power various instrument and control circuits. The specific circuits which utilize the 120/240 VAC Electrical System can be found using CHAMPS. The requirements for the 120/240 VAC Electrical System are discussed in Section 2.7.

TABLE 1-1
DBD/CHAMPS SCOPE DIFFERENCES

A. The following equipment is included in the scope of this DBD, but is not listed as AFW in CHAMPS:

Equipment I.D.	Equipment Name
1MS-2019	SG B Steam Header 1P-29 AFP Steam Supply
1MS-2019-O	SG B Steam Header 1P-29 AFP Steam Supply Operator
1MS-2020	SG A Steam Header 1P-29 AFP Steam Supply
1MS-2020-O	SG A Steam Header 1P-29 AFP Steam Supply Operator
2MS-2019	SG B Steam Header 2P-29 AFP Steam Supply
2MS-2019-O	SG B Steam Header 2P-29 AFP Steam Supply Operator
2MS-2020	SG A Steam Header 2P-29 AFP Steam Supply
2MS-2020-O	SG A Steam Header 2P-29 AFP Steam Supply Operator
1MS-2019-M	1P-29 AFP Steam Supply Motor-Operated Valve Motor
1MS-2020-M	1P-29 AFP Steam Supply Motor-Operated Valve Motor
2MS-2019-M	2P-29 AFP Steam Supply Motor-Operated Valve Motor
2MS-2020-M	2P-29 AFP Steam Supply Motor-Operated Valve Motor
1POS-2019	1P-29 AFP Steam Supply MOV Position Switch
1POS-2020	1P-29 AFP Steam Supply MOV Position Switch
2POS-2019	2P-29 AFP Steam Supply MOV Position Switch
2POS-2020	2P-29 AFP Steam Supply MOV Position Switch
1MS-2082	1P-29 AFP OVERSPEED TRIP Throttle Valve
1MS-2082-M	1P-29 AFP OVERSPEED TRIP Motor-Operator Motor
1MS-2082-O	1P-29 AFP OVERSPEED TRIP Motor-Operator Operator
1MS-2082-S	1P-29 AFP OVERSPEED TRIP Solenoid
2MS-2082	2P-29 AFP OVERSPEED TRIP Throttle Valve
2MS-2082-M	2P-29 AFP OVERSPEED TRIP Motor-Operator Motor
2MS-2082-O	2P-29 AFP OVERSPEED TRIP Motor-Operator Operator
2MS-2082-S	2P-29 AFP OVERSPEED TRIP Solenoid

The following equipment is listed as AFW in CHAMPS, but is not included in the scope of this DBD (applicable DBD, if known, is listed in parentheses).

AF-4007A-S	P-38A AFP Cooling Water Solenoid Valve (DBD-12, Service Water)
AF-4014A-S	P-38B AFP Cooling Water Solenoid Valve (DBD-12, Service Water)
AF-04053	AF-04012 Nitrogen Backup Regulator (DBD-6, IA and SA)
AF-04058	AF-04019 Nitrogen Backup Regulator (DBD-6, IA and SA)
AF-04052	AF-04012 Nitrogen Backup Supply Relief (DBD-6, IA and SA)
AF-04057	AF-04019 Nitrogen Backup Supply Relief (DBD-6, IA and SA)
----------	Back-up Nitrogen Bottles for AF-4012/4019 operation (DBD-6, IA and SA)
AF-0137	P-38A AFP AF-4012 Discharge Control Valve Nitrogen Backup Regulator Test Flow Needle Valve

TABLE 1-1
DBD/CHAMPS SCOPE DIFFERENCES
(continued)

AF-0157	P-38B AFP AF-4019 Discharge Control Valve Nitrogen Backup Regulator Test Flow Needle Valve
PI-4051	P-38A AFP AF-4012 Discharge Control Valve Nitrogen Backup Regulator Outlet Pressure Indicator
PI-4054	P-38A AFP AF-4012 Discharge Control Valve Nitrogen Backup Regulator Inlet Pressure Indicator
PI-4056	P-38B AFP AF-4019 Discharge Control Valve Nitrogen Backup Regulator Outlet Pressure Indicator
PI-4059	P-38B AFP AF-4019 Discharge Control Valve Nitrogen Backup Regulator Inlet Pressure Indicator
AF-0145	P-38A AFW AF-4012 Discharge Control Valve Nitrogen Backup South Bottle Outlet Check Valve (DBD-6, IA and SA)
AF-0142	P-38A AFW AF-4012 Discharge Control Valve Nitrogen Backup North Bottle Outlet Check Valve (DBD-6, IA and SA)
AF-0162	P-38B AFW AF-4019 Discharge Control Valve Nitrogen Backup South Bottle Outlet Check Valve (DBD-6, IA and SA)
AF-0165	P-38B AFW AF-4019 Discharge Control Valve Nitrogen Backup North Bottle Outlet Check Valve (DBD-6, IA and SA)

2.0 SYSTEM DESIGN BASES

This section is divided into four levels: System Functions, Performance Requirements, Supporting Design Requirements and Other Design Information.

FUNCTIONS define the overall Auxiliary Feedwater System goals. The functions are classified as safety-related and non-safety-related.

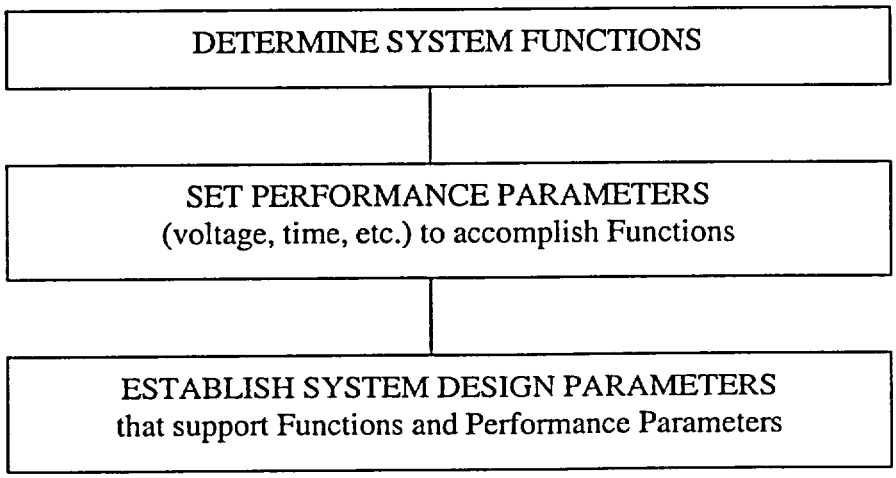
PERFORMANCE REQUIREMENTS (and their values) directly support system functions. Performance requirements typically have measurable values that establish limits that must be met for the system to accomplish its functions. Examples of Auxiliary Feedwater System performance parameters include fluid system flow and response-time limits.

SUPPORTING DESIGN REQUIREMENTS are constraints on the system configuration. Examples include system redundancy, interlocks, equipment protection, and design codes. Design requirements are often imposed to help the system accomplish its functions under adverse conditions, such as during single failures, hazards, and plant accidents.

OTHER DESIGN INFORMATION is information that does not directly support the system functions or performance requirements, but is still useful to the reader in understanding the design basis. Examples include system design capabilities, as-built rating information, and non-mandatory design codes.

System-level performance parameters and design requirements are summarized on the System Parameters Summary sheet. Worksheets explaining the reasons behind the parameter values and design requirements follow the System Parameters Summary sheet. Many of these worksheets interrelate, so the reader should expect cross-referencing.

The diagram below shows the thought process followed to relate system functions, performance parameters, and design parameters. The same relationship applies at the component level.



2.1 System Functions

2.1.1 Safety-Related Functions

Below is a summary of Safety-Related AFW System functions. The PBNP Q-List can be used as a primary source for determining which systems are classified as either safety-related, augmented quality, or non-QA (Reference AM 6-3, NP 11.4.6, and Design Guideline DG-G06). Further discussion of each corresponding FSAR Chapter 14 event is discussed in Appendix B of this DBD.

2.1.1.1 The AFW System shall automatically start and deliver sufficient AFW System flow to maintain acceptable steam generator levels during accidents which may result in steam generator pressure safety relief valve opening. This function prevents overfilling the pressurizer (due to RCS expansion), overpressurizing the primary system, and limits fuel peak clad temperature. Such accidents which are time-sensitive to AFW Start-up include LONF (Loss Of Normal Feedwater) and LOAC (Loss of All AC) events. [REF 9.2.57 Sections 14.1.10, 14.1.11].

2.1.1.2 The AFW System shall automatically start and deliver sufficient AFW System flow to maintain acceptable steam generator levels during accidents which require rapid RCS cooldown within the limits of the analysis. Such accidents include SGTR (Steam Generator Tube Rupture) and MSLB (Main Steam Line Break) [REF 9.2.57 Sections 14.2.4 and 14.2.5]

2.1.1.3 The AFW System shall be capable of isolating the AFW steam and feedwater supply lines from the ruptured steam generator following a SGTR event or an MSLB (to prevent containment overpressure caused by overfeeding the ruptured steam generator [Ref 9.4.44]). [REF 9.5.76, 9.2.57 Section 14.2.4, 14.2.5].

2.1.1.4 The AFW System shall automatically start and deliver sufficient AFW System flow to provide for rapid cooldown and depressurization of the RCS during a SGTR event to stop primary to secondary break flow in the ruptured SG within 30 minutes. [REF 9.2.57 Section 14.2.4].

2.1.1.5 The AFW System shall passively maintain the AFW system pressure boundary integrity. [DG-G06 (REF 9.5.107)]

Figures 2-1 through 2-4 are Logic Tree Diagrams showing the origin of these functions and their associated performance requirements.

2.1.2 Non-Safety-Related QA Functions (Augmented Quality)

2.1.2.1 Plant Fires

In the event of plant fires, including those requiring evacuation of the control room, AFW shall be capable of manual initiation to provide feedwater to a minimum of one steam generator at sufficient flow and pressure to remove decay and sensible heat from the Reactor Coolant System over the range from hot shutdown to RHR cut-in conditions [REF 9.1.2, 10 CFR 50.48 and 10 CFR 50 Appendix R, and 9.2.59 (Section 4.3.4)]. The AFW System, in conjunction with the RHR System, shall be capable of achieving Cold Shutdown within a 72-hour period [REF 9.2.59 section 4.3.4]. However, single failures are not assumed to occur coincident with this event [REF 9.2.59 (Section 4.7.2)]

2.1.2.2 Station Blackout (SBO)

In the event of a station blackout (prolonged loss of offsite and onsite AC power) affecting both units, the AFW System shall be capable of automatically supplying sufficient feedwater to remove decay heat from both Reactor Coolant Systems without any reliance on AC power for one hour. During the remaining three hours of the coping duration, alternate AC power from the Gas Turbine and one EDG is available. [REF 9.1.2 (10 CFR 50.63), 9.2.64, 9.2.57 Appendix A.1, and 9.2.107].

Additional single failures are not assumed to occur coincident with this event.

2.1.2.3 Anticipated Transient Without Scram (ATWS)

The AFW System shall automatically start on an ATWS Actuation Signal after a time delay and deliver sufficient flow to steam generators to ensure acceptable RCS cooling to ultimately keep RCS pressure below 3200 psig (ASME BPV Code Level C service limit stress criteria). [REF 9.3.25]

ATWS Mitigating System Actuation Circuitry (AMSAC) requirements are provided in REFs 9.2.83, 9.2.84, and 9.2.85, and 9.5.120.

2.1.3 Non-Safety-Related Non-QA Functions

2.1.3.1 Normal Startup and Shutdown

The AFW System shall be capable of providing feedwater flow to the steam generators to maintain water level while the unit is in hot shutdown or at low reactor power. The AFW System may be used during plant startup and shutdown. [REF 9.5.69 and 9.5.70].

2.1.3.2 Steam Generator Lay-up, Chemical Addition, and Leak Testing

The AFW System shall be capable of manually injecting chemicals into the steam generators during plant shutdown to maintain secondary chemistry control and to establish wet lay-up conditions [REF 9.5.69]. In addition the AFW System provides a means of pressurizing the steam generators during plant shutdown for secondary system leak testing [REF 9.5.143, 9.5.144, 9.5.145, and 9.5.146].

Basis for Functional Requirement:

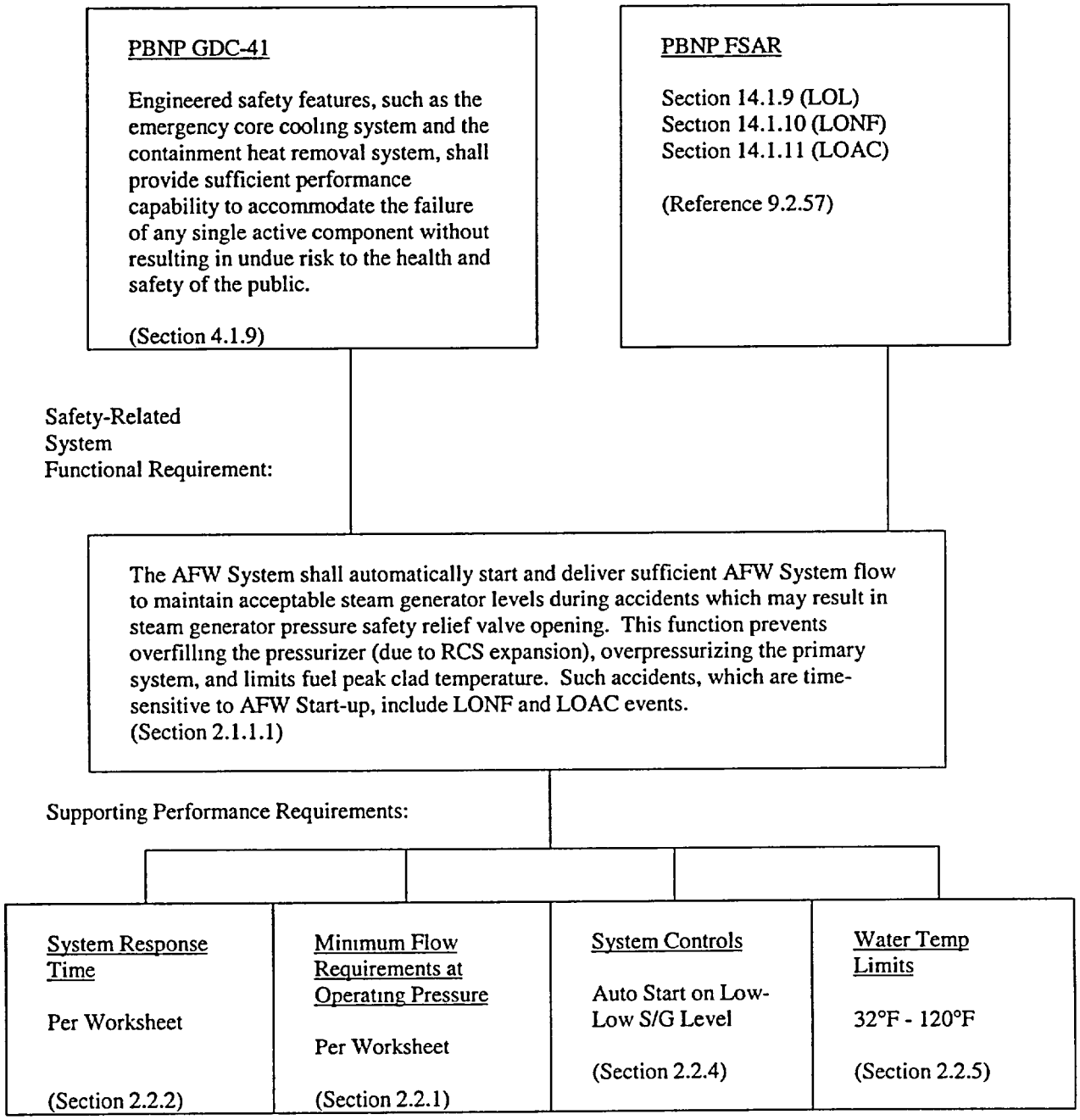


Figure 2-1
AFW Logic Tree
Accident Mitigation Requiring Decay Heat Removal

Basis for Functional Requirement:

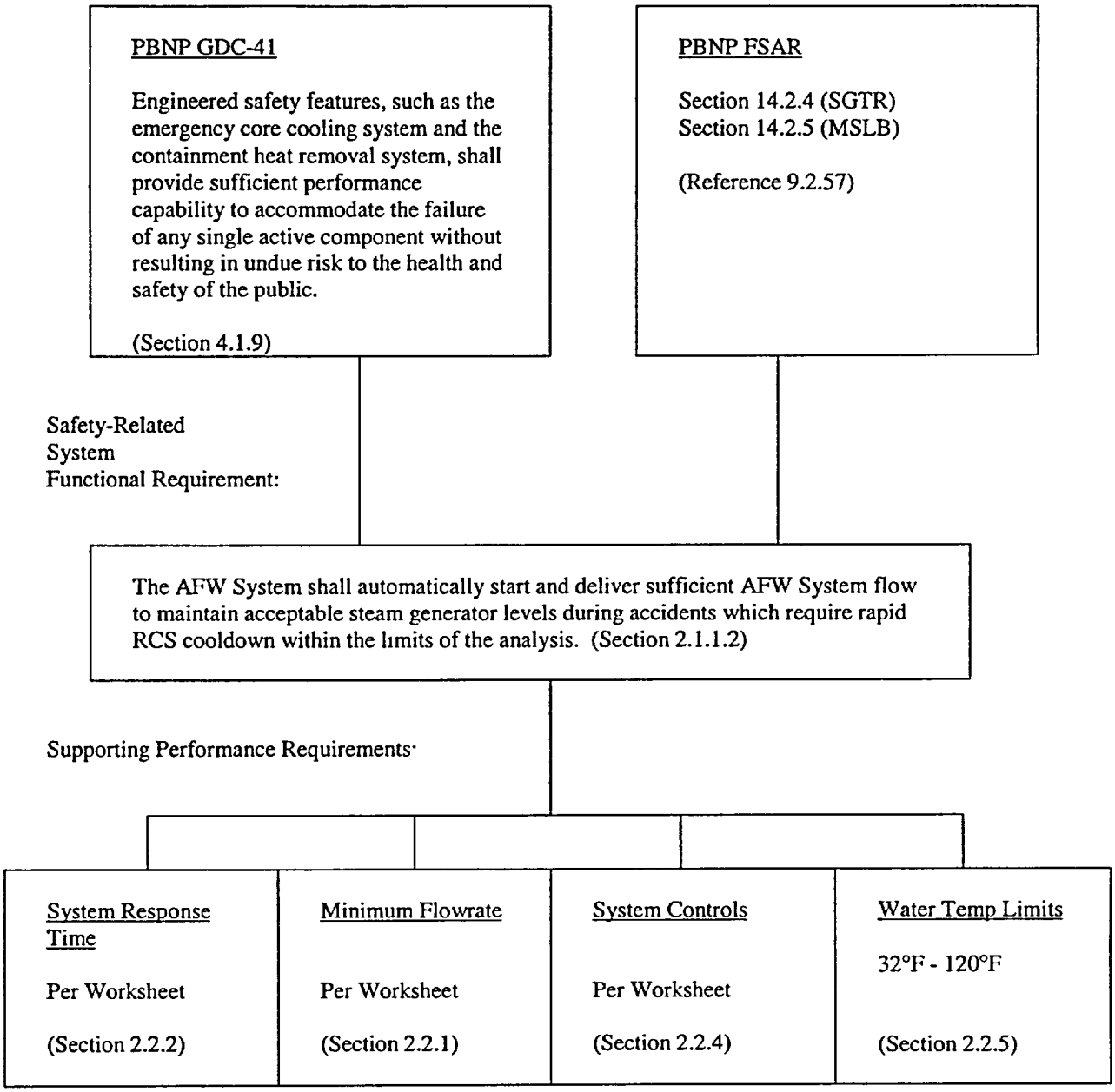


Figure 2-2
AFW Logic Tree
Accident Mitigation Requiring SG Level Maintenance

Basis for Functional Requirement:

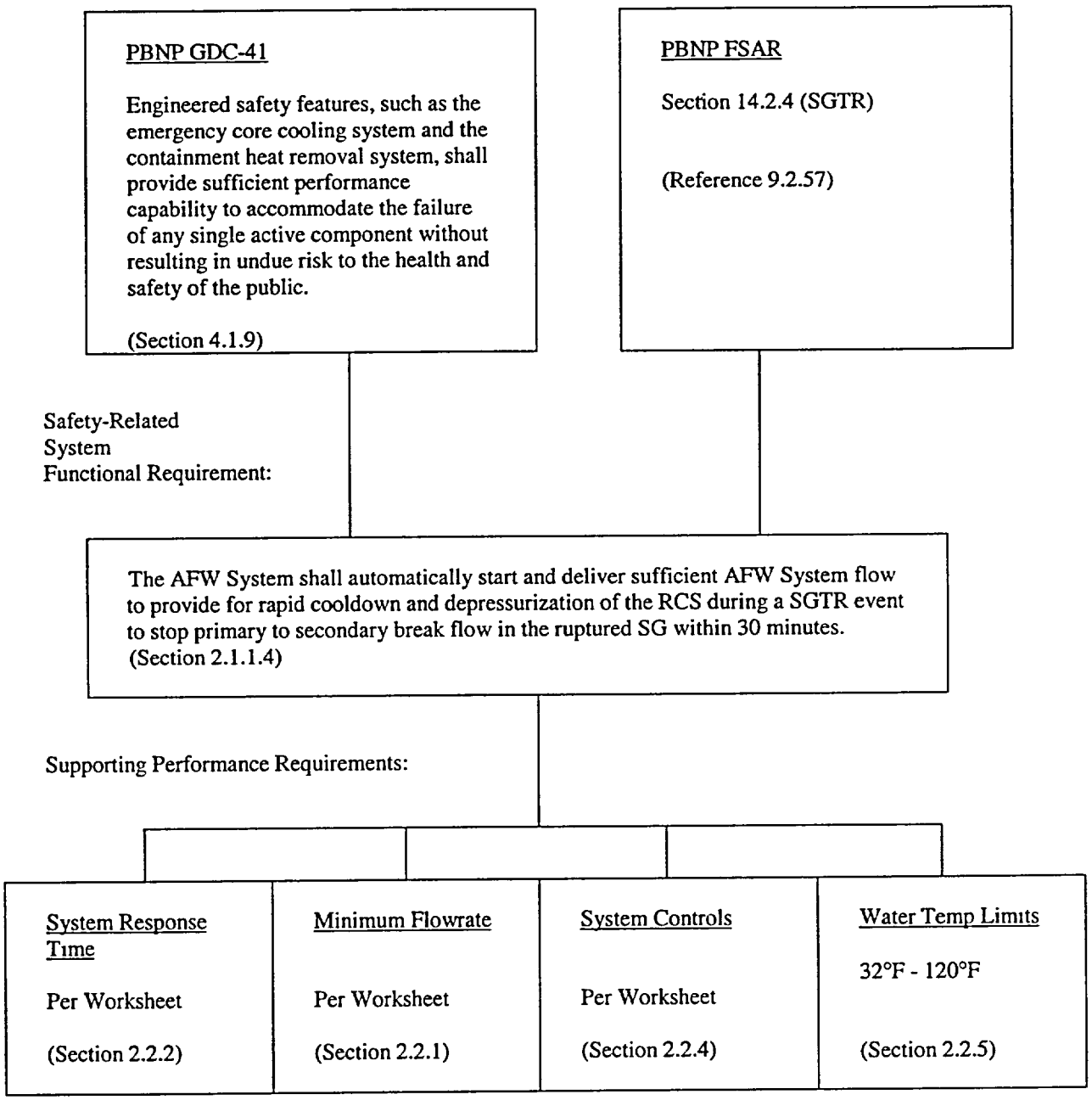


Figure 2-3
AFW Logic Tree
Accident Mitigation Requiring Forced Cooldown for SGTR

Basis for Functional Requirement:

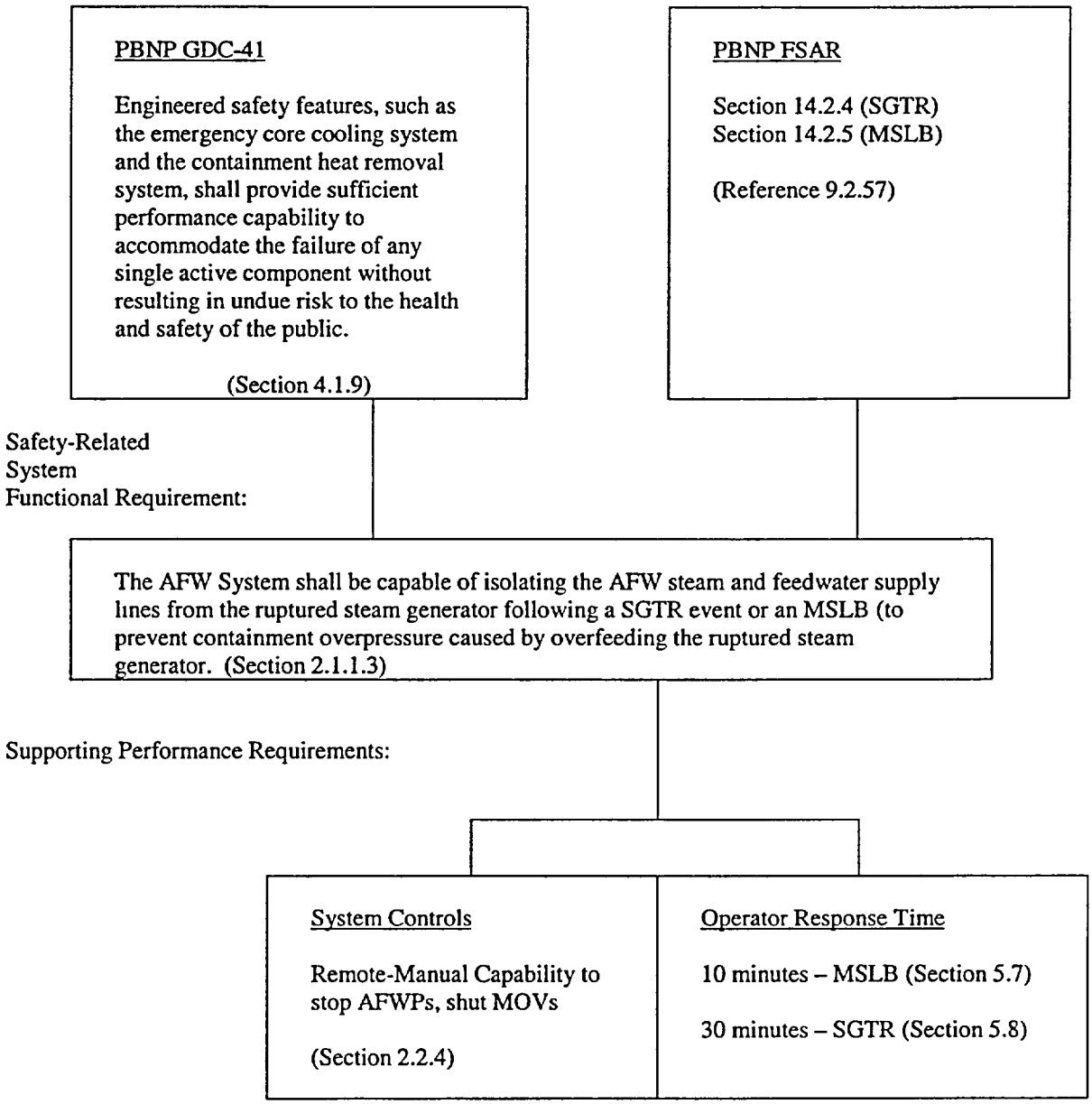


Figure 2-4
AFW Logic Tree
AFW Isolation of a Faulted Steam Generator

SYSTEM PARAMETERS SUMMARY
Section 2.2

PARAMETER	VALUE	REFER TO
SYSTEM PERFORMANCE REQUIREMENTS:		
1. Minimum Flow Requirements at Operating Pressure	Per Worksheet	2.2.1
2. System Response Time	See Worksheet	2.2.2
3. System Endurance ("Run-Time")		2.2.3
• Short-Term Endurance	60 minutes	
• Long-Term	72 hours minimum continuous with indefinite intermittent operation	
4. System Controls		2.2.4
• Automatic Initiation	Lo-Lo S/G Level (ESF signal) AMSAC Signal w/ 27 sec delay	
• Remote-Manual Control	Per Worksheet	
SUPPORTING DESIGN REQUIREMENTS:		
5. Water Temperature Operating Limits	32° - 120°F	2.2.5
6. Power Requirements	Per Worksheet	2.2.6
7. System Hydraulic Requirements	Per Worksheet	2.2.7
8. System Design Codes	USAS B31.1, 1967, and others	4.2
9. System Design Pressure/Temperatures	See Worksheet	2.2.8
10. Seismic Design Requirements	Per Worksheet	2.2.9
11. Vibration and Reaction Force Requirements	Per Worksheet	2.2.10
12. Environmental Qualification Requirements	Per Worksheet	2.2.11
13. System Interlocks & Permissives	Per Worksheet	2.2.12
14. Redundancy, Diversity, Separation	Per Worksheet	2.2.13
15. System Material Requirements	Per Worksheet	2.2.14
16. System Chemistry Requirements	Per Worksheet	2.2.15

SYSTEM PARAMETERS SUMMARY
Section 2.2 (Continued)

SUPPORTING DESIGN REQUIREMENTS:

PARAMETER	VALUE	REFER TO
17. Fire Protection Requirements	Per Worksheet	2.2.16
18. Containment Isolation Requirements	Per Worksheet	2.2.17

OTHER DESIGN INFORMATION:

19. System Response Capability	60 sec (automatic - original design)	2.2.2

SYSTEM PARAMETER WORKSHEET
Section 2.2.1

A. Parameter Minimum Flow Requirements at Operating Pressure

B. Value See Below

C. Source
1. PBNP FSAR (Chapter 14) [REF 9.2.57]
2. W WCAP 10858 Rev. 1, "ATWS" [REF 9.3.25]
3. AFW DBD Validation Report [REF 9.3.32]
4. FFDSAR 14.1.11 [REF 9.2.56]
5. WCAP 7769, Rev. 1, 06-72 [REF 9.3.34]
6. WCAP 12327 [REF 9.3.35]
7. PB-WMP-362, dated 10/2/67 [REF 9.3.36]
8. PBW-WMP-493, dated 1/15/68 [REF 9.3.37]
9. WE Calc N-91-007 [REF 9.4.9]
10. LER 91-001 [REF 9.2.88]
11. WE Calc N-90-095 [REF 9.4.8]
12. W LONF/LOAC Analysis [REF 9.3.41]
13. WE Internal Memo dated 5/18/67 [REF 9.3.39]
14. AABD Module 11.0 LONF/LOAC [REF 9.3.26]
15. VPNPD-93-143 [REF 9.2.90]
16. WE E-Mail Memo (Adams to Pridgeon) [REF 9.3.51]
17. AABD Module 15.0 SBLOCA [REF 9.3.48]
18. MSSM 92-09 [REF 9.5.133]
19. W Calc PDC-SSC-W-3, TDAFWP Sizing, 12/28/66 [REF 9.4.23]
20. W Calc, WEP Aux Motor Driven FWP, 2/5/68 [REF 9.4.24]
21. W LONF/LOAC Analyses Evaluation, New AFW Flows [REF 9.3.100]
22. W Seismic Analysis [REF 9.3.101]
23. W LONF Evaluation [REF 9.3.102]
24. Bechtel Calc, AFW System Headloss [REF 9.4.25]
25. Internal W Ltr, dated 1/16/69 [REF 9.3.111]
26. W WCAP-8404, ATWT Analysis [REF 9.3.112]
27. Modification MR 97-038 [REF 9.5.134]
28. PBNP Emergency Operating Procedure EOP-0, Reactor Trip or Safety Injection, [REF 9.5.72]
29. PBNP Emergency Operating Procedure EOP-0.1, Reactor Trip Response, U1&U2 [REF 9.5.73]

D. Background/Reason for Value

Generally, there is one condition which constrains the basis for minimum AFW flow requirements:

1. For RCS overpressure and heatup transients (LONF, LOAC, LOL, Seismic/Tornado-Induced LONF), AFW flow must be sufficient [at S/G design pressures] to support continuous secondary heat removal, so that transient conditions following reactor trip will not cause a solid pressurizer (not cause a pressurizer safety valve to lift).

SYSTEM PARAMETER WORKSHEET
Section 2.2.1 (continued)

There are two additional types of analyses which assume AFW flow, but do not create a limiting demand on the minimum AFW flow requirement:

2. For SGTR, AFW flow must be sufficient [at reduced S/G pressures] to remove secondary heat for RCS cooldown, removing both decay and sensible heat. Analysis of this accident provides AFW flow as an output, not a limiting input requirement. See Attachment B, 4. Steam Generator Tube Rupture Events, for more information.

3. For other design basis accidents which are mitigated primarily by ECCS and containment cooling systems, the AFW System is modeled, but not significantly relied on.

Other conditions which affect the definition of AFW minimum flow requirements include:

4. Flow-Balancing Requirements Between Steam Generators of One Unit
5. Flow-Balancing Requirements Between Units (Applicable for Dual-Unit Events)
6. System Response ("Startup") Time Requirements

After a brief historical perspective, this worksheet will discuss general requirements imposed during each of the conditions numbered 1 through 5 above. System Response Time Requirements (condition 6, above) are described in section 2.2.2.

Historical Perspective

Historically, licensing basis documents have been vague about AFW System flow requirements and response-times. In the few cases where the FSAR has presented actual flow values, it has provided no indication of the available tolerance in the value. Similarly, there is uncertainty with the necessary precision of AFW flow-balancing. The Accident Analysis Basis Documents (DBD-T-35) provide more information on AFW flow requirements during design basis events.

1. Minimum Flow Requirements to Achieve Decay Heat Removal:

The minimum design basis flow is determined by the requirement of the AFW system (in conjunction with main steam safety valves) to remove sufficient energy from the RCS to prevent liquid water relief through the pressurizer safety valves for RCS overpressure transients (e.g., LONF, LOAC) [REF FSAR 14.1.10]. The outcome of these events is directly affected by the AFW System performance. Early AFW calculations for sizing the MDAFW pumps **[Source 19]** determined that a minimum AFW flow of 176 gpm (initiated at 60 seconds) to only one steam generator would provide acceptable steam generator level to remove residual heat. Conversely, a similar calculation for the TDAFW pumps determined that a minimum AFW flow of slightly more than 200 gpm would be required **[Source 20]**. An additional early calculation for the MDAFW pumps suggested that 260 gpm would be required to fully mitigate a LONF event with the RCPs running (additional sensible heat) **[Source 25]**.

SYSTEM PARAMETER WORKSHEET
Section 2.2.1 (continued)

Performance requirement for the FSAR Chapter 14 LONF/LOAC
For LONF/LOAC analyses, **Source 1** states that the LONF/LOAC analyses assume an AFW system actuation delay of 300 seconds (5 minutes) from receipt of the low-low steam generator level signal until the AFW system is assumed to be providing 200 gpm of flow to a single steam generator. The single unit LONF event has long been considered the design basis event with the most limiting AFW flow demand at steam generator design pressures (although the LOAC event is really the same). Therefore, the Chapter 14 licensing basis analyses establish a 200 gpm performance requirement for flow to a single steam generator following a LONF or LOAC event.

Performance Requirement for the Seismic/Tornado Induced LONF
A special case for this parameter has been identified with the recognition that the Condensate Storage Tanks (CSTs), the initial AFW water source, are not safety-related or fully seismic (damage may still occur from Class 2 over 1 structures falling onto the CSTs and nearby AFW suction piping as well as from tornado generated missiles in the immediate vicinity of the CSTs). Recent evaluations determined the effect of delaying AFW flow delivery by five minutes if the CSTs were not available (e.g. during a seismic/tornado event), to allow time for remote-manual switchover of AFW suction to Service Water. The evaluations concluded that a five minute delay on a LOAC/LONF event is acceptable because the steam generators contain enough mass inventory to maintain primary-to-secondary heat transfer throughout the feedwater starvation period. These analyses establish that 100 gpm to the unit within 5 minutes and 200 gpm within 6 minutes of the event will provide adequate cooling **[Sources 21, 22, and 23]** See AABD Module 11, Section 11.4.5 for additional details.

Less-Limiting Events in this category include:

a. LOL: The Loss of Load event is typically used in assessing the adequacy of the pressurizer surge line, the pressurizer safety valves, the main steam safety valves, and the reactor protection system **[Source 5]**. The sequence of events indicate that the crucial times and events occur early in the transient - well before the AFW system would have any bearing on the event **[Source 3]**.

b. SBO: The minimum required AFW flow in the event of an SBO should be no greater than that required for the LONF or the LOAC [FSAR 14.1.10, 14.1.11] since the crucial parameters (e.g., initial power level, time of actuation signal, time until core decay heat = AFW heat removal capacity) will either be the same or have additional margin. **[Source 3]**

c ATWS: The limiting ATWS initiating events assume a loss of feedwater occurs. Therefore, initiation of AFW flow is important for mitigation of the ATWS event. The generic ATWS analyses for plants with Model 44 steam generators (applicable to PBNP) **[Sources 2 and 26]** assumes an AFW flow value of 800 gpm. These analyses determined that a turbine trip and timely initiation of AFW would limit RCS pressure to an acceptable value following an ATWS event. It is important to note that the 800 gpm AFW flow value is not considered a performance requirement for PBNP response to the ATWS event. As described above, 800 gpm is the flow value assumed in the generic Westinghouse analysis. Sensitivity studies were also documented in Source 26 that demonstrated a reduction in AFW flow for 2-loop plants could yield acceptable ATWS mitigation results. No PBNP specific analysis exists that calculates a minimum acceptable AFW flowrate for ATWS mitigation.

SYSTEM PARAMETER WORKSHEET
Section 2.2.1 (continued)

Inherently, AFW flow requirements during the limiting RCS overpressure transients should be defined at the design pressure (safety relief setpoint) of the steam generators (1085 psig). For accuracy, this pressure value may be adjusted to accommodate safety valve accumulation. When defining AFW pump performance requirements, some consideration for velocity head and static head (due to elevation difference between AFW pump discharge and steam generator feedwater sparger ring) must be made. Although the design basis research did not uncover these parameters, we do note that AFW pumps were specified to achieve design flow at 1192 psig [**Source 1**]; indicating that some consideration of these parameters was taken.

2. Minimum Flow Requirements to Achieve the Limiting Plant Cooldown (for SGTR Event):

In certain cases, the AFW System must provide sufficient flow to not only remove the decay heat load, but to achieve a required cooldown rate as well. Particularly during a SGTR event, the AFW System must satisfy such steam generator flow requirements to achieve the plant cooldown rate assumed in the analysis. In this case, steam dumps are opened and steam generator pressures are reduced below safety valve setpoints (<1085 psig). AFW flowrate must match the steaming rate at these pressure/flow points. These points have not been defined. However, the FSAR indicates that: "The ... auxiliary feedwater pump capacities are adequate to cool down at 50°F/hour." No capacity is specified [**Source 3** . See Attachment B, 4, Steam Generator Tube Rupture Events, for more information.

3. Minimum Flow Requirements for Maximum Credible Accidents Requiring ECCS

AFW system performance during reactor-design limiting events (such as LOCA) has a relatively insignificant impact on the outcome of these events. The outcome of these events are more affected by the performance of Engineered Safety Features (SI, RHR, Containment Spray, and Containment Fan Coolers) than by AFW. Descriptions of these analyses do not usually refer to AFW system performance, and in no cases have these analyses described particular sensitivity to AFW flow.

The AFW system may be initiated during a LBLOCA or SBLOCA, but the events have been analyzed with no credit for auxiliary feedwater [AABD Modules 15, 16, FSAR 14.3.1].

4. Flow-Balancing Requirements Between Steam Generators

The PBNP Emergency Operating Procedures (EOP-0 & EOP-0.1) [**Sources 28, 29**] require that the operator monitor AFW flow to the affected unit(s), and adjust flow if necessary to maintain > 200 gpm to each unit. The procedures would therefore allow either 200 gpm to a single steam generator or 100 gpm to each steam generator. As documented in **Sources 14 and 21**, Westinghouse performed undocumented sensitivity studies on the LONF and LOAC analyses for the Delta 47 replacement steam generators and determined that when AFW flow is split equally between the two steam generators (100 gpm to each), the LONF transient becomes slightly more limiting and the LOAC transient becomes less limiting. Westinghouse also states that for the LONF analyses with a large margin to pressurizer overfill, the impact of the AFW flow split can be judged to be negligible.

SYSTEM PARAMETER WORKSHEET
Section 2.2.1 (continued)

Additionally, Westinghouse has stated that "one electric driven boiler feed pump could remove the total decay heat of the core, but that thermal transients would be more severe, such as, one steam generator being brought to the totally dried out condition" **[Sources 7, 8, and 13]**. Therefore, it has been a design provision that the reactor plant be capable of adequate decay heat removal with unbalanced AFW flow. It is prudent, however, to balance flow as much as possible to limit the thermal transient on the steam generators.

5. Flow-Balancing Requirements Between Units (Applicable for Dual-Unit Events)

Although there was little original analysis of automatic flow balancing requirements for dual unit events, resolution of LER 91-001 **[Source 10]** provided further analysis. This LER reported the possibility that a 50 psi pressure differential between units could divert all MDAFW pump flow to one unit **[Source 11]**. It further postulated that the other unit may get no automatic AFW flow if its TDAFW pump fails (the single failure). To mitigate the consequences of such an extreme case, the LER took credit for manual operator action to recognize the condition and restore sufficient flow to both units within a five-minute period.

Therefore, it has been Wisconsin Electric's position that automatic AFW System response to these extreme flow-imbalances between units is not a design basis requirement. Rather, it is the WE position that EOPs provide adequate guidance, and the plant design provides adequate time to ensure that decay heat removal from the steam generators is achieved. LER 91-001 **[Source 10]** also postulated that spurious failure[1] of the non-safety-related pneumatic controllers of the MDAFWP discharge pressure control valves would have a comparable effect on automatic flow balancing between units. Accordingly, a safety-related upgrade of the pneumatic controllers was initiated. [Refer to **Source 18**]. Modification MR 97-038 **[Source 27]**, which upgraded the air-supply to the MDAFWP discharge pressure control valves to a safety-related source (nitrogen accumulators) and resolved electrical separation issues, has now been installed in the plant. This modification included design for single failure criteria such that these valves do not fail to the open position upon loss of normal instrument air.

[1] These valves must have a fail-open design as discussed in section 3.9.2. LER 91-001 postulated that these valves could fail shut. It could not be assumed that these valves would fail to their fail-safe position if the valves were non-safety grade.

SYSTEM PARAMETER WORKSHEET
Section 2.2.2

A. Parameter System Response Time

B. Value See Below

C. Source
1. PBNP FSAR [REF 9.2.57]
2. WE Calc N-91-007 [REF 9.4.9]
3. AFW DBD Validation Report [REF 9.3.32]
4. W Steam Systems Criteria (1/10/67) [REF 9.3.1]
5. W Steam Systems Criteria (10/10/67) [REF 9.3.21]
6. FFDSAR (Section 14.1.11) [REF 9.2.56]
7. W Drawing 883D195 Sh. 23, Rev. 1, 2/13/90 [REF 9.6.100]
8. W WCAP-8404, ATWT Analysis [REF 9.3.112]
9. W LONF/LOAC Analysis [REF 9.3.100]
10. W Seismic Analysis [REF 9.3.101]
11. W LONF Evaluation [REF 9.3.102]
12. WE Ltr to NRC, RE: Response to Steam Binding in AFW pumps [REF 9.2.70]

D. Background/Reason for Value

AFW System Response Time Capability
The time requirement for AFW full flow delivery to the steam generators is based on assumptions in the plant accident analyses. For events where normal feedwater is assumed to be lost (Loss of All AC power and Loss of Normal Feedwater), five minutes has been identified as the time limit from receipt of the actuation signal for AFW valves to re-position and pumps to accelerate to full flow capability and flow to be adjusted (as necessary) to meet the accident analysis [**Source 1**]. Use of this time limit in the accident analyses gave acceptable transient response for reactor coolant system temperature, pressure, and primary-secondary heat transfer.

Early Westinghouse design criteria [**Sources 4 and 5**] referred to a two-minute criterion for AFW flow delivery, which included the actuation signal detection and processing time, as well as the AFW equipment response. However, this was subsequently revised and incorporated in the FFDSAR [**Source 6**].

Performance Requirement for the FSAR Chapter 14 LONF/LOAC
For LONF/LOAC analyses, **Source 1** (chapter 14) states that the LONF/LOAC analyses assume an AFW system actuation delay of 300 seconds (5 minutes) from receipt of the low-low steam generator level signal until the AFW system is assumed to be providing 200 gpm of flow to a single steam generator. This delay includes startup and acceleration of the Emergency Diesel Generators (if required), load sequencing onto the emergency buses, valve stroking delays and startup and acceleration of the AFW pumps. This extended five minute delay also provides a time allowance for operator action to balance AFW flow to the steam generators, if necessary.

Since the MFW and AFW lines can be safely assumed to be filled, no additional delays for pipe-filling and fluid transport need be considered. MFW lines must be filled during normal operation.

SYSTEM PARAMETER WORKSHEET
Section 2.2.2 (continued)

AFW suction lines are kept filled as a result of their elevation below CSTs. Also, AFW discharge lines are monitored for steam backleakage by monitoring the upstream and downstream piping from the 2nd off and pump discharge check valves on a per shift basis, usually by hand touch. AFW pump discharge line temperatures are recorded monthly to be evaluated for any temperature trends **[Source 12]**. When the AFW system is operable per Tech Spec requirements, the AFWS piping is considered to be filled from the CSTs to the tie-in point of the MFW system at all times. **[Source 3]**

Performance Requirement for the Seismic/Tornado Induced LONF

A special case for this event has been identified with the recognition that the Condensate Storage Tanks (CSTs), the initial AFW water source, are not safety-related or fully seismic (damage may still occur from Class 2 over 1 structures falling onto the CSTs and nearby AFW suction piping as well as from tornado generated missiles in the immediate vicinity of the CSTs). Recent evaluations determined the effect of delaying AFW flow delivery by five minutes if the CSTs were not available (e.g. during a seismic/tornado event), to allow time for remote-manual switchover of AFW suction to Service Water. The evaluations concluded that a five minute delay on a Loss of All AC/LONF event is acceptable because the steam generators contain enough mass inventory to maintain primary-to-secondary heat transfer throughout the feedwater starvation period. These analyses establish that 100 gpm to the unit within 5 minutes and 200 gpm within 6 minutes of the event will provide adequate cooling **[Sources 9, 10, and 11]**. The 5 minute AFW time delay begins two seconds after the low-low steam generator level reactor trip signal is attained to account for signal processing delays. The 5 minute time delay includes anticipated time for the operators to open the SW isolation valves to the AFW pumps, since the CSTs are not assumed available due to the event. The 100 gpm value at 5 minutes recognizes the effects of the open minimum flow valve upon start-up of the AFW pump, and the 200 gpm value at 6 minutes accounts for minimum flow valve closure due to reaching flow setpoint and delay time before the minflow valve is allowed to close.

Anticipated Transient Without Scram (ATWS)

The limiting ATWS initiating events assume a loss of feedwater occurs. Therefore, initiation of AFW flow is important for mitigation of the ATWS event. The generic ATWS analysis for plants with Model 44 steam generators (applicable to PBNP at that time) **[Source 8]** assumes there is a total time delay of 60 seconds from the beginning of the ATWS event to AFW flow delivery. For the ATWS event, there is very little margin available in this response-time parameter. There is a 27 second time delay relay in the circuit **[Source 7]** to delay the time from initiating event until AMSAC trips the turbine and starts the AFW pumps. Then there is a 25 second (motor driven AFW pump discharge MOVs) or 30 second (turbine driven AFW pump steam admission valves) time for the required valves to stroke fully open. If an additional one second for the response/actuation of all the other circuit components is assumed, then a margin of 2-7 seconds exists. **[Source 3]** For illustrative purposes, it should be noted that in the case of the MOVs opening time that a significant percentage of the flow is realized within a few seconds of valve opening. In the case of the steam admission valves the effective supply of steam to pump turbine occurs in less than 2 seconds to achieve up to 80% of the turbine's initial speed. The discharge MOVs for MDAFW pumps effectively allow full flow of the pump within 5 seconds. Therefore, a realistic expectation of the margin being discussed could be more in the time frame of 25 to 30 seconds in relation to achieving full flow to the steam generators within 60 seconds of the initiating event.

SYSTEM PARAMETER WORKSHEET

Section 2.2.2 (continued)

It is important to note that the 60 second AFW system response time is not considered a performance requirement for PBNP response to the ATWS event. As described above, 60 seconds is the value assumed in the generic Westinghouse analysis. Sensitivity studies were also documented in **Source 8** that demonstrate a longer AFW system response time for two loop plants could yield acceptable ATWS mitigation results. No PBNP-specific analysis exists that calculates a maximum acceptable AFW system response time for ATWS mitigation.

It is apparent from the above information that the AFW system was originally designed and built with the capability of responding to an event within 60 seconds. As a gauge for continued system operation, this 60 second response time should be used as the time basis to evaluate the automatic responses of the various equipment within the AFW system.

SYSTEM PARAMETER WORKSHEET
Section 2.2.3

A. Parameter System Endurance ("Run-Time")

B. Value

Short-Term Endurance	60 minutes
Long-Term (supplied by SW)	72 hours minimum continuous indefinite intermittent operation

C. Source
1. PBNP Technical Specifications [REF 9.2.58]
2. CR 97-1918, RE: AFW pump protection [REF 9.5.150]
3. AFW DBD Validation Report [REF 9.3.32]
4. WE Calculation N-89-001, Rev. 2, 5/31/90 [REF 9.4.4]
5. FFDSAR Amendment 7 (Original TS) 15.3.4-2 [REF 9.2.56]
6. WE Ltr to NRC, VPNPD-90-459, dated 10/3/90 [REF 9.2.65]
7. WE letter, "Seismic Qualification of AFW System", 4/26/85 [REF 9.2.4]
8. WCAP-7306 [REF 9.3.31]
9 WE Ltr to NRC, dated 7/8/80 [REF 9.2.95].
10. PBNP Test Procedure, WMTP 11.21, Rev. 0 [REF 9.5.137]
11. PBNP Test Procedure, WMTP 11.22, Rev. 0 [REF 9.5.148]
12. W LONF/LOAC Analysis [REF 9.3.100]
13. W Seismic Analysis [REF 9.3.101]
14. W LONF Evaluation [REF 9.3.102]
15. S&L Ltr to WE, SL-WE-97-142, Service Water Hydraulic Modeling [REF 9.3.98]
16. WE Internal Memo, dated 6/24/80 [REF 9.3.60]
17. NRC Ltr to WE, dated 5/16/80 [REF 9.2.93]

D. Background/Reason for Value

The AFW System was originally designed to start automatically and run without intervention while plant transients were assessed and immediate actions taken. The critical factors in achieving this requirement were (1) CST volume, and (2) AFW flowrate. Since the CSTs were designed as the initial water source, an operational limit had to be imposed on the system to switch the suction source to Service Water before the original source was depleted. **Source 5** identified the original short-term endurance of the AFW System in the following basis:

> "One motor-driven auxiliary feedwater pump can supply sufficient feedwater for removal of decay heat from a unit. The minimum amount of water in the condensate storage tanks is the amount needed for 25 minutes of operation/unit, which allows sufficient time for operator action.
>
> An unlimited supply is available from the lake [Lake Michigan] via either leg of the plant service water system for an indefinite time period."

Source 5 did not provide the supporting assumptions for this statement; however, the associated flowrate to deplete 10,000 gals in 25 minutes is 400 gallons per minute (equivalent to using 1 TDAFW pump at 400 gpm).

SYSTEM PARAMETER WORKSHEET
Section 2.2.3 (continued)

The original system capability was challenged by the Station Blackout rule, whereby the minimum CST volume requirement was revised to provide adequate time to shift the AFW suction source to Service Water. This was particularly important since the SW pumps as well as the SW-to-AFW suction MOVs are AC-powered and inoperable during the coping period (1 hour until Gas Turbine is available to supply AC to SW pumps). Although no supporting analysis was provided by **Source 6**, it may be inferred that MDAFW pump flow during the coping period was necessarily excluded and AFW flowrate to either unit would be attributable to a TDAFW pump throttled to 200 gpm. This value is derived from the new 13,000 gal capacity being exhausted in 60 minutes (13,000 gals, 60 mins » 200 gals/min ~217 gpm).

Plant conditions which are less-controlled than those discussed above will obviously result in a much shorter endurance. If nominal design flow rates are assumed (400 gpm for a turbine driven pump and 200 gpm for a motor driven pump), the CST could be depleted in about 22 minutes. Although no analysis was located which examined the CST depletion at maximum credible AFW flowrates, **Source 3** estimated very short endurance periods. Based on some of the flow rates used in runout studies (1039 gpm to a faulted steam generator per **Source 4**), **Source 3** estimated that the CST could be depleted in less than ten minutes. However, the combination of a faulted steam generator and a loss of AFW suction supply from the CSTs may not be considered part of the plant's licensing basis. **[Source 3 and 14]**

Other Factors to Ensure AFW System Endurance

To ensure that the AFW system will function for at least 1 hour following a loss of all AC (station blackout) it is necessary to ensure that (1) there is an sufficient supply of water from the condensate storage tank (CST), and (2) there is adequate cooling water from the fire protection system pumps (for bearing cooling) to operating AFW. **Source 3** validated the plant's capability under these conditions.

Special Case

System Endurance in the short-term is constrained by CST volume. However, the CST is not seismically qualified (see Section 3.2.5) and the CST supply potentially unavailable as a result of a seismic/tornado event. Therefore, some analysis has been done to show that decay heat removal capabilities are not compromised by a loss of AFW suction supply from the CSTs. In this event (seismic/tornado-induced loss of AFW suction supply from the CSTs), the AFW pumps are designed to trip off on low suction pressure; disabling automatic system response. Operator action is then required to establish an alternate supply of AFW from service water. **Source 2** raised concerns with the adequacy of the low suction pressure trip for AFW pump protection. As a result of these concerns, evaluations in **Sources 12, 13, and 14** assume 100 gpm AFW can be established within 5 minutes and 200 gpm within 6 minutes per unit. This will provide adequate decay heat removal. Note that **Source 7** states that operators are capable of making the switchover of AFW supplies from the control room within the 5-minute limit.

SYSTEM PARAMETER WORKSHEET
Section 2.2.3 (continued)

In further support of the plant's inherent capability to accommodate delays in AFW initiation, **Source 8** presents some generic plant information on the subject. **Source 8** provides conservative analyses of LONF events on typical two-loop plants. In these analyses, AFW initiation of AFW was delayed as long as 24 minutes after the loss of feedwater. In these analyses, the pressurizer filled in about 3 minutes, and the core is uncovered only after 24 minutes have elapsed. Manual actuation of AFW (200 gpm per steam generator) at this time adequately mitigates the accident (See **Source 8**).

Long-Term System Endurance

In the long-term, the licensing basis (FSAR) does not specify the duration of plant events. However, **Source 5** did specify that Lake Michigan would be an unlimited supply via the service water system for an indefinite time period. Operations has required that the AFW system be able to operate for 72 hours continuously as a minimum. A 72 hour endurance run on each of the four AFW pumps was completed in 1979 per **Sources 10 and 11** in order to comply with post-TMI commitments for the AFW System discussed in **Sources 9, 16 and 17.**

SYSTEM PARAMETER WORKSHEET
Section 2.2.4

A. Parameter System Controls

B. Value Automatic Initiation
Remote-Manual Control from Control Room
Remote-Manual Control from an alternate control station

C. Source
1. NUREG-0737 Section II.E.1.2 [REF 9.1.4]
2. SER on NUREG-0737 [REF 9.2.39]
3. NRC Internal Memo [REF 9.2.60]
4. MR 83-104 [REF 9.5.51]
5. W Ltr PBW-B-1051, dated 3/15/68 [REF 9.3.2]
6. W Ltr PBW-B-917, dated 2/6/68 [REF 9.3.3]
7. PBNP GDC (Criterion 12) [REF 9.1.1]
8. PBNP Setpoint Document STPT 14.11 [REF 9.5.28]
9. PBNP Fire Protection Evaluation Report [REF 9.2.59]
10. FSAR [REF 9.2.57]
11. WE Ltr VPNPD-87-124 dated 4/23/87 [REF 9.2.83]
12. W WCAP-10858 [REF 9.3.25]
13. EOP-3.1, "Post-SGTR Cooldown Using Backfill" [REF 9.5.78]
14. EOP-3.2, "Post-SGTR Cooldown Using Blowdown" [REF 9.5.79]
15. EOP-3.3, "Post-SGTR Cooldown Using Steam Dump" [REF 9.5.80]
16. EOP-3.0, "Steam Generator Tube Rupture" [REF 9.5.77]
17. EOP-2, "Faulted Steam Generator Isolation" [REF 9.5.76]
18. NCR 90-181, RE: Loss of DC bus, dated 8/31/90 [REF 9.3.61]
19. W Ltr WEP-87-173, dated 6/19/87 [REF 9.3.109]

D. Background/Reason for Value

Automatic Initiation

The AFW System must initiate automatically [**Sources 1, 2, 4, 6, 19**]. Therefore, the AFW System shall be capable of aligning valves and starting pumps as required to supply flow to the affected unit within the response-time constraints of the accident analyses and without operator action [**Sources 1, 2, 3**]. The motor-driven AFW pumps must be started automatically and the associated discharge valves automatically opened for affected unit(s), and closed on the unaffected unit. The turbine-driven AFW pump must be started automatically by means of opening at least one of its DC-powered steam admission valves. Normal system valve alignment must establish a "standby" condition which requires no other active component functions to achieve system startup. (Refer to Sections 3.4.3 and 3.7.4 for discussion of valve control requirements on the valves discussed above.)

SYSTEM PARAMETER WORKSHEET
Section 2.2.4 (continued)

Although other instruments have been employed to anticipate reduced steam generator inventories, Steam Generator Level Instruments were selected as the primary, safety-related instruments to startup the AFW System. Both motor-driven AFW pumps, P-38A and P-38B, are automatically started by a low-low level signal in either steam generator. In addition, the associated turbine-driven AFW pump, 1P-29 or 2P-29, will automatically start due to a low-low level signal in both steam generators [**Source 10** Section 14.1.10]. **Source 6** provided the design criteria for the AFW starting logic. **Sources 1 and 2** require that the automatic initiation signals and circuits be designed so that a single failure will not result in the loss of auxiliary feedwater system function. **Source 18** reiterated that no single failure would result in the automatic starting of a TDAFW pump (in that case, due to a loss of A01 or A02 DC control power)

Automatic initiation of individual components is discussed in Section 3 of this DBD.

For the ATWS (Anticipated Transient Without Scram) event, AFW must be automatically initiated only at power levels above 40% power. AMSAC (ATWS Mitigating System Actuation Circuit) is designed to automatically enable AFW initiation above this power level, and defeat it below that power level (after a nominal time delay of 27 seconds) [**Source 11**]. AFW initiation for ATWS is required to "avoid the long term consequences of operating without any heat sink" [**Source 12**]

Certain controls were applied to the shared AFW components (i.e., MDAFWPs) to allow one unit to be taken out of service without initiating an unnecessary automatic start of AFW. Refer to Section 2.2.12, "System Interlocks and Permissives" for more details.

Remote-Manual Control from the Control Room

AFW system design must provide the capability to initiate auxiliary feedwater from the control room. These controls shall be designed so that a single failure in the manual circuits will not result in the loss of system function. [**Sources 1, 2, 6**]

Also, to mitigate Steam Generator Tube Rupture (SGTR) events, the AFW System shall be designed to allow remote-manual isolation of the affected steam generator and to provide continued feedwater flow to the unaffected steam generator to remove decay heat until the Reactor Coolant System reaches RHR cut-in conditions [FSAR Section 14.2.4, **Sources 1, 2, 3**]. In addition, the AFW System is designed to provide flow to the affected steam generator to maintain the desired level during the event [**Sources 13, 14, 15**]. As stated in **Source 16**, the feed flow must be controlled (probably reduced flowrate) to the ruptured steam generator to maintain thermal stratification and prevent depressurization (while minimizing the potential for steam generator overfill). [RCS] Pressure reduction may result if the steam generator tubes become uncovered.

To mitigate MSLB events, the AFW System shall be designed to allow remote manual isolation of feedwater flow to the affected steam generator to limit containment pressure increase, prevent AFW pump runout, and increase flow to the unaffected steam generator [**Source 17**].

SYSTEM PARAMETER WORKSHEET
Section 2.2.4 (continued)

These remote-manual operations to isolate AFW flow must be performed within the time limits of the accident analyses. Refer to Section 5 of this DBD for further discussion of these operational requirements.

Remote-Manual Control from an Alternate Control Station

Source 5 established the original requirement and design criteria for an alternate control station for the AFW System. It stated: "to bring both units to a hot shutdown condition in the event the control room must be evacuated, additional control stations shall be provided outside the control room for motor driven auxiliary feedwater pumps P38A, P38B." This control station must be located near the motors **[Source 5]**. Appendix R requirements reinforced the need for this alternate control station during plant fires requiring control room evacuation **[Source 9]**.

The local control stations shall consist of the following: **[Source 5]**

- A transfer switch,
- Start-stop pushbuttons, and
- A red indicating lamp (breaker or starter closed).

The transfer switch shall be used to transfer all remote breaker or starter control to the local pushbuttons. Whenever a transfer switch is placed in the "local" position, a common alarm shall be actuated in the control room **[Source 5]**.

General Instrument and Control Requirements

Instrumentation and controls shall be provided as required to monitor and maintain variables within prescribed operating ranges **[Source 7]**. Instrument ranges shall be selected to include all values from the expected minimum to the expected maximum of the monitored parameter. The required instrument ranges are addressed in Sections 3.16, 3.17, 3.18. The setpoints of AFW instruments are listed in the PBNP Setpoint Document **[Source 8]**.

In addition to control requirements discussed above, the AFW System shall meet the following design requirements **[Sources 1, 2]**:

- Testability of the initiating signals and circuits shall be a feature of the design.
- The initiating signals and circuits shall be powered from the emergency buses.
- The AC motor-driven pump and valves in the auxiliary feedwater system shall be included in the automatic actuation (simultaneous and/or sequential) of the loads onto the emergency buses.

SYSTEM PARAMETER WORKSHEET
Section 2.2.4 (continued)

The AFW System shall also provide the appropriate signals to the Steam Generator Blowdown System to isolate blowdown when AFW is initiated. This function will prevent the loss of steam generator inventory, which would reduce the effectiveness of the AFW System to support its decay heat removal functions. Accordingly, **Source 10** (FSAR Figure 10.2-1) indicates that AFW pump start signals cause steam generator blowdown isolation.

Annunciators shall alert operators to off-normal conditions or conditions which might otherwise require immediate operator attention. Refer to Table 2-2 for the existing design of AFW System Alarm Circuits. All AFW alarm functions are non-safety related. Annunciator design guidelines are documented in the WE NPBU Design & Installation Guidelines Manual [REF 9.5.107, DG-G01 (Section 6)]. The configuration design (placement, labeling, style of component, etc.) of AFW instrumentation and controls on the main and local control boards shall take human factors into consideration. Main control board human factors analysis is an on-going process which is administered via the Control Room Design Review Program Plan (WE PB-174) [**Source 1** Supplement 1 (Section 5)].

Design requirements applicable to only particular instruments are discussed in Section 3 of this DBD.

TABLE 2-2
ALARM CIRCUITS

Alarm	Location	Engraving	REF
A-2-8	C01	Unit 1 AFWS DISABLED	9.6.49
A-2-9	C01	CONDENSATE STORAGE TANKS A OR B LEVEL HI-LO	9.6.51
A-2-10	C01	Unit 2 AFWS DISABLED	9.6.49
A-3-8	C01	AFWP P38A SUCT PRESS TRIP DISABLED	9.6.50
A-3-9	C01	CONDENSATE STORAGE TANKS A OR B LEVEL LO-LO	9.6.52
A-3-10	C01	AFWP P38B SUCT PRESS TRIP DISABLED	9.6.50
A-4-8	C01	AFWP P38A LO SUCTION PRESS TRIP	9.6.50
A-4-9	C01	AFWP SUCTION PRESS LO	9.6.48
A-4-10	C01	AFWP P38B LO SUCTION PRESS TRIP	9.6.50
1D-3-8	1C03	AFWP 1P29 LO SUCTION PRESS TRIP	9.6.50
1D-4-8	1C03	AFWP 1P29 SUCT PRESS TRIP DISABLED	9.6.50
2D-3-4	2C03	AFWP 2P29 LO SUCT PRESS TRIP	9.6.50
2D-4-4	2C03	AFWP 2P29 SUCT PRESS TRIP DISABLED	9.6.50

SYSTEM PARAMETER WORKSHEET
Section 2.2.5

A. Parameter Water Temperature Operating Limits

B. Value 32° - 120°F

C. Source 1. AFW DBD Validation Report [REF 9.3.32]
2. Operating Instructions OI-1A, 1B, 2A, 2B [REF 9.5.143, 9.5.144, 9.5.145, 9.5.146]

D. Background/Reason for Value

The AFW System must provide feedwater at temperatures within a range limited by the temperatures assumed in plant accident analyses. Or conversely stated, plant accident analyses must use conservative values of possible AFW temperatures. Theoretically, the lowest possible AFW temperatures could be established at 32°F to describe the possible condition of Service Water as the suction source. The maximum is established by procedure as high as 110°F (procedural maximum temperature) to describe the remote possibility that suction is drawn from the condensate system **[Source 2]**. Although both these limits are based on infrequent operations at extreme conditions, it should be noted that no controls (i.e., Technical Specifications) have been developed to ensure that an extreme AFW system water temperature does not violate accident analyses assumptions.

Section 3.2.2 provides the operating temperature limits (32° - 120°F maximum design temperature) based on known accident analysis assumptions.

SYSTEM PARAMETER WORKSHEET
Section 2.2.6

A. Parameter Power Requirements

B. Value See Below

C. Source
1. 10CFR50 [REF 9.1.2]
2. SER on Station Blackout [REF 9.2.64]
3. PBNP Technical Specifications [REF 9.2.58]
4. W Internal Memo SSE-W-1258, 3/12/68 [REF 9.3.13]
5. SER on Station Blackout [REF 9.2.107]

D. Background/Reason for Value

Active AFW components were designed to be powered by diverse sources to accommodate the diversity of design basis events which had to be mitigated. Combinations of Main Steam motive power and AC/DC on-site electrical power were employed. Therefore, there are two perspectives related to AFW "Power Requirements":

1. **REQUIREMENTS TO ASSIGN THE APPROPRIATE POWER SOURCE TO AFW SYSTEM ACTIVE COMPONENTS:** Power sources were deliberately selected based on their guaranteed capability to perform when required. For instance, the designer could not have relied on AC-powered MOVs to admit steam to the TDAFWPs if the TDAFWPs were required to mitigate a Station Blackout event. The designer could not have relied on a TDAFWP to mitigate a MSLB if it received steam from only one steam generator. Particularly, electrical components of the AFW System must be powered from an emergency power source (EDGs or station batteries) and all active electrical components of one "train" of AFW must be assigned power which is independent and separated from the power source of the redundant AFW "train". **Source 4**, for example described the assignment of emergency power supplies to selected AFW MOVs. (Refer to the 4160 KV and 480 V DBDs (DBD-22, DBD-21) for details regarding safety-related power supplies.)

   Some of these power-assignment design decisions are discussed below:

   a. Station Blackout

      In the event of a station blackout (prolonged loss of offsite and onsite AC electrical power) affecting both units, the AFW System shall be capable of automatically providing 200 gpm of feedwater flow to each affected unit. The AFW System shall be capable of operation without any reliance on AC power for the first hour of the event **[Source 2]**. During the remaining three hours of the coping duration, alternate AC power from the standby gas turbine is available **[Source 5]**.

SYSTEM PARAMETER WORKSHEET
Section 2.2.6 (continued)

During the first hour of the event the turbine driven AFW pumps, 1P-29 and 2P-29, must operate independently of AC power. The pump discharge valves, 1AF-4000, 1AF-4001, 2AF-4000 and 2AF-4001, are powered from the 125 V DC Electrical System and will remain operable. The AFW system will automatically start as a result of undervoltage to the Main Feedwater Pumps. The gas turbine generator (GTG) G-05 will start, accelerate to rated

a. Station Blackout (continued)

frequency and voltage, and restore power to the safety-related plant loads within the first hour of SBO initiation. An EDG will start, accelerate to rated frequency and voltage, and restore power to the safety-related loads within ten minutes of SBO initiation (this is not required in the first hour). Backup cooling water for the turbine-driven AFW pump seals is provided by the Fire Protection System and will remain operable. The AFW water supply is from the CST for the first hour of the event. The PBNP Technical Specifications require a minimum of 13,000 gallons of water per operating unit in the CSTs **[Sources 2 and 3** (S.R. 3.7.6.1)]. During the remaining three hours of the coping duration, the Service Water System will be available to provide an alternate AFW supply and AFW pump cooling water **[Source 5]**. Other requirements to withstand and recover from a station blackout event are given in DBD-T-46, Station Blackout.

b. Other Design Basis Events

The remainder of design basis events may include a concurrent loss of offsite power and a limiting single failure of an active component. Refer to Section 2.2.13 for further discussion of power assignments and the limiting single failure.

2. **REQUIREMENTS ON THE POWER SYSTEM TO PROVIDE QUALITY POWER:** Once selected, the power source must be available when required, and must provide the quality of power for the duration required by the AFW System. For instance, the 480 V electrical distribution system must provide electrical power at voltage levels within tolerance of the electrical components of the AFW System. The Main Steam system must reliably provide steam at sufficient pressure/flow to power steam-driven components. These general power requirements are discussed below (and in Section 1.4.2). Specific power requirements for individual components will be discussed in Section 3.

a. Steam Power Requirements

The Main Steam System must provide steam of high quality and at sufficient pressure to drive the associated TDAFWP during design operating conditions. (Note that each TDAFWP is assigned only to one unit). To reliably perform this function, the Main Steam supply must not rely on an active AC-powered component. Accordingly, the steam supply line is provided upstream of MSIVs. Also, the steam supply to each TDAFWP must have an independent source. Accordingly, there are two steam supply lines to each TDAFWP; one from each of the unit's steam generators. Refer to Section 3.1 for the specific steam requirements to TDAFWPs.

SYSTEM PARAMETER WORKSHEET
Section 2.2.6 (continued)

b. Electrical Power Requirements

Safety-related electrical supplies must be used for active electrical components which serve the AFW System safety functions described in Section 2.1. These safety-related components shall supply the required electrical energy to:

- Start and operate the motor-driven AFW pumps, P-38A and P-38B, over the entire pump operating range from the station 480 VAC distribution system. (Note that MDAFWPs are shared between Units 1&2).

- Open and close the 480 VAC motor-operated valves from the station 480 VAC distribution system.

- Open and close the 125 VDC motor-operated valves from the station 125 VDC distribution system.

- Power the safety-related instrumentation used to initiate, modulate, and/or monitor the system processes from the station 120 VAC or the 125 VDC distribution systems.

For requirements and design of supporting electrical distribution systems, refer to:

- DBD-21, 480 VAC Electrical System
- DBD-17, Vital Instrument Bus 120 VAC
- DBD-19, 125 VDC Electrical System

Specific power requirements for individual components are discussed in Section 3. Requirements for electrical redundancy and train separation are described in Section 2.2.13. Refer also to DBD-P-50, Electrical and Mechanical Separation.

The electrical distribution system shall provide sufficient electrical energy during normal operation to power non-safety-related equipment from the 125 VDC and 120 VAC distribution systems. Non-safety related AFW loads may be powered from non-safety related power supplies.

SYSTEM PARAMETER WORKSHEET
Section 2.2.7

A. Parameter System Hydraulic Requirements

B. Value See Below

C. Source
1. WE Calc P-87-001 [REF 9.4.1]
2. MR IC-325, 326, 327 [REF 9.5.39, 9.5.40, 9.5.41]
3. WE Calc P-87-003 [REF 9.4.2]
4. WE Calc N-89-001 [REF 9.4.4]
5. MR 97-099 [REF 9.5.135]
6. MR 97-038 [REF 9.5.134]
7. LER 97-014-00 [REF 9.2.108]
8. PBNP Abnormal Operating Procedure AOP-5B (Attachment R), Loss of Instrument Air, Revision 13, 1/28/99. [REF 9.5.182]

D. Background/Reason for Value

The AFW system must not only be configured and sized to meet minimum steam generator flow requirements, but other system hydraulic requirements as well:

1. **NPSH available**. The AFW System must provide sufficient NPSH to AFW pumps under all operating conditions. The available NPSH is addressed by calculation P-87-001 **[Source 1]** and the calculation included in Modification Requests IC-325, IC-326, and IC-327 **[Source 2]**. These calculations conclude that sufficient NPSH is available from the CST(s). In addition, the pumps would trip due to low suction pressure, when required, to prevent damage. **[Sources 2, 5]**

2. **Flow Resistance to Prevent Pump Runout**. The AFW System must provide acceptable pressure drops, under all operating conditions, to prevent AFW pump runout. Potential pump runout was addressed by calculations P-87-001, P-87-003, and N-89-001 **[Sources 1, 3, 4]**. These calculations indicate that the motor driven AFW pumps could go to a runout condition and trip with the discharge flow control valves, AF-4012 and AF-4019, fully open and one steam generator depressurized. Although failure to the full open position was identified to possibly cause a significant and deleterious increase in MDAFW pump flowrate, **Source 1** concluded that the CSTs would provide sufficient NPSH (and flow restrictions would be adequate) to prevent MDAFW pump runout with these valves.

LER 97-014 **[Source 7]** identified that the previous analyses for this potential runout condition considered general steam generator pressure conditions at near the relief valve setpoint for maintaining the AFW system below the runout conditions for the MDAFW pumps. The LER noted that under more realistic conditions, the steam generator pressure would decrease as the accident runs its course. The early design was noted as taking credit for operator action to control MDAFW pump flowrates under these accident conditions and relied on resetting of the MDAFW pumps if they tripped as well as restarting the instrument air compressors to maintain system flow controls.

SYSTEM PARAMETER WORKSHEET

Section 2.2.7 (continued)

The original design basis did not specifically analyze the capability of the operating crew to take local-manual control for all events and preclude the loss of the MDAFW pumps. As such, the original design did not provide ample assurance that the MDAFW pumps would automatically function during all design basis events. Therefore, to preclude the potential to go to a runout condition, **Source 6** added safety-related backup nitrogen accumulators to maintain pressure control (at 1200 psig pump discharge pressure) after a loss of instrument air [Source 8]. As a result of this modification, only one pressure control valve would go to fully open when applying a single failure assumption. This single failure would result in a runout condition and trip of one pump, not two. The other pump would be controlled by its respective pressure control valve.

SYSTEM PARAMETER WORKSHEET
Section 2.2.8

A. Parameter System Design Pressures/Temperatures

B. Value

AFW Suction Piping	50 psig / 100°F (minimum design requirements)
	15 psig / 50-70°F (norm service conditions)
Service Water operation	50-55 psig/32°F-60°F (norm)
	100 psig (max)/32°F (min), 75°F (max)
AFW Discharge Piping	1440 psig / 220°F (design rating)
(up to CIV)	1350 psig/ 70°F (norm)
AFW Discharge Piping	1310 psig / 220-330°F (design rating)
(CIV to S/G)	730-1000 psig / 60-330°F (norm)
MS to AFWP Turbines	1085 psig / 555°F (design rating)
	765 psig / 515°F (norm service conditions) or
	820 psig (~521°F) for 100% power in SG
	1000 psig (~545°F) for 0 % power in SG
AFWP Turbine Exhaust	10 psig / 240°F (design rating)

C. Source
1. Design & Installation Guidelines Manual (DG-M03) [REF 9.5.107]
2. NCR N-90-233 [REF 9.3.28]
3. CRs 91-534, 535 [REF 9.3.38]
4. AFW DBD Validation Report [REF 9.3.32]
5. PBNP OI-1A, 1B, 2A, 2B [REF 9.5.143, 9.5.144, 9.5.145, 9.5.146]

D. Background/Reason for Value

Existing pipe ratings for Bechtel- and Westinghouse- specified pipe can be found in the original piping specifications and are reproduced in the Design and Installation Guidelines Manual (DG-M03) **[Source 1]**. These values are provided above for convenience. However, these documents do not provide the basis for these values.

DBD research could not uncover any original documentation which might have provided a basis for AFW System design pressure and design temperature conditions. Research was directed at locating documents which might identify the original rules for defining "design pressure" and "design temperature" conditions. Also, research was directed at identifying any documents which described the limiting plant conditions which caused the extreme/limiting values of system pressure and temperature. Ideally, each design pressure/temperature value for a particular section should be related to the plant conditions such as pump shutoff pressure, or normal condenser hotwell temperature, etc. which define the value.

The design pressure and temperatures of the AFW System piping shall be at least as high as the **maximum sustained operating conditions** in accordance with the requirements of USAS B31.1.

SYSTEM PARAMETER WORKSHEET
Section 2.2.8 (continued)

AFW Suction Piping

For AFW suction piping, "normal service" conditions (15 psig, 50-80°F normal, 32-120°F design maximum range) appear to originate from AFW alignment to the vented CST. The origins of the

100°F value are unknown, but the value is conservatively higher than normal CST temperature. The origin of "minimum design specification ratings" (50 psig, 100°F) are equally vague. Since normal SW pressure exceeds 50 psig (normally 50-55 psig), it must not have been based on AFW system alignment to SW.

The original design pressure (50 psig) was challenged by NCR-90-233 because the value did not consider the SW alignment to AFW. Subsequently, the existing pipe was deemed acceptable based on an IEB 79-14 analysis which found that all code allowable stresses would be met at a 120 psig pressure[1] **[Source 2]**.

NCR-90-233 also challenged the system design temperature of 100°F because it did not consider that AFW suction and discharge piping would be subjected to temperatures as high as 180°F during steam generator hydrostatic tests now indicated as 110°F maximum in procedures **[Source 5]**. Consequently, the NCR evaluated that the elevated temperature would not add significant stresses such that the existing piping stress analysis would be invalid. Notwithstanding the fact that the design ratings were not revised (in DG-M03) as a result of these evaluations, the new conditions (120 psig, 120°F) were considered as credible maximum sustained conditions, and should be considered in future evaluations.

AFW Discharge Piping (up to the CIV, and including recirculation pipe)

Upstream of the containment isolation valves[2], the AFW discharge piping (including the recirculation line up to the control valve) is subject to steam generator pressures when the valves are open, and subject to pump shutoff conditions when the valves are closed. Therefore, "normal service" conditions (1350 psig at pump discharge) appear to originate from the AFW system operation to steam generators at their relief setpoints (1085-1125 psig) plus margin for safety valve accumulation (normally 3% of set pressure), velocity head in the discharge piping, and static elevation difference between pump discharge and steam generator feed ring sparger (-67 feet). The origin of the "design rating" (1440 psig) appears to assume AFW pump operation with discharge valves shut. The 1440 psig value appears to have originated from a TDAFW pump shutoff pressure of 1340 psig plus the "design rating" (100 psig per **Source 1**) of service water.

1 SW pump shutoff head is approximately 285 feet, or 120 psig (per pump curves).
2 Normally locked open manual AFW valves 1AF-18, -19, 31, 44, and 2AF-32, -45, -56, -57 (per FSAR table 5.2-1 and figures 5.2-5/6).

SYSTEM PARAMETER WORKSHEET

Section 2.2.8 (continued)

The original minimum design temperature ratings (100°F) of all AFW discharge piping were challenged when PBNP experienced elevated system temperatures caused by back-leakage through the AFW discharge check valves in the standby alignment **[Sources 2 and 3]**. Early data indicated temperatures in excess of 220° F measured at AFW pump discharge check valves. More recent data revealed temperatures in excess of 330°F upstream of the first off check valves, but before the AFW discharge pipe exited containment. Although these conditions actually occurred, corrective actions are ongoing to preclude the high temperature conditions from future consideration as credible design conditions **[Source 4]**. These corrective actions included keeping the MDAFWP discharge MOVs normally shut, regularly monitoring discharge piping temperatures (e.g. daily temperature check by

touch, monthly recording of temperatures on discharge piping), and improving IST testing methodology. **[Sources 2 and 3]**

AFW Discharge Piping (downstream of the CIV)

Downstream of isolation valves, AFW discharge piping is subject to steam generator pressures, which should never exceed the safety valve setpoints (plus accumulation). Therefore, the basis for the "design rating" (1310 psig) appears conservatively large. The "normal service" conditions (nominally 900 psig and from historical data - 730 psig at 100% power to 1000 psig at 0% power) can not be related to any particular condition.

Main Steam to AFWP Turbines and AFWP Turbine Exhaust

MS lines to AFWP turbines were designed to the same "design rating" as main steam lines (1085 psig / 555°F) which might occur when AFW pumps are called to duty with steam generator pressure at its first relief setpoint. The "design rating" temperature corresponds to the pressure rating at saturation conditions.

Other design ratings of main steam lines to/from AFW pump turbines can not be related to any particular operating condition.

SYSTEM PARAMETER WORKSHEET
Section 2.2.9

A. Parameter Seismic and Other Environmental Hazards Design Requirements

B. Value See Below

C. Source
1. FSAR [REF 9.2.57]
2. WE Memo NEPB-85-213 dated 8/6/85 [REF 9.3.42]
3. WE Memo NEPB-87-250 dated 4/16/87 [REF 9.3.43]
4. MR 97-075 [REF 9.5.149]
5. WE to NRC Ltr dated 9/14/81 [REF 9.2.87]
6. NUREG-0737 [REF 9.1.4, Item II.E.1.1]

D. Background/Reason for Value

The safety-related portions of the AFW system are classified as Seismic Class I as described in the PBNP FSAR **[Source 1]**. These portions of the system are required to perform their safety functions in the event of an earthquake or tornado **[Sources 4, 5, and 6]**. The CSTs are seismically designed, but not Seismic Class I. Also, the tanks are not sufficiently protected from tornado generated missiles **[Source 4]**. Refer to Section 3 of this DBD for seismic requirements on specific AFW components.

Refer to DBD-T-45, Seismic Design and Analysis, for overall requirements.

Environmental Protection Requirements

The safety-related portions of the AFW system shall be capable of withstanding the effects of natural phenomena (i.e. flooding, external missiles, tornadoes) [FSAR GDC 2], as well as man-made hazards. Refer to DBD-T-41, Hazards, for the overall plant requirements.

Flooding

Flooding in the AFW Pump Room was evaluated in **Sources 2 and 3**. Potential sources of flooding were (1) the SW suction lines to AFW pumps, and (2) flooding from the Turbine Building. SW flooding from suction lines is not significantly mitigated by floor drains or equipment drains in the room. Therefore, the evaluation **[Source 2]** took credit for operator action, prompted by indications from the SW and AFW systems.[1] Additional SW pumps would start to maintain system pressure, and AFW flowrate would drop (or AFW pumps would trip on low suction pressure), when the AFW system was drawing suction from the SW System. For the potential case of flooding from the Turbine Building through the subsoil drainage system, plant changes were made to bolt down the subsoil drain covers.

As identified by the PBNP PSA, AFW pumps are also vulnerable to flooding as the water level might displace lubricating oil in the pump-case and cause pump bearing failure.

[1] **Source 2** considered the AFW pump motors as the most vulnerable component to flooding and calculated that SW flooding from the suction of a TDAFW pump suction line would allow just 18 minutes before the water level reached the motors.

SYSTEM PARAMETER WORKSHEET
Section 2.2.10

A. Parameter Vibration and Reaction Force Design Requirements

B. Value See Below

C. Source
1. SER on SG Water Hammer [REF 9.2.33]
2. WE Internal Memo NEPB-85-583, dated 1/2/86 [REF 9.5.11]
3. WE Ltr to NRC, RE: Water Hammer, dated 11/1/77 [REF 9.2.94]
4. W Ltr to WE, RE: Water Hammer, dated 7/31/80 [REF 9.3.58]
5. WE Ltr to W, RE: Water Hammer, dated 8/14/80 [REF 9.3.57]
6. WE Ltr to NUS, RE: Water Hammer, dated 9/17/81 [REF 9.3.59]

D. Background/Reason for Value

The AFW System piping is designed in accordance with USAS B31.1. The code addresses design considerations for piping. However, no specific mechanical requirements related to vibration, stress, or shock have been identified for the AFW system. No significant dynamic loadings have been identified in the PBNP AFW System **[Sources 1, 2, 4, 5, 6]**. The 1st off check valves (1/2 AF-100/101) are credited to preclude water hammer conditions in the upstream AFW piping **[Sources 3 and 6].**

SYSTEM PARAMETER WORKSHEET
Section 2.2.11

A. Parameter Environmental Qualification Requirements

B. Value See Below

C. Source
1. PBNP EQ Master List [REF 9.5.1]
2. FSAR Table 7.5-1 [REF 9.2.57]
3. WE Calc. 85-008 [REF 9.4.40]
4. SE 97-092 [REF 9.5.188]

D. Background/Reason for Value

The following safety-related electrical AFW equipment is required to be environmentally qualified **[Source 1]**:

- 1MS-2019-M 1P-29 AFP Steam Supply MOV Motor
- 1MS-2020-M 1P-29 AFP Steam Supply MOV Motor
- 2MS-2019-M 2P-29 AFP Steam Supply MOV Motor
- 2MS-2020-M 2P-29 AFP Steam Supply MOV Motor
- 1MS-2019-O 1P-29 AFP Steam Supply MOV Operator
- 1MS-2020-O 1P-29 AFP Steam Supply MOV Operator
- 2MS-2019-O 2P-29 AFP Steam Supply MOV Operator
- 2MS-2020-O 2P-29 AFP Steam Supply MOV Operator
- 1FT-4036 AFW to 1HX-1A Flow Transmitter
- 1FT-4037 AFW to 1HX-1B Flow Transmitter
- 2FT-4036 AFW to 2HX-1A Flow Transmitter
- 2FT-4037 AFW to 2HX-1B Flow Transmitter
- LT-4038 T-24A CST Level Transmitter
- LT-4039 T-24B CST Level Transmitter
- LT-4040 T-24A CST Level Transmitter
- LT-4041 T-24B CST Level Transmitter

Refer to DBD-T-39, Equipment Qualification, for overall requirements and implementation of the PBNP Equipment Qualification Program.

The time after an accident in which the steam supply to turbine driven auxiliary feed water pump (TDAFP) motor-operated valves, 1/2 MS2019/20, are expected to have completed their safety function is currently being changed from 30 minutes to 10 minutes per **Sources 2 and 4.** This change is required because the environmental qualification of the TDAFWP steam supply MOVs can only be demonstrated for a short period of time while saturated steam conditions are present in the steam generator following a steam line break in the vicinity of these MOVs (see **Source 3**).

SYSTEM PARAMETER WORKSHEET
Section 2.2.12

A. Parameter System Interlocks and Permissives

B. Value See Below

C. Source 1. Engineering Change Notice WIS-70053, 10/13/70 [REF 9.5.106]
2. MR 85-213, 214 AMSAC Installation [REF 9.5.120]

D. Background/Reason for Value

BLOCK of AFW Automatic Initiation

With the construction of Unit 2 in 1970 came the need to share certain AFW components between units. Controls had to be applied to shared components to ensure that the deliberate shutdown of one unit did not startup the AFW System unnecessarily[1]. Unless Steam Generator Lo-Lo Level signals and Tripped-MFW-Pump signals were blocked, routine shutdown operations would initiate AFW when it was not required for either unit. Accordingly, **Source 1** installed a block of the Steam Generator Lo-Lo Level and Tripped-MFW-Pump signals which ordinarily started the Motor-Driven AFW Pumps (MDAFWPs). The block was designed to activate when the MFW pump control switch was placed in the "Pull-to-Lock" position; an indication that the unit had been deliberately secured.

Because the installation of AMSAC displaced the original Tripped-MFW-Pump signal, the block was modified somewhat. Consequently, the block was designed to disable automatic AFW initiation (of the motor-driven pumps) caused by a SG Lo-Lo signal or AMSAC signal. **[Source 2]**

Other

There are several controls within the AFW system which might be classified as "interlocks", but in general there is no direct interlock between the AFW system and other plant systems. Component controls are discussed in Section 3 of the DBD.

Examples of misinterpreted "interlocks" might include:

- recirculation control valve opens with pump start (actually it's "controlled" by pump discharge flow) and remains open after the pump is secured.
- Seal cooling supply valve opens with pump start (actually a "control" function, and not an "interlock" or "permissive").

[1] A shared system cannot simply be disabled when it is no longer required for one unit, because it is still required for the other.

SYSTEM PARAMETER WORKSHEET
Section 2.2.13

A. Parameter Redundancy, Diversity, Separation Requirements

B. Value See Below

C. Source
1. Bechtel Specification M-6, AFW Pumps [REF 9.6.90]
2. DBD-P-50, Electrical and Mechanical Separation
3. WE ltr to NRC dated 4/9/81 [REF 9.2.35]
4. NRC SER on NUREG-0737 Item II.E.1.2 [REF 9.2.39]
5. WE Internal Memo NEPB-87-250, dated 4/16/67 [REF 9.3.43]
6. PBNP Fire Protection Evaluation Report [REF 9.2.59]
7. PBNP FSAR [REF 9.2.57]
8. Modification Request 97-099 [9.5.135]

D. Background/Reason for Value

The AFW system shall be provided with sufficient redundancy and diversity to perform its safety functions under accident conditions assuming a concurrent single failure and loss of offsite electrical power (Refer to Section 4.1.9). As addressed in Section 3.1.5, the two motor driven AFW pumps and their associated valves are provided with independent electrical power supplies. Each turbine driven AFW pump is powered from the applicable unit's Main Steam System. The valves required to operate the turbine driven AFW pump shall be independent from AC power **[Sources 3, 4]**.

The operability of the AFW pumps and valves in the event of a limiting single active failure is addressed below:

Each motor-driven AFW pump, P-38A and P-38B, is designed to provide a flow of 200 gpm **[Source 1]**. Flow from one pump is sufficient to meet the minimum AFW flow requirements for the licensing basis accident analysis (see Section 2.2.1). Pump P-38A is powered from electrical bus 1B03 and pump P-38B is powered from bus 2B04. The valves associated with pump P-38A, AF-4009, AF-4022, and AF-4023, are all powered from bus 1B03 or 2B03. The valves associated with pump P-38B, AF-4016, AF-4020, and AF-4021, are all powered from bus 2B04 or 1B04. Therefore, at least one motor-driven AFW pump and its associated valves will remain operable in the event of the failure of a single safety-related electrical power supply or a single active component. A recent modification to the electrical and control circuitry for the AFW System has addressed DC power failure concerns that could have affected the ability of the AFW System to perform its function following a seismic event or tornado **[Source 8]**.

SYSTEM PARAMETER WORKSHEET
Section 2.2.13 (continued)

Each turbine-driven AFW pump, 1P-29 and 2P-29, is designed to provide a flow of 400 gpm **[Source 1]**. The turbine-driven AFW pumps, 1P-29 and 2P-29, are supplied with steam from the Main Steam System via valves 1MS-2019, 1MS-2020, 2MS-2019 and 2MS-2020. These valves are powered from the 125 VDC Electrical System. As shown in CHAMPS, the two motor-operated valves associated with each pump are powered from diverse DC electrical panels. The motor-operated discharge valves associated with the turbine-driven AFW pumps, 1AF-4000, 1AF-4001, 2AF-4000 and 2AF-4001 are also powered from diverse DC electrical panels such that each pump can supply at least one steam generator of its associated unit if one DC power supply is lost.

However, the turbine-driven AFW pumps themselves and their associated suction valves from the Service Water System, (1AF-4006 and 2AF-4006), are not redundant. Therefore, the single failure of an active component (i.e. turbine-driven AFW pump) could prevent flow from the turbine-driven AFW pump to the affected unit. Valve 1AF-4006 is powered from 480 VAC bus 1B04 and 2AF-4006 is powered from 480 VAC bus 2B04. The loss of 480 VAC buses 1B04 and 2B04 could prevent remote manual operation of the suction valves from the Service Water System to the turbine-driven pump of the affected unit as well as preventing operation of motor-driven pump P-38B and its associated valves. On a loss of a DC bus in conjunction with an event that requires the TDAFW pumps to be shut down, one of the steam supply valves to each TD pump will fail as-is, which will result in both TD pumps continuing to operate. A modification has been completed to use the trip throttle valves, 1/2 MS-2082, which are downstream of BOTH steam supply valves for each TDAFW pump, to close and thereby shut down the respective TDAFW pump when required. This modified trip circuitry can withstand a single failure **[Source 8]**.

The most limiting single active failure could result in one motor-driven AFW pump remaining operable for the affected unit. The AFW System is capable of automatically providing the required flow in the event of a loss of normal feedwater, with a limiting single active failure or single electrical failure.

The AFW System shall be capable of providing the required flow with a limiting single failure [REF 9.1.1 (Criterion 41), 9.2.49 and 9.3.1]. For the SGTR event, the affected steam generator must be isolated and AFW flow directed to the unaffected steam generator. Therefore, only one motor-driven AFW pump (i.e., the one assigned to the unaffected S/G) and one turbine-driven AFW pump (i.e., the one assigned to the affected unit) are available for service (to the unaffected S/G) and subject to single failure. Therefore, in the event of a single failure only one AFW pump may be available to provide flow to the intact steam generator of the affected unit.

<u>Separation</u>

SYSTEM PARAMETER WORKSHEET

Section 2.2.13 (continued)

AFW equipment separation requirements were not well documented in the original plant design bases. However, subsequent licensing issues such as 10 CFR 50 Appendix R and Internal Flooding have resulted in evaluation and justification of the original AFW System equipment layout with little change. No particular AFW System separation requirements were established or reinforced in the PBNP response to INPO SOER 85-5 **[Source 5]**; wherein it was stated that "PBNP is able to withstand all postulated internal and external flooding events without losing redundant trains of safety-related equipment." The Fire Protection Evaluation Report **[Source 6]** established an objective for Safe Shutdown Systems (including AFW) to achieve and maintain safe shutdown regardless of the location of the fire while assuming concurrent loss of offsite power. As discussed in **Source 6**, two auxiliary feedwater pumps are required for safe shutdown. In accordance with the 20-foot separation requirement of Appendix R, a postulated fire could affect no more than two adjacent auxiliary feedwater pumps. Local control stations are also located in the [AFW pump room] and are separated by more than 20 feet. Appendix E of FSAR **[Source 7]** identifies no AFW System separation requirements to preserve AFW System functional integrity in the event of potential High Energy Line Breaks (HELBs). More recent evaluation of cable and power train separation issues in the AFW system have resulted in modifications to the system to ensure separation criteria are met **[Source 8].**

General separation requirements are addressed in **Source 2.**

SYSTEM PARAMETER WORKSHEET
Section 2.2.14

A. Parameter System Material Requirements

B. Value See Below

C. Source 1. MR 88-99 [REF 9.5.117]

D. Background/Reason for Value

The AFW System piping and pressure retaining components must be compatible with the contained fluid. Any special material requirements associated with the environmental qualification of electrical equipment is addressed in DBD-T-39, Equipment Qualification. No additional special material requirements have been identified.

[Source 1] specified that piping and valves in the new recirculation lines should be stainless steel because mini-recirc systems are susceptible to cavitation damage.

SYSTEM PARAMETER WORKSHEET
Section 2.2.15

A. Parameter System Chemistry Requirements

B. Value See Below

C. Source
1. NP 3.2.3, Secondary Water Chemistry Monitoring Program [REF 9.5.154]
2. W Guidelines for Secondary Water Chemistry [REF 9.3.18]
3. Appendix 5, WE/W Steam Generator Settlement [REF 9.3.44]
4. EPRI NP-2704-SR [REF 9.3.45]
5. EPRI NP-5056-SR [REF 9.3.46]
6. EPRI NP-6239 [REF 9.3.47]

D. Background/Reason for Value

The PBNP Secondary Water Chemistry Monitoring Program **[Source 1]** presents the feedwater and condensate chemistry requirements. These requirements are based on the water chemistry requirements in **Sources 2 through 6**. This secondary water chemistry program seeks to minimize or control steam generator tube degradation and secondary system corrosion in general.

Control Parameters	Normal Value (> 5% Rx Power)
Feedwater:	
pH	8.8 - 9.7
Cation Conductivity, µmhos/cm at 25 °C	~ 0.3
Sodium, ppb Na	≤ 3
Dissolved Oxygen, ppb O_2	≤ 5
Hydrazine, ppb N_2H_4	≥ 5
Total Iron, ppb	≤ 3
Total Copper, ppb	≤ 0.1
Total Conductivity, µmhos/cm	≥ 1.8, ≤ 11.6
Ethanolamine, ppm	1 - 5
Condensate:	
Dissolved Oxygen, ppb O_2	≤ 10

	Normal Value (Cold S/D/Wet Layup - RCS < 200°F)
Auxiliary Feedwater (monitor CST by grab samples at AFW pump suction)	
Dissolved Oxygen, ppb O_2	≤ 100

The initial water chemistry limits and treatment recommended by Westinghouse included use of phosphate injection along with hydrazine and morpholine injection. Early operating experience in other Westinghouse plants produced a number of steam generator problems including sludge formation, tube corrosion, and tube denting which were found to be related to the water chemistry.

The Westinghouse and EPRI recommendations for water chemistry have been revised over the operating life of PBNP to minimize steam generator degradation. These changes include changing to all-volatile chemical treatment, revising the pH of the water, and reducing the limits for certain impurities in the feedwater.

SYSTEM PARAMETER WORKSHEET
Section 2.2.16

A. Parameter Fire Protection Requirements

B. Value See Below

C. Source
1. Fire Protection Evaluation Report (Sections 6.6.4, 6.9.4.2.1, Table 6.7-1) [REF 9.2.59]
2. S&L Calc M-09334-212-AF.1, "TDAFWP Low Pressure Capability" [REF 9.4.42]
3. WE ltr to NRC, RE: AFW pump room App. R exemption request, dated 8/5/94 [REF 9.2.96]
4. WE ltr to NRC, RE: Clarification of AFW pump room App. R exemption request, dated 9/9/94 [REF 9.2.97]
5. WE ltr to NRC, RE: Clarification of AFW pump room App. R exemption request, dated 10/31/94 [REF 9.2.98]
6. WE ltr to NRC, RE: Clarification of AFW pump room App. R exemption request, dated 2/28/95 [REF 9.2.99]
7. NRC ltr to WE, RE: Issuance of App R Exemption in AFW Pump Room Fire Area, dated 7/18/95 [REF 9.2.100]
8. PBNP Procedures AOP-10A, 10B [REF 9.5.123, 9.5.184]

D. Background/Reason for Value

The AFW System is required to remove decay heat in the event of a fire and a loss of offsite power, to maintain the plant in a safe shutdown condition **[Source 1]**. The AFW pumps and various valves are identified as safe shutdown components to achieve hot shutdown. These components are listed in Table 2-3 **(Source 1, Table 6.7-1).** Therefore, the AFW system shall be protected to prevent a loss of function due to a single fire **[Source 1]**.

In the event of a plant fire, including fires requiring evacuation of the control room, the AFW System shall be capable of manual initiation to provide approximately 200 gpm of feedwater flow to at least one steam generator, to support maintaining reactor safe shutdown. The combination of AFW components credited with achieving this function vary with the specific fire location, and are defined by the analysis of each zone fire in the PBNP Fire Protection Evaluation Report **[Sources 1, 3, 4, 5, 6, 7]**. Fire scenarios are principally differentiated as follows:

1) **For local fires not requiring Alternate Shutdown**, the AFW System and Fire Protection System shall be (jointly) designed to ensure sufficient AFW components survive any postulated fire so that operators can maintain the required Hot Shutdown condition. Table 2-3 provides a list of AFW components which can be used to achieve Safe Shutdown. However, for each postulated fire, it is the FPER which describes the particular combination of these components which must survive the fire and be available to maintain Hot Shutdown from the Control Room.

SYSTEM PARAMETER WORKSHEET
Section 2.2.16 (continued)

2) **For Control Room and Cable Spreading Room fires requiring Control Room evacuation and Alternate Shutdown**, the AFW System and Fire Protection System shall be (jointly) designed to ensure sufficient AFW components remain locally operable so that operators can cooldown the RCS to the RHR cut-in temperature (350 °F). In these scenarios, the Turbine-Driven AFW Pumps and the manual operators of AFW valves in the flowpath (and other system components) must be operable to help achieve Cold Shutdown using only the "B" steam generator. [**Sources 1, 3, 4, 5, 6, 7**].

The AFW System shall be capable of performing this Alternate Shutdown function concurrent with a loss of offsite electrical power for 72 hours. This is to include considerations of natural circulation in the RCS and sufficient supply of steam to operate the TDAFW pumps down to RHR cut-in (RCS = 350°F). **Source 2** concludes that the TDAFW pumps can supply required flow to cool down to 375°F. A sequence of TDAFW pump operational steps would be required to bring the RCS temperature down to RHR cut-in. This sequence would be to 1) feed steam generators, 2) stop pump, 3) allow S/G pressure to go up, and 4) blowdown, then start cycle again until RHR cut-in has been reached. The manual actions required to operate the AFW System under this condition are addressed by **Sources 1** (Section 6.9.4.2.1, and 6.9.4.2.2) **and 8**.

In the context above, "Fire Protection System" includes fire protection, fire detection, fire suppression, combustible controls, and other measures which comprise the defense in depth methodology adopted under the FPER.

Refer to DBD-T-40, Fire Protection/Appendix R for overall plant requirements for response to a fire.

TABLE 2-3
SAFE SHUTDOWN COMPONENTS

Equipment ID	Equipment Name
A. Pumps:	
P-38A	Auxiliary Feedwater Motor Driven Pump
P-38B	Auxiliary Feedwater Motor Driven Pump
1P-29	Auxiliary Feedwater Turbine Driven Pump
2P-29	Auxiliary Feedwater Turbine Driven Pump
B. Motor-Operated Valves:	
AF-4009	P-38A AFP Suction from SW
AF-4016	P-38B AFP Suction from SW
AF-4020	AFP P-38B Discharge to 2HX-1B Steam Generator
AF-4021	AFP P-38B Discharge to 1HX-1B Steam Generator
AF-4022	AFP P-38A Discharge to 2HX-1A Steam Generator
AF-4023	AFP P-38A Discharge to 1HX-1A Steam Generator
1AF-4000	AFP 1P-29 Discharge to 1HX-1B Steam Generator
1AF-4001	AFP 1P-29 Discharge to 1HX-1A Steam Generator
1AF-4006	1P-29 AFP Suction from SW
1MS-2019	SG B Steam Header 1P-29 AFP Steam Supply
1MS-2020	SG A Steam Header 1P-29 AFP Steam Supply
1AF-4000	AFP 2P-29 Discharge to 2HX-1B Steam Generator
2AF-4001	AFP 2P-29 Discharge to 2HX-1A Steam Generator
2AF-4006	2P-29 AFP Suction from SW
2MS-2019	SG B Steam Header 2P-29 AFP Steam Supply
2MS-2020	SG A Steam Header 2P-29 AFP Steam Supply
1MS-2082	1P-29 Trip Throttle Valve (not included in the FPER at this time)
2MS-2082	2P-29 Trip Throttle Valve (not included in the FPER at this time)
C. Air-Operated Valves:	
AF-4007	P-38A AFP Mini Recirc. Control
AF-4012	P-38A AFP Discharge Control
AF-4014	P-38B AFP Mini Recirc. Control
AF-4019	P-38B AFP Discharge Control
1AF-4002	1P-29 AFP Mini Recirc. Control
2AF-4002	2P-29 AFP Mini Recirc. Control

SYSTEM PARAMETER WORKSHEET
Section 2.2.17

A. Parameter Containment Isolation Requirements

B. Value See Below

C. Source
1. FSAR [REF 9.2.57]
2. CHAMPS Q-List [REF 9.5.27]
3. PBNP IST Program (Section 2.5) [REF 9.5.85]

D. Background/Reason for Value

Containment penetrations 5 and 6 for each unit supply AFW to each Steam Generator. The containment isolation licensing basis for these penetrations is found in FSAR section 5.2 and Figures 5.2-5 and 5.2-6. Based on the FSAR, these penetrations are considered Class 4, requiring a closed system inside containment and at least one manual isolation valve located outside containment to provide redundant containment barriers in the event of a loss-of coolant accident.

For this reason, the FSAR identifies normally-open (locked open) Unit 1 manual valves AF-18, -19, -31, -44 and Unit 2 manual valves AF-32, -45, -56, -57 as "containment isolation valves" in conjunction with the closed system inside containment consisting of the steam generator secondary pressure boundary. Condition Report 98-1782 questioned the classification of valves in secondary system containment penetrations as "containment isolation valves" and whether these valves require in-service testing as CIVs. Action #1 from this CR provided a technical (not licensing) justification for removing the CIV label from secondary system valves, based on the premise that the closed secondary system provides a single adequate passive containment barrier after a LOCA, and that the valves for these penetrations do not perform a containment isolation function.

Therefore, based on the resolution of CR 98-1782 Action #1, the AFW valves identified in the FSAR as CIVs do not perform a containment isolation function. DBD-T-38 has created an open item (OI #3) to address changing terminology for CIV's associated with closed systems in general, although they may continue to be regarded as a redundant containment "barrier" which could be manually isolated if the secondary closed system were breached following a LOCA. Note that such a breach is beyond the design basis of the plant, and the closed system design criteria precludes a LOCA-induced loss of secondary pressure integrity (Refer to DBD-T-38, Containment Isolation for further discussion of this issue).

Valves whose sole function is to provide redundancy related to failure of passive components are exempt from in-service testing **[Source 3]**. The normally open AFW manual valves designated as containment isolation valves would provide a redundant containment barrier should a failure occur in the closed secondary system inside containment. Therefore, these valves are exempt from operability and seat leakage testing under the in-service testing program.

3.0 COMPONENT DESIGN BASIS

This section provides design bases and supporting design information for individual components and groups of redundant or "like" components within the system boundary. Only "major" components were selected for inclusion based on their satisfaction of the following criteria:

- actively support a system function, or
- protect the system from damage, or
- provide control, alarm, or monitoring functions.

Accordingly, the following "major" components are discussed:

Component Groups	Section
AFW Pumps	3.1
Condensate Storage Tanks	3.2
AFW Piping	3.3
MOV - MDAFW Pump Discharge Valves	3.4
MOV - TDAFW Pump Discharge Valves	3.5
MOV - AFW Pump Suction Valves from Service Water	3.6
MOV - Steam Supply Valves to AFW Pump Turbines	3.7
AOV - AFW Pump Recirc Flow Control Valves	3.8
AOV - MDAFW Pump Discharge Pressure Control Valves	3.9
Check Valve - AFW Pump Suction Check Valves	3.10
Check Valve - AFW Pump Discharge Check Valves	3.11
Check Valve - Second-Off AFW Check Valves	3.12
Check Valve - First-Off AFW Check Valves	3.13
RV - AFW Pump Suction Relief Valves	3.14
RV - AFW Pump Recirculation Line Relief Valve	3.15
RO - AFW Pump Recirculation Line Restricting Orifices	3.16
Flow Transmitters	3.17
Pressure Transmitters	3.18
Level Transmitters	3.19
Check Valve - First-Off AFW Backup Nitrogen Accumulator Check Valves	3.20
TDAFW Pump Trip Throttle Valves	3.21

Passive components within the boundary that provide little more than pressure boundary integrity or merely align the system for maintenance are not included in Section 3. Accordingly, the following components are not included:

Manual Vent , Drain, and Isolation Valves
Chemical Addition Tank
Turbine Valves (excluding trip throttle valves)
Local Instruments
Power Distribution Cable to Electrical Components
Supporting Structures

COMPONENT FUNCTIONS
Section 3.1

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

Safety-Related Functions

1. Each pump shall automatically start and deliver sufficient AFW System flow to maintain acceptable steam generator levels during accidents which may result in steam generator pressure safety relief valve opening. Such accidents which are time-sensitive to AFW Start-up include; LONF, LOAC, and LOL Events. **[REF 9.3.1, 9.3.111, 9.2.57** Sections 14.1.10, 14.1.11, 14.1.9]

2. Each pump shall automatically start and deliver sufficient AFW System flow to maintain acceptable steam generator levels during a seismic/tornado event which may result in steam generator pressure safety relief valve opening. Seismically/tornado induced accidents which are time-sensitive to AFW Start-up include LONF and LOAC Events. **[REF 9.2.57** Sections 14.1.10, 14.1.11]. Additionally, the AFW pumps shall be automatically protected from damage due to a seismically/tornado induced loss of AFW suction supply from the CSTs, which will result in a loss of suction pressure to the pumps. The protection of the AFW pumps allows for the pumps to be aligned to the SW system as a safety-related long term source of water for the steam generators (ultimate heat sink) **[REF 9.2.34, 9.2.36, and 9.2.39]**.

3. Each pump shall automatically start and deliver sufficient AFW System flow to maintain acceptable steam generator levels during SGTR and MSLB events **[REF 9.3.85, 9.2.57** (Sections 14.2.4 and 14.2.5)].

4. Each pump shall automatically start and deliver sufficient AFW System flow to provide for rapid cooldown and depressurization of the RCS during a SGTR event to stop primary to secondary break flow in the ruptured SG within 30 minutes. [REF 9.2.57 Section 14.2.4].

5. Each pump shall passively maintain the AFW system pressure boundary integrity.

Non-Safety Related Functions

Augmented-Quality Functions

1. Each turbine-driven pump shall be capable of manual start and shall deliver sufficient AFW System flow to maintain acceptable steam generator levels during plant fires. The flow requirement must support the cooldown and depressurization of the RCS to RHR system cut-in conditions for fires requiring Control Room evacuation. This capability is sufficient for RCS conditions where natural circulation is occurring and steam generators have steam pressure at 350°F saturation temperature **[REF 9.4.42, 9.2.59 Section 6.5.4]**.

COMPONENT FUNCTIONS
Section 3.1 (continued)

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

Augmented-Quality Functions (continued)

2. Each turbine-driven pump shall automatically start and deliver sufficient AFW System flow to maintain acceptable steam generator levels during the first hour of a Station Blackout event **[REF 9.2.64, 9.2.65, 9.2.57 Appendix A.1]**.

Non-QA Functions

1. Each motor-driven AFW pump shall be capable of manual start and deliver sufficient flow to support manual chemical addition during low power operation and wet lay-up plant operations **[REF 9.5.69]**.

2. Each motor-driven AFW pump shall be capable of manual start and deliver sufficient flow to maintain acceptable steam generator water levels while the unit is in hot shutdown or at low power **[REF 9.5.69]**.

3. Each motor-driven AFW pump shall be capable of manual start and deliver sufficient flow to fill its associated steam generator during cold shutdown and refueling conditions **[REF 9.5.69]**.

COMPONENT PARAMETERS SUMMARY
Section 3.1 (continued)

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

PARAMETER	VALUE	REFER TO
PERFORMANCE REQUIREMENTS		
1. Delivered Flow Requirements	See Worksheet	2.2.1
2. Allowable Time to Reach Full Capacity		3.1.2
Motor-Driven Pump	See Worksheet	
Turbine-Driven Pump	See Worksheet	
SUPPORTING DESIGN REQUIREMENTS		
3. Minimum Recirculation Flow		3.1.3
Motor-Driven Pump	70 gpm (nominal 89 gpm)	
Turbine-Driven Pump	100 gpm (nominal 126 gpm)	
4. Required NPSH (near runout)		3.1.4
Motor-Driven Pump	37 ft (at 500 gpm per pump curves)	
Turbine-Driven Pump	40 ft (at 700 gpm per pump curves)	
5. Power Supply Requirements		3.1.5
Motor-Driven Pump	460 vac +/- 10%	
Turbine-Driven Pump	Steam Pressure 680 - 1085 psig Intermittent High Steam Pressure of 1193 psig down to low of ~165 psig (375°F) w/ natural circulation in RCS	
6. Control Signals	See Worksheet	3.1.6
7. Design Code		9.6.90
• Pump	Unspecified	2.2
• Turbine	Unspecified	
8. Pump Protection Signals		3.1.7
• Low Suction Pressure Alarm	7 psig	
• Low Suction Pressure Trip	6.5 psig (with 20 second time delay)	
9. Seismic Requirements	Per Worksheet	3.1.8

COMPONENT PARAMETERS SUMMARY

Section 3.1 (continued)

PARAMETER	VALUE	REFER TO
OTHER DESIGN INFORMATION		
10. Delivered Flow/Head		3.1.1
Motor-Driven Pump		
• Design Operating Point	200 gpm at 1192 psi (2754 ft)	
• Shutoff Head	1305 psi	
Turbine-Driven Pump		
• Design Operating Point	400 gpm at 1192 psi (2754 ft)	
• Shutoff Head	1340 psi	
11. Cooling Water Flows		3.1.9
• Minimum Flow to 1 jacket (turbine only)	2.0 gpm	
• Nominal Flow to 1 Pump	15 gpm	
12. Turbine Speed Controls	Per Worksheet	3.1.10
13. Nominal Ratings		
Electric Motor	250 HP at 3552 rpm	9.7.2
Turbine	415 BHP at 3600 rpm	9.7.1
14. Reverse-Rotation Features	See Worksheet	3.1.11

COMPONENT PARAMETER WORKSHEET
Section 3.1.1

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Delivered Flow/Head

B. Value

Motor-Driven Pump	
• Design Operating Point	200 gpm at 1192 psi (2754 ft)
• Shutoff Head	1305 psi
Turbine-Driven Pump	
• Design Operating Point	400 gpm at 1192 psi (2754 ft)
• Shutoff Head	1340 psi

C. Source
1. W Calc, WEP Aux Motor Driven FWP, 2/5/68 [REF 9.4.24]
2. W Calc PDC-SSC-W-3, TDAFWP Sizing, 12/28/66 [REF 9.4.23]
3. FSAR [REF 9.2.57]
4. Bechtel Specification Spec M-6, AFW Pumps [REF 9.6.90]
5. Reactor Coolant System DBD (DBD-09)

D. Background/Reason

In a 1968 calculation of MDAFW pump sizing, **Source 1** determined that a minimum AFW flow of **176 gpm (initiated at 60 seconds)** to only one steam generator would provide acceptable steam generator level to remove residual heat. In 1968, **Source 2** determined that a 400 gpm capacity of the TDAFWP was more than sufficient to satisfy residual heat removal requirements of a "blackout" (**Source 2** stated that a delivery rate slightly over 200 gpm would be sufficient for PBNP).

Source 3 states that the [Turbine-Driven AFW] pumps are designed for 400 gpm at 2754 feet (1192 psi), and the [Motor-Driven AFW] pumps are designed for 200 gpm at 2754 feet. **Source 4** specified a shutoff head of 1305 psi for the Motor-Driven AFW Pump and 1340 psi for the Turbine-Driven AFW Pump. Regardless of specified values, actual design-basis-required values are derived from the limiting values of head/flow found in the accident analyses. This should be a locus of points on the head/flow graph. From this curve, margin may be added to describe the Tech Specs and acceptance values for inservice testing.

The limiting requirement on AFW Pump head/flow should be evident from the accident analyses. Refer to Section 2.2.1 for discussion of AFW System minimum flow requirements. Figures 3-1 through 3-4 provide (for information only) the performance curves of the AFW Pumps based on the AFW Pump performance curves procured from the vendor. These head/flow points do not necessarily represent the design basis as discussed above.

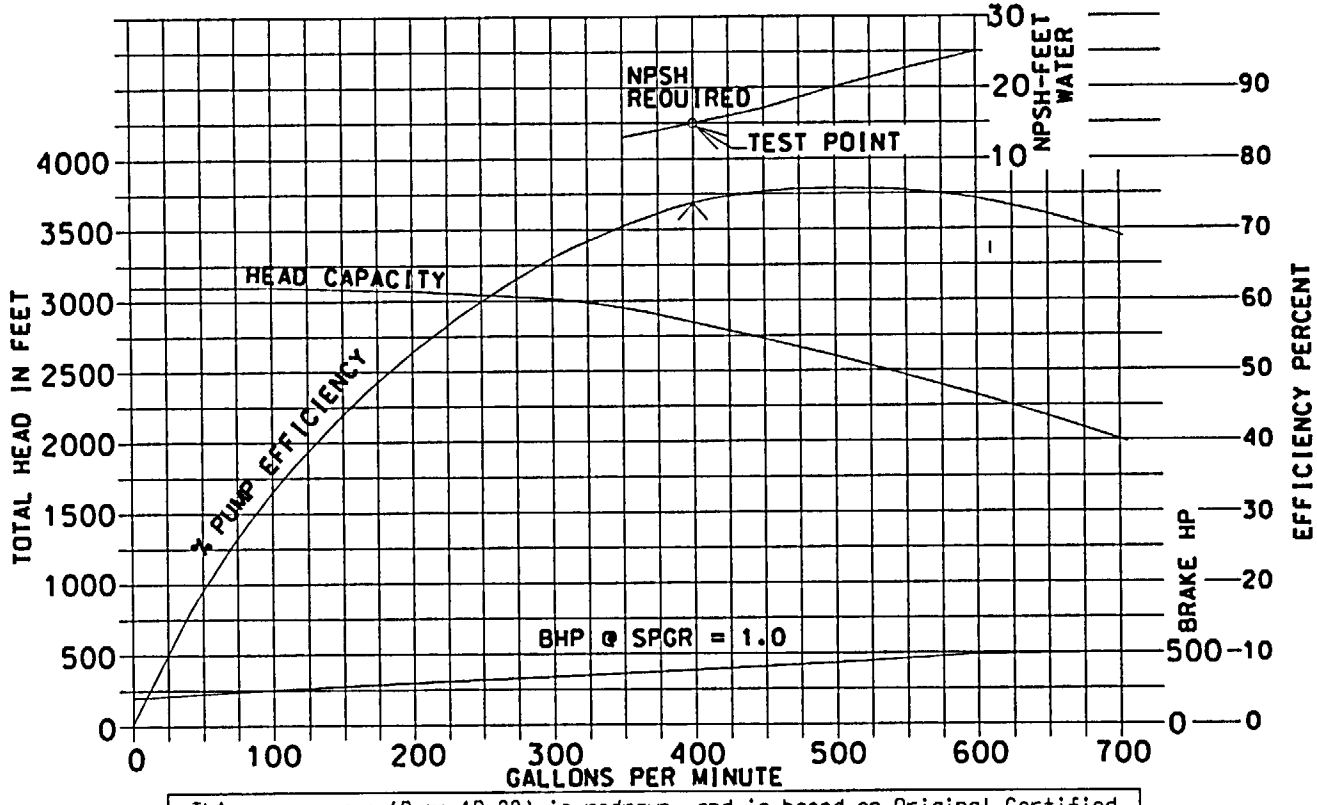
COMPONENT PARAMETER WORKSHEET
Section 3.1.1 (continued)

These pumps provide the auxiliary feedwater flow to the steam generators in events where Main Feedwater is not available (e.g., following a loss of AC power). In the accident analysis assumptions, the delivery of AFW is specified in terms of flow delivered at some time interval following receipt of an actuation signal.

In the original plant design, the AFW flow was specified as 200 gpm (per unit) delivered within one minute following generation of the AFW actuation signal [**Source 3**]. The limiting event for determining the flow requirement is typically the Loss of Normal Feedwater (LONF) event for Westinghouse plants. In this event, the reactor is tripped on Low-Low SG level. Following the reactor trip, pressurizer level drops to a minimum value and then increases (due to thermal expansion) as RCS temperatures increase. The increasing temperatures are a result of the loss of secondary heat removal (due to the loss of feedwater to the SGs). Pressurizer level continues to increase until secondary heat removal is restored by the delivery of the AFW flow. The AFW flow requirement is based on halting the increase in pressurizer liquid level before it reaches the level of the pressurizer PORVs and safety valves [**Source 3** Section 14.1.10], because these valves were not sized to pass liquid water [**Source 5**]. Relief of liquid water through such valves would lead to a significant loss of coolant inventory from the RCS. Accordingly, Westinghouse specified pump performance as described above (200 or 400 gpm at 1192 psig pump discharge pressure) based on the need for 200 gpm per unit at the high-pressure conditions of the steam generator. The specified pump performance considered the single failures which could lead to the net flow per unit of one MDAFWP (two (2) MDAFWPs split between both units) or one-half the flow from a TDAFWP.

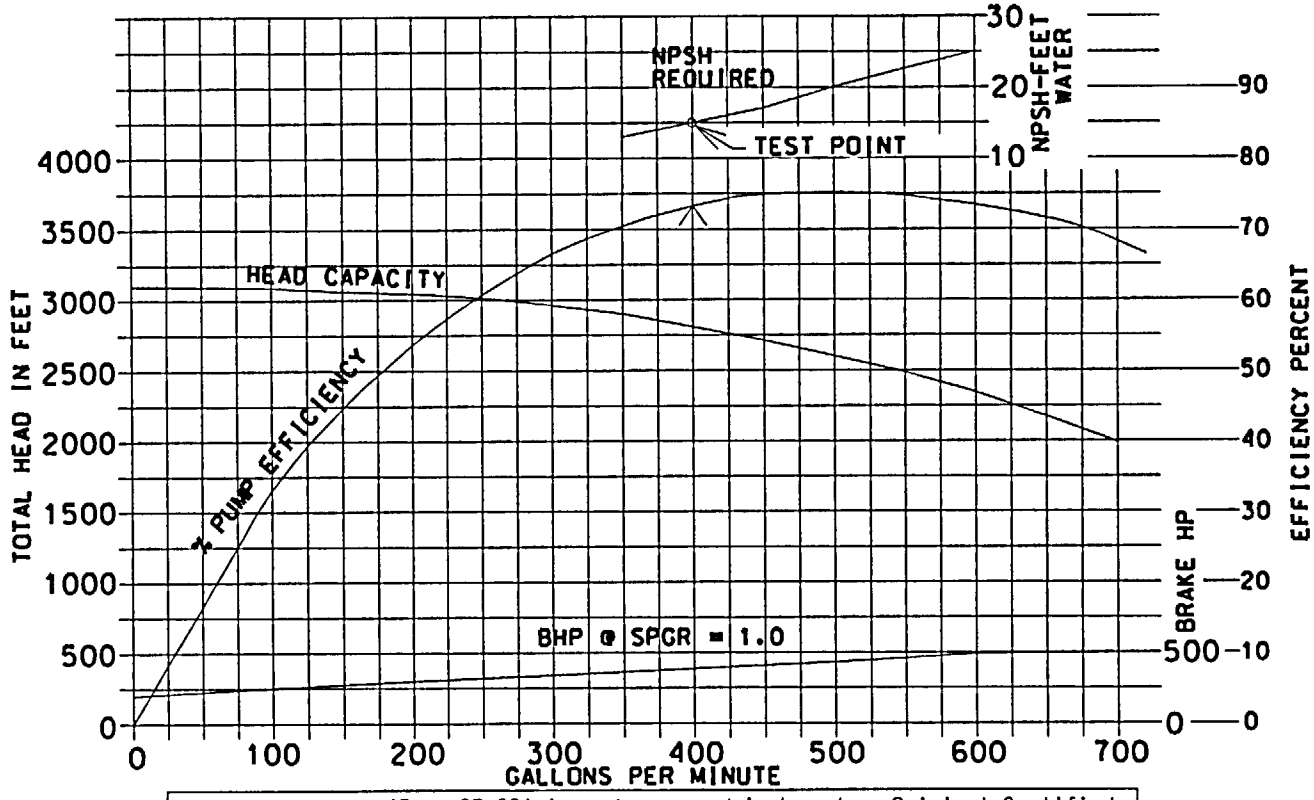
Refer to section 3.1.4 for discussion of the pump maximum flow (runout) limits, particularly with respect to NPSH requirements.

FIGURE 3-1
UNIT 1 TURBINE-DRIVEN AFW PUMP (1P-29) PERFORMANCE CURVE (1969)



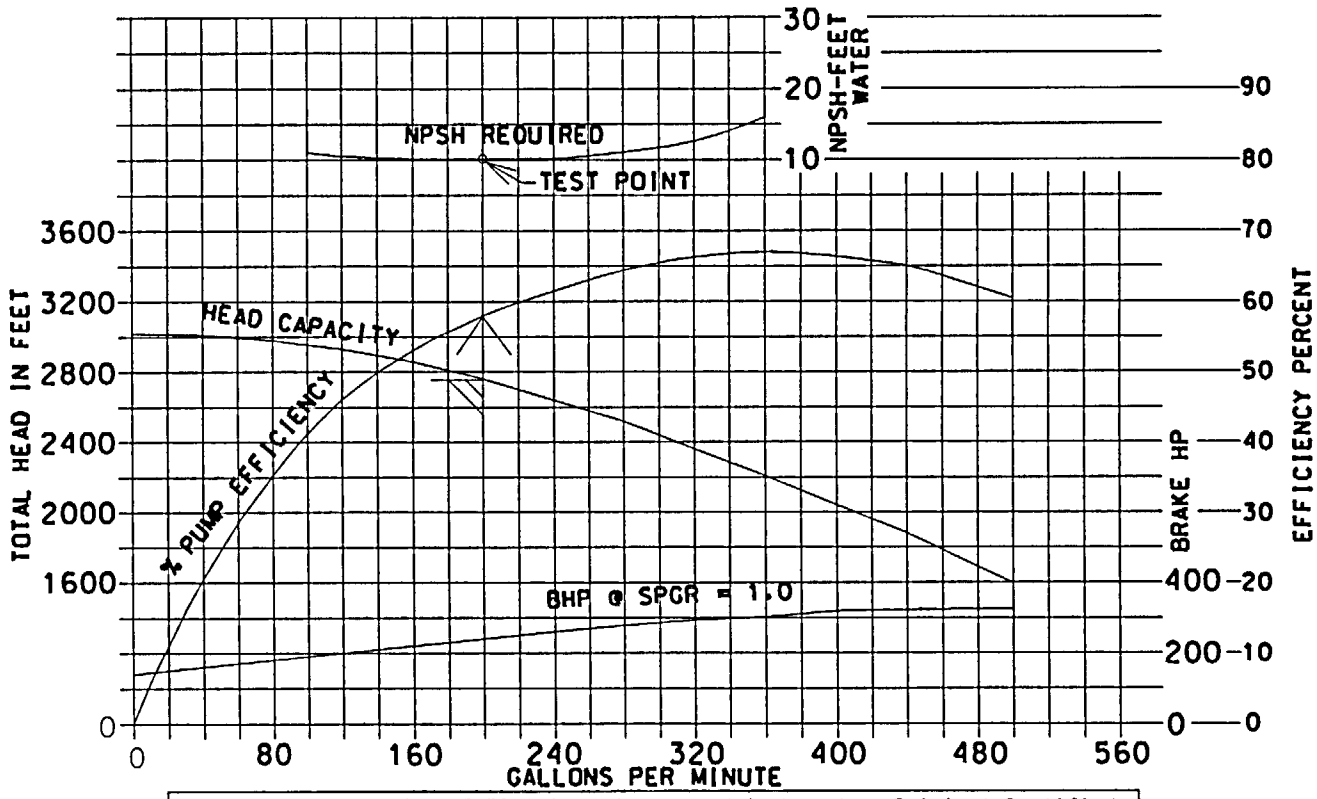
This pump curve (Pump 1P-29) is redrawn, and is based on Original Certified Correct curve data obtained from Byron Jackson Test T-30951-1 dated 8-19-69.

FIGURE 3-2
UNIT 2 TURBINE-DRIVEN AFW PUMP (2P-29) PERFORMANCE CURVE (1969)



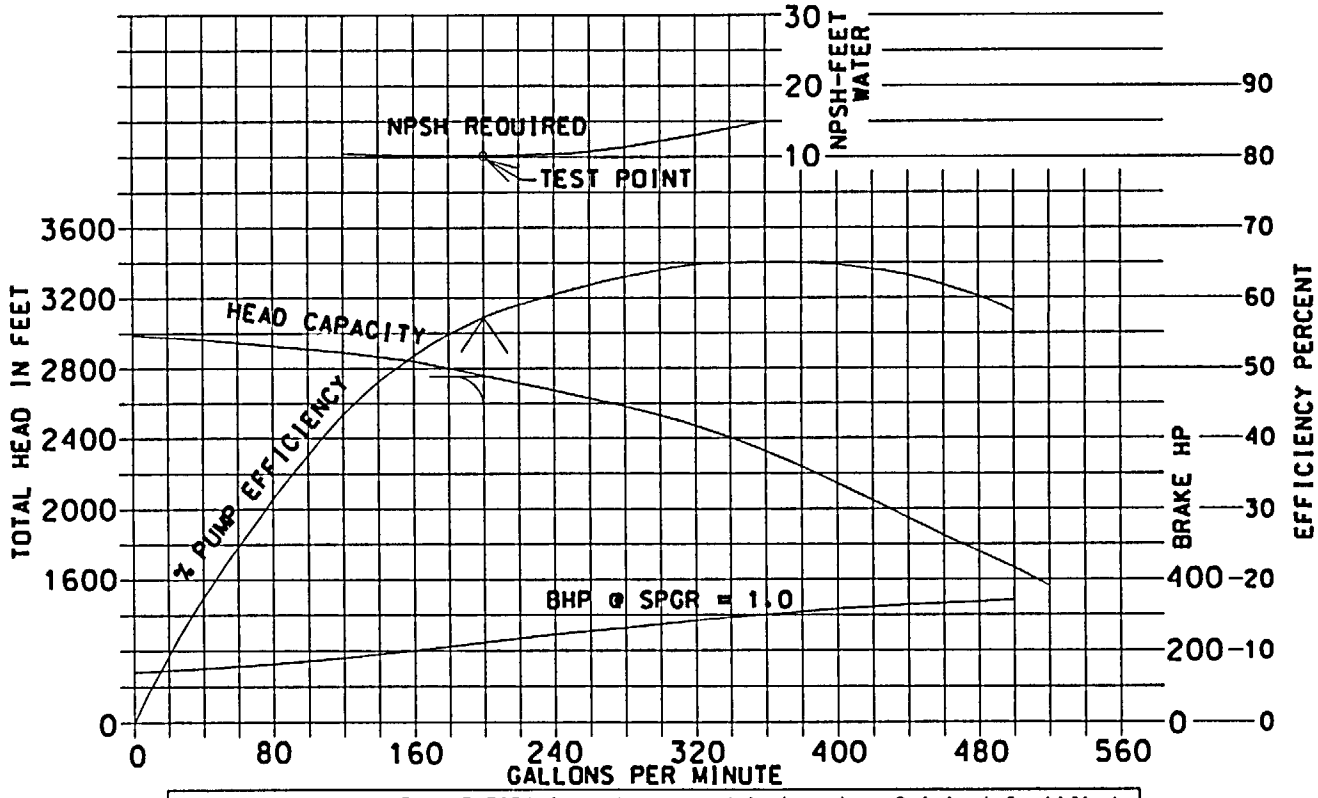
This pump curve (Pump 2P-29) is redrawn, and is based on Original Certified Correct curve data obtained from Byron Jackson Test T-30947-1 dated 8-8-69.

FIGURE 3-3
MOTOR-DRIVEN AFW PUMP (P-38A) PERFORMANCE CURVE (1969)



This pump curve (Pump P-38A) is redrawn, and is based on Original Certified Correct curve data obtained from Byron Jackson Test T-30944. dated 7-29-69.

FIGURE 3-4
MOTOR-DRIVEN AFW PUMP (P-38B) PERFORMANCE CURVE (1969)



This pump curve (Pump P-38B) is redrawn, and is based on Original Certified Correct curve data obtained from Byron Jackson Test T-30945 dated 8-11-69.

COMPONENT PARAMETER WORKSHEET
Section 3.1.2

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Allowable Time to Reach Full Capacity

B. Value See Below

C. Source
1. FSAR [REF 9.2.57]
2. W Steam System Criteria [REF 9.3.1]
3. W Steam System Criteria [REF 9.3.21]
4. AFW Pump Spec M-6 [REF 9.6.90]
5. MR 86-123, 87-25 [REF 9.5.114, 115]

D. Background/Reason

The time requirement for AFW full flow delivery to the steam generators is based on assumptions in the plant accident analyses. Currently, this time is identified as 5 minutes (See Section 2.2.2 of this DBD and Chapters 10 and 14 of the FSAR for specific details). Previous FSAR documentation was based on a 60 second criteria derived from previous accident analysis.

Early Westinghouse criteria **[Sources 2, 3]** referred to a two-minute criterion for AFW flow delivery, which included the actuation signal detection and processing time, as well as the AFW equipment response. At present, a one-minute capability (See Section 2.2.2) includes only AFW equipment response (i.e., actuation signal time is a separate limit).

Source 4 specified that "pumps shall be designed for quick start with no warm-up and shall be capable of reaching design conditions in 30 seconds or less when power is supplied to the driver (steam to the turbine and electric power to the motor)".

Source 5 determined the AFWP start-up time to only be 3 seconds (as a result of increasing the steam admission MOV stroke time to 21 seconds). This start-up time delay (relative to the 2-second value when the MOV stroked in 13 seconds) was determined to be insignificant to the existing margin to provide AFW flow within the 60-second time limit.

Given a total AFW equipment response time of 60 seconds, the approximate margin to accommodate pump acceleration-time may be estimated by subtracting all the other equipment starting delays from the 60-second overall limit.

COMPONENT PARAMETER WORKSHEET
Section 3.1.3

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Minimum Recirculation Flow

B. Value

Motor-Driven Pump	70 gpm (design minimum)
	89 gpm (nominal from modification)
Turbine-Driven Pump	100 gpm (design minimum)
	126 gpm (nominal from modification)

C. Source
1. MR 88-99 [REF 9.5.117]
2. Byron Jackson Ltr 8/7/89 [REF 9.3.20]
3. WMTP 11.21 [REF 9.5.137]
4. WMPCo Ltr to W dated 5/31/67 [REF 9.3.56]

D. Background/Reason

The original recirculation line capacity (30 gpm) was established solely on the basis of pumped fluid temperature rise **[Source 1**; Final Design Description]. 72 hour endurance runs performed on 1P-29 and 2P-29 circa 12/79 revealed that the bearing temperatures in long-term recirculation of 30 gpm remained adequately steady **[Source 3]**. Additionally, early design information regarding the tie-in point for the recirculation line back into the suction side of the pump concluded that the temperature rise was acceptable and no appreciable increase in pump operating temperature was expected **[Source 4]**. This design was not implemented as the recirculation line for each pump runs back to the CSTs.

In response to IE Bulletin 88-04, the amount of minimum recirculation flow was evaluated to ensure that AFW pumps were protected from the adverse effects of hydraulic instability at low flow rates. It should be noted that the minimum recirculation flows are higher for hydraulic instability at low flow rates than for temperature concerns discussed above. Accordingly, the pump manufacturer stated that the following minimum flows should be followed to avoid pump damage (for accumulated operating time of 60 hrs/year):

Motor-Driven AFW Pump	70 gpm	
Turbine-Driven AFW Pump	100 gpm	**[Source 2]**

Note that these values of minimum required flow provide the basis for sizing the pump recirculation line and restricting orifice **[Source 1]**. The nominal flow values of 89 gpm and 126 gpm for the MDAFW and TDAFW pumps, respectively, were derived from final flow orifice sizing established and installed per **Source 1**.

COMPONENT PARAMETER WORKSHEET
Section 3.1.4

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Required NPSH (near runout)

B. Value

Motor-Driven Pump	37 ft (at pump curve runout of 500 gpm)
Turbine-Driven Pump	40 ft (at pump curve runout of 700 gpm)

C. Source
1. Borg Warner Ltr dated 7/10/87 [REF 9.3.22]
2. WE Calc N-89-001 [REF 9.4.4]
3. Byron Jackson Ltr dated 8/7/89 [REF 9.3.20]
4. MR IC-325, 326, 327 [REF 9.5.39, 9.5.40, 9.5.41]
5. OI-62A/B, IT-8A/9A [REF 9.5.69, 9.5.70, 9.5.88, 9.5.90]

D. Background/Reason

Source 1 recommended an available Net Positive Suction Head ($NPSH_{avail}$) of 40 ft[1] absolute to operate the Turbine-Driven AFW pump at 700 gpm and 37 ft absolute to operate the Motor-Driven AFW pump at 500 gpm. This letter further recommended that operation with NPSH-available below these values be limited to less than 3 minutes. These values of NPSH-required could be reduced further by providing more line resistance to limit pump runout. Note that **Source 2** determined the maximum (runout) flows as follows:

MDAFW Pump	450 gpm
TDAFW Pump	590 gpm

Source 5 establishes the maximum administrative (runout) flows as follows:

MDAFW Pump	240 gpm based on supply breaker tripping
TDAFW Pump	450 gpm

Therefore, the limiting values of NPSH-available appear to have been selected from conservative values of maximum flow.

[1] All references to NPSH are in **absolute** units, of water column, not gauge.

COMPONENT PARAMETER WORKSHEET

Section 3.1.4 (continued)

Source 3 included an AFW Pump performance curve, including an extrapolated curve of NPSH-required. This curve reached an NPSH-required value of 80 feet at pump runout of 720 gpm. The required NPSH is determined by the pump design, and varies with the delivered flow. The available NPSH is determined by the water level in the condensate storage tank (CST), the piping layout between the tank and the pump suction nozzle, and the delivered flow. The available NPSH must be greater than the required value (at any given flowrate) to preclude cavitation and possible pump damage. Calculations **[Source 2]** show that available NPSH exceeds the requirement (for 600 gpm flow, 27 ft NPSH absolute required as determined from pump curve) throughout all of the CST usable volume.

The calculation supporting the AFW Pump Low Suction Pressure setpoints **[Source 4]** states that available NPSH will exceed 50 ft, even with the CST level down to the bottom of the outlet pipe. Refer to the component-level discussion on the CST elevation parameter and the pump trip on low suction pressure.

COMPONENT PARAMETER WORKSHEET
Section 3.1.5

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Power Supply Requirements

B. Value

Motor-Driven Pump	460 VAC +/- 10%
Turbine-Driven Pump	Steam Pressure ~95 - 1085 psig Intermittent High Steam Pressure of 1193 psig down to low of ~165 psig (375°F) w/ natural circulation in RCS

C. Source
1. Byron Jackson Vendor Manual [REF 9.7.2]
2. Terry Turbine Vendor Manual [REF 9.7.1]
3. AFW Pump Spec M-6 [REF 9.6.90]
4. AFW DBD Validation Report [REF 9.3.32]
5. Byron Jackson Ltr dated 5/2/68 [REF 9.3.29]
6. W Steam Systems Criteria [REF 9.3.21]
7. W Steam Systems Criteria [REF 9.3.1]
8. WE Internal Ltr dated 4/1/76 [REF 9.3.30]
9. OP-7A, Placing RHR System in Operation [REF 9.5.129]
10. Sargent and Lundy Calculation M-09334-212-AF.1 [REF 9.4.42]

D. Background/Reason

MDAFW Pump Electrical Power Requirements

Source 1 states the following nominal voltage/frequency continuous requirements: "the motor will operate satisfactorily with a 10% variation in voltage, a 5% variation in frequency, or a combined voltage and frequency variation of 10%, but not necessarily in accordance with the standards of performance established for operation at normal rating". Pump motors and power supplies must also accommodate the transient ratings which cover a wider range of voltage/frequency. Refer to the 480 V DBD (DBD-21) for further details.

The electric power supplies for the motor driven AFW pumps, P-38A and P-38B, shall be independent to satisfy the safety-related performance requirements addressed in Section 2.2.6, assuming a single active failure.

COMPONENT PARAMETER WORKSHEET
Section 3.1.5 (continued)

TDAFWP "Steam" Power Requirements

The Terry Turbine vendor manual **[Source 2]** provides little information on turbine steam requirements, and only states the nominal steam conditions of 1085 psig/ 556°F. **Source 3** specified

steam conditions of 680-1085 psig (500°-556°F)[1] and an intermittent maximum steam pressure of 1193 psig, at exhaust pressure of 10 psig. **Source 10** derived and evaluated the minimum steam conditions available to operate the TDAFW pumps and concluded that a steam supply pressure of 95 psig was the most limiting condition. The steam conditions of 95 psig to 1193 psig define the full steam supply pressure range for intermittent operating conditions for the TDAFW pumps.

The original Bechtel specification **[Source 3]** required a steam pressure range of 680-1085 psig for the turbine-driver. The vendor indicated that, "while the turbine has a capability of handling steam at a maximum pressure of 1193 psig, it is mechanically sized to handle the rated horsepower at 680 psig" **[Source 5]**. However, the Westinghouse Steam Systems Criteria **[Source 6]** clearly indicated that the AFW pumps would be needed until steam generator pressure had been reduced to 125 psia and that "the turbine of the steam driven pump should be suitable for operation with both high and low pressure steam." Although the original pump spec (issued for bid 05-04-67) pre-dates this Westinghouse requirement (an earlier version of the Westinghouse Steam Systems Criteria **[Source 7]** did not contain this "reactor cool down" section), subsequent versions of the pump spec were not revised to include this requirement.

A 1976 WE calc **[Source 8]** investigated the simultaneous supply of steam to the radwaste system and to the AFW pump turbine and concluded that below about 500 psia the "available energy to AFWP turbine was decreased below requirement." However, it should be noted that as the cool down progresses the decay heat input is decreasing and the required AFW flow will be less than the design value. In addition, the steam generator pressure is decreasing and so the head that the pump must develop is also reduced. Since the flow and head values will be reduced, the required pump horsepower will be less and the limiting value arrived at in this calc is not necessarily correct. **[Source 4]**

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[1] Note that the steam tables give the following as saturation conditions:

335°F	110 psia (95 psig)	500°F	680 psia (665 psig)
375°F	~182 psia (167 psig)	556°F	1098 psia (1083 psig)

[2] OP-7A [Source 9] establishes 350°F (~150 psig steam conditions) as the maximum primary temperature at which RHR cooling may be initiated.

COMPONENT PARAMETER WORKSHEET
Section 3.1.5 (continued)

Regardless of the inconsistencies contained in the above references, the TDAFWP must be capable of cooling down the plant to RHR cut-in conditions (RCS temperature of 350°F) for certain accidents (MSLB and SGTR), thereby defining the performance requirement to deliver sufficient flow to the S/G when the turbine's steam supply will be no better than 350°F[2] / 120 psig (saturation temperature/pressure). **Source 10** verified the design adequacy of the TDAFW pumps to operate at low steam generator pressures. This calculation considered the most limiting scenario for TDAFW pump operation as described in the Fire Protection Evaluation Report where the TDAFW pump must be capable of removing decay heat from the RCS, under natural circulation flow, with one TDAFW pump operating and only one steam generator available. The results of the calculation show that the TDAFW pump will operate to cooldown the RCS to a hot leg temperature of 375°F (~ 165 psig). In order to achieve acceptable RCS cooldown, the steam generators were credited with supplying steam at a pressure of 95 psig to the TDAFW pumps. It should be noted that the TDAFW pump should not be considered inoperable during this scenario when hot leg temperatures are below 375°F. However, the above statement reflects the inability to definitively show, via the analytical tools available, that the TDAFW pump has the capability to maintain SG level when the RCS hot leg temperature is reduced below 375°F.

In order to demonstrate the capability to cooldown the RCS to a condition (RCS hot leg temperature equal to 350°F) where the RHR system can be used to cool the unit to cold shutdown it was necessary to update AOP-10B "Safe to Cold Shutdown in Local Control" to reflect the assumed conditions of the calculation. These conditions are summarized below and have been incorporated into AOP-10B Revision 5: (1) Procedural guidance shall be given to maintain a minimum SG level of 500 inches wide range at conditions where low steam pressures may begin to affect TDAFW pump operation and (2) Guidance shall be given to maintain a cooldown rate of at least 20°F/hr when RCS hot leg temperature are less than 375°F. The SG level and minimum cooldown rate will ensure sufficient steam generator volume for secondary side steam venting to cool the plant to RHR cut-in conditions in order to transfer the function of removing decay heat and plant cooldown to the RHR system.

While researching the operation of the TDAFW pump at low steam pressure, test data or operational data for the pumps at Point Beach could not be located. However, test data was obtained from the Kewaunee and Prairie Island Nuclear Plants. Note that these plants have the same Terry Turbine model number (ZS-4), but different pumps. The test data from these plants was reviewed determining that there were no operability concerns for their TDAFW pumps at low steam pressures.

COMPONENT PARAMETER WORKSHEET
Section 3.1.6

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Control Signals

B. Value See Below

C. Source
1. W Ltr PBW-B-917 dated 2/6/68 [REF 9.3.3]
2. MSSM 90-23 [REF 9.5.121]
3. MR 85-213, 214 AMSAC [REF 9.5.120]
4. W Ltr PBW-B-1051, "Aux Electrical System" dated 3/15/68 [REF 9.3.2]
5. Dwg 883D195 Sht 20, AFW Pumps Start-Up Logic [REF 9.6.89]
6. W Internal Memo SE-CPS-34, 2/2/68 [REF 9.3.40]
7. NPBU Design and Installation Guidelines Manual [REF 9.5.107]
8. Dwg 883D195 Sht. 23, Loss of Feedwater Turbine Trip [REF 9.6.88]

D. Background/Reason

1. The starting logic for the motor-driven AFW pumps shall be as follows **[Sources 1 and 5]**:

- **Both MDAFWPs shall start on Low-Low level in any steam generator (either unit).** This signal is symptomatic in nature and not anticipatory. From a delay-time perspective, it is generally most conservative to take credit for this signal in analyses which require prompt AFW initiation to mitigate the event. This actuation is blocked[1] when Main Feedwater (MFW) pump control switches are placed in the "Pull-To-Lock" position; an indication that the MFW system has been shutdown deliberately. It should be noted that this 'block' is rarely implemented.

- **Both MDAFWPs shall start when both Main Feedwater Pump circuit breakers in either unit open** [there is a nominal 30 second (27 second on logic diagram) time delay for the signal]. This is an AMSAC [ATWS (Anticipated Transients Without Scram) Mitigating System Actuation Circuit] signal; anticipatory of the steam generator inventory loss caused by the LONF. This actuation is blocked[1] when: 1) Either or both the Main Feedwater (MFW) pump control switches for the respective unit are placed in the "Pull-To-Lock" position; an indication that the MFW system has been shutdown deliberately or, 2) Reactor power is ≤ 40% (as indicated by the 1st stage turbine pressure P-20 permissive.) This signal is more time-responsive than the Low-Low Steam Generator Level signal, but lacks the pedigree of that signal as a safety-related RPS-ESFAS component. This function is augmented quality (AQ) **[Source 7, DG-G06].**

[1] Refer to Section 2.2.12 for more information on this "block".

COMPONENT PARAMETER WORKSHEET
Section 3.1.6 (continued)

- **Both MDAFWPs shall start when both MFW Control Valves on the affected unit are closed.** This function was added to mitigate an ATWS event **[Source 3]**. This reduces

the severity that a steam generator level signal failure would have on the initiation of AFW. This signal is anticipatory of the steam generator inventory loss caused by the LONF. This is an AMSAC (ATWS Mitigating System Actuation Circuit) signal which is blocked[1] when: 1) Either or both the Main Feedwater (MFW) pump control switches for the respective unit are placed in the "Pull-To-Lock" position; an indication that the MFW system has been shutdown deliberately or, 2) Reactor power is $\leq 40\%$ (as indicated by the 1st stage turbine pressure P-20 permissive.). This function is augmented quality (AQ) **[Source 7, DG-G06].**

- **Both MDAFWPs shall start on a Safety Injection sequence in either unit.** The reason for this requirement is not well documented. However, it appears to relate more to diesel loading than to an immediate need for Auxiliary Feedwater to mitigate SI-based accidents.

  As discussed in Sections 2.2.1 and 2.2.2, there is no evidence that AFW has a significant role in mitigating the short-term effects of those accidents which generate SI signals. If AFW initiation had been considered a critical function to complement the ECCS and containment heat removal systems, the original designers would have required startup of the TDAFWP as well as MDAFWPs to satisfy single failure criteria. This was not the case. Rather, it is evident that the original designers had to include MDAFWPs in the SI-Safeguards sequence to prevent the disruption of diesel-loading that might have occurred if AFW had been allowed to start at any time (e.g., on an independent S/G Low-Low signal).

- **Both MDAFWPs shall be capable of manual initiation from local or remote control stations**

2. The Turbine-Driven AFW Pump assigned to one unit shall start on **[Source 1]**:

   - **Low-Low level in both steam generators of the associated unit.** Note that the MDAFWPs are started on a Low-Low level signal in either steam generator, while the start of a TDAFWP requires the Low-Low level signal in both steam generators. This logic allows less frequent starts of the TDAFW pump than the MDAFW pump. In general, this logic would automatically start the TDAFW pump only for Loss of All AC Power events or when water was needed in both steam generators. Westinghouse considered this logic to have both operational and safety advantages, particularly for steam break and tube rupture accidents. **[Source 6]**

[1] Refer to Section 2.2.12 for more information on this "block".

COMPONENT PARAMETER WORKSHEET
Section 3.1.6 (continued)

- **Loss of voltage on both 4KV buses that supply Main Feedwater Pumps of the associated unit.** This is an anticipatory signal not required to be safety-grade **[Source 2]**. Loss of this pump-start signal would not prevent the turbine-driven AFW pumps from starting from a diverse signal. The AFW Pumps would still start on Low-Low Steam Generator **[Source 2]**. Refer to the LONF/LOAC Accident Analysis Design Basis (DBD-T-35) for further confirmation that this loss of voltage AFW actuation is not relied upon for LONF/LOAC events.

- **Upon the opening of both MFW Pump circuit breakers in the associated unit.** This function was added to mitigate an ATWS event. This reduces the severity that a S/G level signal failure would have on the initiation of AFW. **[Source 3]**[1]

- **Upon the closing of both MFW Control Valves on the associated unit.** This function was also added to mitigate the consequences of an ATWS event. **[Source 3]**[1]

- **Manual Initiation from the control room**

3. Local Control Stations

In order to make it possible to bring both units to a hot shutdown condition in the event the control room must be evacuated, control stations shall be provided for the motor-driven AFW pumps, located near the pump motors. The local control stations shall consist of the following: **[Source 4]**

- A transfer switch,

- Start-stop pushbuttons, and

- A red indicating lamp (breaker or starter closed).

The transfer switch shall be used to transfer all remote breaker or starter control to the local pushbuttons. Whenever a transfer switch is placed in the "local" position, a common alarm shall be actuated in the control room **[Source 4]**.]

[1] Note that none of the TDAFWP starting signals are blocked by the MFW Pump "Pull-To-Lock" signal. Refer to section 2.2.12 for discussion of the block's applicability to MDAFW Pumps.

COMPONENT PARAMETER WORKSHEET
Section 3.1.7

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Pump Protection Signals

B. Value

Low Suction Pressure Alarm	7 psig
Low Suction Pressure Trip	6.5 psig (with 20 second time delay)

C. Source
1. SER on NUREG-0737 [REF 9.2.36]
2. NUREG-0737 [REF 9.1.4]
3. MR IC-325, 326, 327 [REFS 9.5.39, 9.5.40, 9.5.41]
4. MR 97-099 [REF 9.5.135]
5. Calculation 97-0215 [REF 9.4.29]
6. MR 97-079 [REF 9.5.136]

D. Background/Reason

AFW pump controls shall include a safety grade automatic trip on low suction pressure. The purpose of this requirement is to prevent damage to the pumps in the event of suction pipe rupture or Condensate Storage Tank failure, resulting in a sudden loss of AFW pump suction pressure. Bypass capability shall be included in the trip circuitry so that operators maintain ultimate system control [**Source 1 and Source 2** Item II.E.1.1].

Source 3 provides the basis for the low suction pressure alarm and trip setpoints (7 and 6.5 psig respectively). Refer to calculation summaries in Sections 8.3 and 8.25 for further discussion of these setpoints.

Recently, concerns were raised as to the adequacy of the low suction pressure trip to protect the AFW pumps upon loss of AFW suction supply from the CSTs. The concern centered around the amount of 'useable' volume of water available in the AFW suction piping that could be credited as available to the respective pump(s) after a seismic/tornado event. After comprehensive system evaluation, three main issues were raised 1) adequate protection from seismic/tornado damage was inadequate to be able to credit the suction piping with sufficient volume of water to safely shut down the pump(s) upon loss of AFW suction supply from the CSTs, 2) separation of cabling did not comply with single failure/common mode failure analysis, and 3) instrument errors associated with the low suction pressure trip transmitters were not adequately addressed. Modifications to the AFW system were completed to address these issues [**Sources 4 and 6**], and a calculation (**Source 5**) was prepared to verify that operation of the AFW pumps during a seismic event is adequately protected.

COMPONENT PARAMETER WORKSHEET

Section 3.1.7 (continued)

Note that pump protection for seismic/tornado events was mandated by the NRC and the system is designed around safely shutting down the AFW pumps. The system design, per original design requirements, was centered around quickly starting the pumps and establishing flow to the respective steam generators at sufficient discharge pressure and flow rate. The requirement to shut down a pump for protection following a seismic or tornado-induced loss of feedwater was contrary to original design and WE initially disagreed with the installation of this pump protection circuitry (the AFW system would be less reliable to provide feedwater to the steam generators on an automatic initiation signal). The inability to close both steam admission valves (when only one open valve is needed to initiate and/or maintain pump operation) upon loss of a DC train is an unintentional case in point. The modification adding trip throttle valves to the TDAFW pumps **[Source 4]** establishes a single (common to both steam admission valves for the respective turbine) flow path that can be secured to safely shut down the respective TDAFW pump after a seismic/tornado event that causes the loss of AFW suction supply from the CSTs.

COMPONENT PARAMETER WORKSHEET
Section 3.1.8

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Seismic Requirements

B. Value See Below

C. Source 1. AFW Pump Spec M-6 [REF 9.6.90]

D. Background/Reason

The pumps are designed to withstand seismic accelerations of 0.06g horizontally and 0.04g vertically occurring simultaneously with normal operating loads, including normal thermal transients, without exceeding code allowable stresses, as well as a simultaneous horizontal acceleration of 0.12g and vertical acceleration of 0.08g in conjunction with the normal loads and the maximum thermal transients without loss of function of equipment, or components **[Source 1]**. Refer to DBD-T-45, Seismic Design and Analysis.

The seismic design and qualification of the AFW pumps is addressed by DBD-T-45, Seismic Design Analysis.

COMPONENT PARAMETER WORKSHEET
Section 3.1.9

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Cooling Water Flows

B. Value

Turbine:	
Minimum Total Flow Per Jacket	2.0 gpm
Motor-Driven AFW Pump:	No cooling water requirements
Turbine-Driven AFW Pump:	No cooling water requirements
Nominal Flows:	15 GPM

C. Source
1. Bechtel Ltr PBB-W-1478 dated 11/19/68 [REF 9.3.5]
2. Bechtel Ltr PBB-W-2182 dated 6/20/69 [REF 9.3.6]
3. Bechtel Ltr PBB-W-2364 dated 8/27/69 [REF 9.3.7]
4. W Ltr PBW-B-2629 dated 8/27/69 [REF 9.3.8]
5. Bechtel Ltr PBB-W-3141 dated 6/30/70 [REF 9.3.19]
6. WE Ltr PBM-WMP-1300 dated 7/17/70 [REF 9.3.9]
7. AFW DBD Validation Report [REF 9.3.32]
8. WE Ltr dated 8/7/79 [REF 9.3.33]
9. MR M-623, M-624 [REF 9.5.126, 9.5.127]
10. WE Calculation N-90-006 [REF 9.4.14]
11. PBNP Component Maintenance Program CMP 1.3 [REF 9.5.153]
12. DBD-12, Service Water DBD [REF 9.3.110]
13. IST Background Document [REF 9.5.119]
14. CR 99-2090, SW Cooling Flow to 1P-29 Stuffing Box
15. SPEED 98-075 [Ref. 9.5.193]
16. SPEED 99-073 [Ref. 9.5.194]

D. Background/Reason

The cooling water supply to the turbine-driven AFW pump bearings and drive shall be controlled to open when the turbine steam supply valves open. Bechtel originally suggested that no temperature controls would be needed on the cooling water lines to the lube oil coolers on the turbine-driven AFW pumps. The minimum design temperature of cooling water supplied to the AFW pumps is 40°F **[Source 1]**. However, to ensure reliability of the turbine-driven AFW pumps, the turbine manufacturer suggested that some method of keeping condensate out of bearing boxes should be provided. Three different methods were proposed by Bechtel to Westinghouse **[Source 2]**. Bechtel's final recommendation was the use of a fail-open solenoid valve (SV-2090) in the cooling water supply line upstream of both pump and turbine, electrically controlled with the turbine steam supply motor-operated valves to open whenever either motor-operated valve is not in the fully closed position **[Source 3]**. This design was approved by Westinghouse and WE **[Source 4]**. As an added measure to ensure reliability, the two AFW turbines were added to the Component Maintenance Program to ensure that preventive maintenance would be performed in order to minimize random corrective maintenance **[Source 11]**.

COMPONENT PARAMETER WORKSHEET
Section 3.1.9 (continued)

The cooling water supply to the motor-driven AFW pump bearings, as currently designed, is controlled with automatically operated valves. In the original proposal by Westinghouse, cooling water valves to the motor-driven AFW pumps were to be manually controlled. When a pump was shutdown, the cooling water would be entirely shut off by means of the outlet globe throttle valve and the inlet gate valve **[Source 5]**. WE did not accept a manual shutoff in the cooling water supply to the MDAFW pumps, and required Westinghouse to provide automatically operated valves in the cooling water supply to the motor-driven AFW pumps similar to the turbine-driven AFW pumps **[Source 6]**. Per **Source 13** there are no longer minimum cooling water flow requirements for the MDAFW pumps (see **Source 12,** the section on the solenoid valves controlling cooling water to the MDAFW pumps, for details).

As discussed in **Source 7, Source 8** committed to performing a test on the TDAFW pump to determine if a cooling water source powered by electrical Alternating Current (AC) was needed. This test was performed for the Unit 1 TDAFW pump per procedure WMTP 11.16, Rev. 0. The test results indicated the turbine outboard bearing reached its operating temperature limit in about 42 minutes with no cooling water supplied. **Source 9** determined that the only acceptable option (of the three options originally recommended) to eliminate the TDAFW pump cooling dependency on an AC powered supply, was to use the fire water system. Modifications M-623/624 **[Source 9]** ensured the availability of TDAFWP cooling water independent of AC power, DC power, and instrument air.

Source 9 provided the following information based on vendor input from Terry Turbine: "The jacket is designed to cool adequately with 1.5 gpm cooling water flow; 75 psi and 90°F are maximum pressure and temperature limits. Ten psi across the water jacket is required to provide 1-1/2 gpm through the jacket." This engineering evaluation determined that the minimum total flow needed was 9 gpm (1.5 x 6 jackets) and a "safe" flow rate was determined to be 15 gpm.

As part of the Generic Letter 89-13 effort, **Source 10** determined the Service Water Flow Balance required to meet emergency loads. This calculation identified that there are between 20-25 gpm available from the Service Water System to cool AFW system pumps 1P-29 and P-38A[1]. SPEEDs 98-075 and 99-073 [Sources 15 and 16] replace the turbine bearing oil coolers on 1/2P-29. These SPEEDs increased the minimum acceptable cooling water flow to 2 gpm. A nominal cooling water flow rate should be established as 15 gpm to each TDAFW pump. This satisfies flow requirements that resulted from replacement of inboard and outboard bearing coolers **(Sources 15 & 16).** The MDAFW pumps by original design have service water supplying the cooling water supply lines to the pumps.

Based on information presented in the response to CR 99-2090 **(Source 14)** the pumps associated with the TDAFW pumps do not require cooling water. According to the Byron Jackson representative, cooling water for the pumps (not the turbines) is only required for pumping applications using water at temperatures above 175° F. The maximum process water supply temperature for the AF pumps is 120° F, therefore, no cooling for the pumps is required.

Since the turbines driving the TDAFW pumps are using steam for their driving force, the turbines will require cooling water. Based on the information presented in **Sources 15 & 16,** a minimum of 2.0 gpm per jacket is required to provide adequate cooling to the turbine drives.

[1] Refer to Service Water System DBD, DBD-12, for latest calculations.

COMPONENT PARAMETER WORKSHEET
Section 3.1.10

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump

A. Parameter Turbine Controls and Protection

B. Value See Below

C. Source
1. Terry Turbine Ltr dated 5/29/68 [REF 9.3.11]
2. Bechtel Ltr dated 6/18/68 [REF 9.3.12]
3. AFW Pump Spec M-6 [REF 9.6.90]
4. MR 97-099 [REF 9.5.136]
5. IE Notice No. 90-45 [REF 9.2.30]

D. Background/Reason

A device shall be used to prevent, on startup of the pump, overspeed and trip-out of the turbine **[Sources 1, 2, 5]**.

The AFW pump turbine drives are designed with hydraulically operated speed control (P-029GOV-Z), overspeed trip mechanisms, and integral trip throttle valves (1/2 MS-2082) with shutoff valves attached **[Source 3]**.

Per **Source 4** the trip throttle valves were replaced with a valve of a new design that will trip automatically to provide shut down capability of the respective TDAFW pump upon receipt of a low suction pressure trip signal (6.5 psig). This will provide pump protection so that a manual switchover to service water can be accomplished with operable TDAFW pumps, as required, when there is a loss of AFW suction supply from the CSTs due to a seismic/tornado event.

COMPONENT PARAMETER WORKSHEET
Section 3.1.11

Component ID	Service
1P29, 2P29	Turbine-Driven AFW Pump
P38A, P38B	Motor-Driven AFW Pump

A. Parameter Reverse-Rotation Features

B. Value See Below

C. Source
1. AFW DBD Validation Report [REF 9.3.32]
2. AFW Pump Spec M-6 [REF 9.6.90]
3. Byron Jackson Vendor Manual [REF 9.7.2]
4. P&ID M-217 [REF 9.6.21]

D. Background/Reason

Source 1 found no provision for anti-rotation on the pump itself. The pump spec **[Source 2]** was reviewed and no such provision was requested. The vendor manual **[Source 3]** was also reviewed and no such feature was indicated.

Anti-rotation protection is provided by the check valves installed in the system. From the point at which the turbine driven pump and motor driven pump discharge lines connect there are two check valves in each pump discharge line and a check valve in each suction line **[Source 4]**.

COMPONENT FUNCTIONS
Section 3.2

Component ID	Service
T-24A/B	Condensate Storage Tank

Safety-Related Functions

None

Non-Safety-Related Functions

Augmented Quality Functions

1. CSTs shall provide sufficient auxiliary feedwater inventory to support (approximately) one (1) hour of automatic AFW System Operation prior to suction switchover to Service Water during accidents requiring long-term decay heat removal, including cooldown to RHR cut-in conditions (for some accidents) **[REF 9.2.4].**

   During Station Blackout, the CST is the only readily-available source for AFW during the first hour. Accordingly, the CST is classified as Augmented Quality. **[REF 9.3.24, 9.3.21, 9.2.57 Appendix A.1]**

2. CSTs shall provide sufficient NPSH to allow operation of AFW pumps as described in Function 1, above **[REF 9.3.17]**. This function shall be met throughout the usable volume of the tank.

3. CSTs shall passively maintain the fluid boundary integrity of the AFW System. As a vented tank, this tank was designed for atmospheric pressure plus the static pressure attributable to fluid level.

Non-QA Functions

1. CSTs shall provide sufficient condensate/feedwater makeup needs under normal plant operation. **[REF 9.3.21, 9.3.103].**

COMPONENT PARAMETERS SUMMARY
Section 3.2 (continued)

Component ID	Service
T-24A/B	Condensate Storage Tank

PARAMETER	VALUE	REFER TO
PERFORMANCE REQUIREMENTS		
1. Volume		3.2.1
Tech Spec Required Reserve Capacity	13,000 gal/unit	
2. Water Temperature Limits	32° - 120°F	3.2.2
SUPPORTING DESIGN REQUIREMENTS		
3. Design Code	AWWA D100-67 AWS D5.2-67	3.2.3
4. Design Pressure, Temperature	15 psia, 120°F	3.2.4
5. Seismic/missile Requirements	Per Worksheet	3.2.5
OTHER DESING INFORMATION		
6. Tank Capacity		3.2.1
Nominal Capacity	45,000 gal/tank	
Condensate System Makeup Capacity	Unspecified	
Capacity at overflow vent	51,200 gal/tank	
7. Instrumentation		3.2.6
CST Level	Control Room	
8. Elevation (useable tank bottom)	+ 29.25 foot elevation	3.2.7
Elevation (physical tank bottom)	+ 27.75 foot elevation	
Elevation of discharge pipe bottom	+ 28.2 foot elevation	
9. Material	1/4" ASTM A 283 Grade C Carbon Steel w/ protective coating	9.6.92

COMPONENT PARAMETER WORKSHEET
Section 3.2.1

Component ID	Service
T-24A/B	Condensate Storage Tank

A. Parameter Volume

B. Value

Nominal Capacity	45,000 gallons per tank
Tech Spec Required Reserve Capacity	13,000 gallons per operating unit
Condensate System Makeup Capacity	Unspecified
Capacity at overflow vent	51,200 gallons per tank

C. Source
1. Technical Specification 15.3.4.A.3 [REF 9.2.58]
2. Tank Spec M-21 [REF 9.6.91]
3. SER on Station Blackout dated 10/3/90 [REF 9.2.64]
4. WE Ltr VPNPD-90-459 dated 11/8/90 [REF 9.2.65]
5. AFW DBD Validation Report [REF 9.3.32]
6. NRC SER on NUREG-0737 [REF 9.2.36]
7. WCAP 7451 dated 2/70 [REF 9.3.55]
8. W Ltr to W on site, dated 6/12/67, Condensate Storage Capacity [REF 9.3.103]
9. SER on Station Blackout dated 10/16/95 [REF 9.2.107]
10. Technical Specification Bases [Ref. 9.2.110]

D. Background/Reason

Condensate Storage Tanks (CSTs) are normally crosstied (locked open manual valves) by their connection to the common AFW system suction line. No design basis documentation could be found to support this configuration; however, **Source 6** discussed the topic to a limited degree in 1982. At that time, WE committed to install redundant CST level detection and alarm based on the plant capability to operate the two CSTs in a "split" configuration. When normally crosstied, the water level in either tank could be sensed by a detector on either tank

No design basis documentation could be found to address the potential vulnerability of the crosstied configuration to common mode failures such as cross-contamination or a line break. However, to address such contingencies, it is important to note that the SW System has always been considered to be the safety-related source of auxiliary feedwater.

Nominal Capacity: Source 2 specified a nominal capacity of 45,000 gallons for the CST (with maximum volume to overflow of 51,200 gallons). Neither the tank specification nor the FSAR provided the basis for this nominal capacity (nor did any other reference researched in drafting the original DBD). However, some information implicitly provides basis for the CST capacity requirements. **Source 8** specified a calculation of 138,000 gallons for two units most likely based on the assumption that 50 gallons of CST water is required per Mwth **[Source 7]**. PBNP constructed CSTs with 90,000 gallons total, which is sized 50% less than **Source 8** recommended. Additionally, some evaluation has been provided for the value of Tech Spec Reserve Capacity. No evaluation could be found for the necessary capacity to fulfill routine condensate system makeup. Such an evaluation would consider the amount of anticipated condensate, feedwater, and steam system leakage, and would attempt to optimize the frequency at which operators would have to refill the CST.

COMPONENT PARAMETER WORKSHEET
Section 3.2.1 (continued)

Tech Spec Reserve Capacity: In response to Station Blackout issues, WE agreed to increase the Technical Specification CST Level from 10,000 to 13,000 gallons per operating unit to ensure acceptable steam generator inventory (at the end of the 1-hour coping period) to allow more time for operator action to switch the suction source to service water. **[Source 4]** According to the bases of Technical Specification SR 3.7.6.1: "The minimum amount [13,000 gals per operating unit] of water in the CST ensures the ability to maintain each unit in MODE 3 for at least one hour concurrent with a loss of all AC power." **[Source 10]** In compliance with **Source 3**, the 13,000 gallons per operating unit is based on taking the 11,800 gallons required for each unit, then adding 10% margin and rounding up to the nearest 100 gallons, which resulted in the current Tech. Spec. change from the original minimum of 10,000 gallons to 13,000 gallons per unit.

In the SBO case, it is only important that there is sufficient steam generator inventory in the 1-hour coping period when no AC power is available; feedwater flow throughout the period is a secondary concern. This inventory can only be achieved by transferring the CST inventory to the steam generators with the TDAFW pump. An excessive steam generator feedrate (and a depletion of the CST prior to one hour) is not of critical impact since the important factor is the endpoint; sufficient steam generator inventory at the end of one hour. There is little difference in feeding the entire CST inventory uniformly during the hour, and feeding it all in the first 30 minutes (with the exception that an early CST depletion may trip the running AFW pumps on low suction pressure and confuse the plant recovery). Therefore, it is important to consider the SBO analysis of CST volume as an endpoint-to-endpoint concern. **[Sources 3, 4, and 9]**

Condensate System Makeup Capacity:

The volume of the CSTs shall be sufficient for the non-safety related performance requirements of the Condensate System in addition to the volume required for the safety-related AFW requirements. Refer to DBD-03, Condensate and Feedwater, for requirements.

Source 5 determined that the makeup requirements are most significantly related to the steam generator blowdown that is operated continuously and not recovered. The target blowdown rate is approximately 40 gpm per steam generator; varying somewhat due to steam generator water chemistry. Therefore, with both units at power, the normal makeup requirement is about 160 gpm **[Source 5]**.

Additional water usage may occur in the Heating Steam System. Condensate from the heating steam system may not be recycled due to water quality issues.

This water demand from the CST is the predominant factor in determining the frequency of operations to initiate makeup to the condensate system.

COMPONENT PARAMETER WORKSHEET
Section 3.2.2

Component ID	Service
T-24A/B	Condensate Storage Tank

A. Parameter Water Temperature Limits

B. Value 32° - 120°F

C. Source
1. Accident Analysis DBD Module #11, LONF [REF 9.3.26]
2. Accident Analysis DBD Module #15, SBLOCA [REF 9.3.48]
3. Accident Analysis DBD Module #12, MSLB [REF 9.3.49]
4. W Ltr WEP-89-142 dated 6/30/89 [REF 9.3.27]
5. WE Calculation, AFWP Lo Suction Pressure Setpoints, dated 1/21/86 [REF 9.5.39]
6. PBNP Procedures OI-1A/1B, OI-2A/2B [REF 9.5.143, 9.5.144, 9.5.145, 9.5.146]

D. Background/Reason

The CSTs must store feedwater at temperatures within a band defined by the assumptions of plant accident analyses. Although the tank itself has no temperature controls, temperature should be monitored to ensure analysis assumptions are not violated.

Minimum Temperature Limit 32°F - For MSLB analyses (core response and containment response), it is conservative to assume lower feedwater temperatures because addition of colder (denser) auxiliary feedwater to a faulted steam generator will result in a greater insertion of positive reactivity and more mass released to the containment during a given period. **Source 3** states that a minimum auxiliary feedwater temperature of 32°F was assumed to maximize the cooling effect on the faulted steam generator which continues to blowdown following the steamline isolation. This minimum temperature value is specific to PBNP. Note, however, that for typical 2-loop Westinghouse plants, **Source 4** indicated that a minimum temperature of 80°F is assumed for the containment analyses of MSLBs inside containment.

Maximum Temperature Limit 120°F - For decay heat removal and AFW pump $NPSH_{avail}$ analyses, it is conservative to assume higher feedwater temperatures. **Source 1** states that the LONF/LOAC analyses assume 120°F auxiliary feedwater to be consistent with the small break LOCA assumptions. **Source 2** confirms that the SBLOCA analyses also assume a maximum AFW temperature of 120°F. Procedurally, the maximum temperature is 110°F **[Source 6]**. Furthermore, **Source 2** states that Westinghouse will typically assume the 120°F CST temperature when no Technical Specifications or other functional limits exist on that parameter.

Notwithstanding the conservative use of the 120°F in accident analyses, one other calculation has established a more limiting assumption for this parameter. Specifically, **Source 5** calculated AFW Pump NPSHa assuming a CST temperature of 80°F. Since NPSHa was considered an extraneous factor in that calculation (because of the large margin between NPSHa and NPSHr), and since there

COMPONENT PARAMETER WORKSHEET

Section 3.2.2 (continued)

is an insignificant difference in vapor pressure between 80°F and 120°F, the use of 80°F in this particular calculation should not be considered a limit on CST water temperature.[1]

Refer also to Section 2.2.5 (Water Temperature Operating Limits) and Section 2.2.8 (System Design Pressures/Temperatures) for more discussion on the AFW temperature parameter.

[1] The vapor pressure at 80°F is 1.2 feet of water (.5 psia). The vapor pressure at 120°F is 4 2 feet of water (1.8 psia). Therefore, the NPSHa is 3 feet of water (1.3 psia) less at 120°F. **Source 5** calculated that NPSHa exceeded NPSHr by a margin of 16 psia (36 ft for the limiting AFW pump) at the stated conditions which included the 80°F assumption. Assuming a CST temperature of 120°F would reduce that margin by only 1.3 psia or 1.8 feet of water. The vapor pressure at 32°F is 0.2 feet of water (0.1 psia) for negligible effect.

COMPONENT PARAMETER WORKSHEET
Section 3.2.3

Component ID	Service
T-24A/B	Condensate Storage Tank

A. Parameter Design Code

B. Value AWWA D100-67 (AWS D5.2-67)

C. Source
1. AWWA D100-67 (AWS D5.2-67) [REF 9.1.6]
2. Specification M-21 [REF 9.6.91]
3. Graver Tank Drawing L-23944-4 dated 04-26-85 [REF 9.6.99]
4. AWWA D100-67 (AWS D5.2-67) [REF 9.1.6]

D. Background/Reason

The tanks shall be designed in accordance with American Water Works Association, AWWA D-100. Specification M-21 **[Source 2]**, and accompanying sketch SK-M-21-4 identify the applicable codes and specs as ASME Sect VIII and IX, ASA B16.5, AWWA D-100. **Source 3** refers to the AWWA-D100 code.

The revision history of AWWA D-100 indicates that the effective code of CSTs was D100-67 (AWS D5.2-67) **[Source 4]**. This revision would have been in effect at the time the procurement specification **[Source 2]** was issued for bid 10/27/67.

COMPONENT PARAMETER WORKSHEET
Section 3.2.4

Component ID	Service
T-24A/B	Condensate Storage Tank

A. Parameter Design Pressure, Design Temperature

B. Value 15 psia (open to atmosphere), 120°F

C. Source 1. Tank Spec M-21 [REF 9.6.91]

D. Background/Reason

The CSTs shall be designed to withstand the maximum operating pressures and temperatures to which they may be exposed during any expected condition. The tanks are designed for a pressure of 15 psia, exclusive of hydrostatic head and an ambient temperature range of 40°F to 120°F [**Source 1**]. The CSTs shall be furnished with a suitable vent above the maximum water level which shall have the capacity to pass sufficient air to prevent the creation of excessive pressure (or vacuum) when water is being injected or discharged from the tank at the maximum possible flowrate.

Refer to Section 2.2.8 (System Design Pressures/Temperatures) for further discussion.

COMPONENT PARAMETER WORKSHEET
Section 3.2.5

Component ID	Service
T-24A/B	Condensate Storage Tank

A. Parameter Seismic/Missile Requirements

B. Value Seismic Construction
NOT CONSIDERED A SEISMIC CLASS I COMPONENT OR MISSILE PROTECTED

C. Source
1. PBNP FFDSAR [REF 9.2.56]
2. WE to NRC Letter dated 2/14/75 [REF 9.2.86]
3. WE Initial Response to GL 81-14 [REF 9.2.6]
4. WE to NRC Ltr dated 9/14/81 [REF 9.2.87]
5. NRC TER (Seismic Qualification of AFW System) [REF 9.2.3]
6. Tank Spec M-21 [REF 9.6.91]
7. PBNP Modification MR 97-075 [REF 9.5.149]
8. PBNP Modification MR 97-079 [REF 9.5.136]
9. Condition Report CR 97-1918 [REF 9.5.150]

D. Background/Reason

Since issuance of the operating license, there has been conflicting description of the seismic requirements of the CST. The discussion centers around the application of original design codes and the tank's location in the non-seismic Turbine Building:

1970 FFDSAR **[Source 1]** Appendix A classified the CSTs as **Seismic Class III** and the Turbine Building as Seismic Class III as well.

1975 In response to an Internal Flooding issue, WE stated (to the NRC) that an engineering review concluded that the CSTs were of **Seismic Class I** design. **[Source 2]**

1981 In response to NRC Generic Letter 81-14, WE stated the CSTs were specified in accordance with ASME and AWWA code, and therefore could be allowed a **Seismic Class II** categorization. **[Source 3]**.

1981 In response to post-TMI NUREG-0737, WE maintained the position that, although **not Class I** water sources, the CSTs were reliable and designed to acceptable seismic criteria. **[Source 4]**

1985 In a TER evaluating WE response to GL 81-14, the NRC considered the CSTs to be **Seismic Class II** and the Turbine Building to be non-seismically qualified. **[Source 5]**

COMPONENT PARAMETER WORKSHEET

Section 3.2.5 (continued)

1997 In conjunction with CR 97-1918 **[Source 9]**, an evaluation was initiated to determine whether the CSTs could be seismically qualified to Class I and adequately missile protected from credible tornado scenarios. The results of the evaluation determined the following: 1) It would be cost prohibitive to missile protect the CSTs, 2) the CSTs are anchored to the concrete base to adequately withstand a Design Basis Event, 3) structures over the CSTs are not Seismic Class I and are assumed to fall onto and catastrophically destroy the CSTs (worst case assumption). In conclusion, the CSTs are considered to be destroyed when a seismic or tornado event is considered. MRs 97-075 **[Source 7]** and 97-079 **[Source 8]** addressed protecting enough suction piping to the AFW pumps to ensure a sufficient quantity of water is provided to protect the pumps when a seismic or tornado induced loss of AFW pump suction pressure occurs.

According to original design specifications **[Source 6]**, the CSTs were required to be designed and constructed to withstand seismic loading of 0.06 g in any direction horizontally and 0.04 g vertically occurring simultaneously, and in conjunction with other loads, without exceeding code allowable stresses. As evidenced from the tank specification, the original designers considered the earthquake load in the tank design. However, the tank has not been assigned any safety-related functions. Therefore, the CST is not required to be listed as a "Safety-Related" component, nor as a "Seismic Class I" component.

COMPONENT PARAMETER WORKSHEET
Section 3.2.6

Component ID	Service
T-24A/B	Condensate Storage Tank

A. Parameter Instrumentation

B. Value CST Level Indication Control Room

C. Source 1. WE RG 1.97 Response dated 9/1/83 [REF 9.2.67]
2. NRC Ltr dated 1/4/85 [REF 9.2.68]

D. Background/Reason

Indication of the Condensate Storage Tank level shall be available in the control room, as well as, indication of the AFW system flow. These parameters must be available to be monitored during and after an accident in accordance with Regulatory Guide 1.97 commitments. **[Sources 1, 2]**.

CST level indication is available in the control room. The indicators are listed in Table 2-2. Refer to DBD-T-44, Post Accident Monitoring, for Regulatory Guide 1.97 commitments.

COMPONENT PARAMETER WORKSHEET
Section 3.2.7

Component ID	Service
T-24A/B	Condensate Storage Tank

A. Parameter Elevation

B. Value

'Useable' Tank Bottom:	+ 29.86 foot elevation
Physical Tank Bottom:	+ 27.75 foot elevation
Discharge Pipe Bottom:	+ 28.2 foot elevation

C. Source
1. MRs IC-325, -326, -327 [REFS 9.5.39, 9.5.40, 9.5.41]
2. WE Calculation N-94-015 [REF 9.4.41]
3. P-118 drawing [9.6.102]
4. Graver Tank & Mfg. Co. drawing L-23944-4 [REF 9.6.99]

D. Background/Reason

Elevation of the CST is important in deriving the NPSH available to the AFW pumps. For instance, **Source 1** took credit for the CST providing at least 50 feet of NPSH to the AFW pumps even with the CST drained down to the bottom of the outlet pipe. This static pressure head is developed by virtue of the tank's bottom (7.34" above the top of the outlet pipe at a maximum system flow rate of 1200 gpm) situated at the +29.25 foot elevation, plus 33 foot contribution from atmosphere, while assuming the AFW pump suction centerline is located at the +10 foot elevation **[Source 2].**

Source 2 calculates the vortex point for the CST with the assumption that the discharge pipe drains from the bottom center of the tank. This is not true but is a conservative assumption in relation to the side discharge that is the actual configuration. The modeling of the vortex point on a side discharge drain is extremely complicated. Therefore, the choice of a bottom center drain which established a vortex point 7.34" above the drain at 1200 gpm and 3.59" above the drain at 200 gpm is used to determine the true useable "bottom" of the tank. This would be the top elevation of the discharge pipe (28' 9-5/16" pipe centerline + 5.01" pipe radius = 29' 3") **[Sources 3 and 4]** plus 7.34" which equates to an elevation ~29' 10-3/8" (29.86'). Note that the vortex point is variable depending on the flow rate out of the CST. For worst case determination of useable tank bottom, 4 pumps running at 1200 gpm total flow rate is used as the most limiting vortex point.

COMPONENT FUNCTIONS
Section 3.3

Component ID	Service
None	Piping

Safety-Related Functions

1. AFW piping shall distribute auxiliary feedwater from the supply source to the feedwater header in containment.

2. AFW piping shall provide acceptable flow resistance in the discharge piping to limit the maximum AFW pump flow to values which will not induce runout and incipient pump damage.

3. AFW piping shall provide acceptable flow resistance in the discharge piping to promote even flow distribution to associated steam generators, considering that pressure differences will exist between steam generators.

4. AFW piping shall maintain the pressure boundary integrity of the AFW System.

Non-Safety-Related Functions

Augmented Quality Functions

None

Non-QA Functions

1. The AFW Pump recirculation line shall provide sufficient flow (at the available pressure drop) to support ISI pump testing at a flow which is a representative point on the pump operating curve, and which will not contribute to AFW pump degradation.

COMPONENT PARAMETERS SUMMARY
Section 3.3 (continued)

Component ID	Service
None	Piping

PARAMETER	VALUE	REFER TO
SUPPORTING DESIGN REQUIREMENTS		
1. Design Code	USAS B31.1-1967	3.3.1
2. Design Pressure, Temperature	Various	2.2.8
OTHER DESIGN INFORMATION		
3. Insulation	Per Worksheet	3.3.2
4. Material	Per Worksheet	2.2.14

COMPONENT PARAMETER WORKSHEET
Section 3.3.1

Component ID	Service
None	Piping

A. Parameter Design Code

B. Value USAS B31.1-1967

C. Source
1. FSAR [REF 9.2.57]
2. Piping Spec M-78 [REF 9.6.93]
3. MR 88-99 [REF 9.5.117]

D. Background/Reason

The AFW system piping shall be designed in accordance with the original piping specification **[Source 2]**, which required use of the latest issue of USAS B31.1. The specification explains that the latest issue "means the issue (including latest published case rulings and addenda) in force at date of award of order." The requisition cover sheet indicates that the revised specification was issued for purchase 11-22-67 (for Unit 1) and 12-15-67 (for Unit 2). Therefore the 1967 revision of the code was adopted.

At least one section of pipe has been analyzed to a later version of piping code. Specifically, **Source 3** indicates that the AFW pump recirculation piping was analyzed to ASME Section III Subsection NC of the B&PV Code 1977 Issue through Winter 1978 Addenda.

Refer to Section 4.2 for other system design code information.

COMPONENT PARAMETER WORKSHEET
Section 3.3.2

Component ID	Service
None	Piping

A. Parameter Insulation

B. Value See Below

C. Source 1. WE Internal Ltr response to IEN 84-06 dated 10/1/84 [REF 9.5.5]

D. Background/Reason

Source 1 recommended removal of appropriate insulation from the vertical run of AFW piping in containment to: (1) reduce the potential for water hammer, and (2) cool backleaking main feedwater well before it reached AFW pumps (and caused steam binding). **Source 1** recommended that 60 feet of the main feedwater line branch-off connection down the containment wall be removed (except where personnel burn hazards existed). Also, **Source 1** made further recommendations for sweat insulation.

COMPONENT FUNCTIONS
Section 3.4

Component ID	Service
AF-4020,4021,4022,4023	MDAFWP Discharge MOVs

Safety-Related Functions

1. These valves shall automatically open (or remain open) to provide a flowpath from the motor-driven AFW pump to the accident unit's steam generators to satisfy unit AFW cooling requirements.

2. These valves shall automatically close (or remain closed) to prevent the diversion of AFW to the unit not requiring AFW flow.

3. These valves shall close remote-manually to isolate or control AFW flow to the ruptured or faulted steam generator.

4. These valves shall remain closed during normal operation to prevent the backflow of MFW to the idle AFW System and establish conditions which may lead to steam binding of the motor-driven AFW pumps. **[REF 9.2.79]** This function is redundant to that of the first-off and second-off check valves.

5. These valves shall passively maintain the AFW system pressure boundary integrity.

Non-Safety-Related Functions

Augmented Quality Functions

None

Non-QA Functions

1. These valves shall open remote-manually to initiate auxiliary feedwater flow when adding chemicals to the selected steam generator.

COMPONENT PARAMETERS SUMMARY
Section 3.4 (continued)

Component ID	Service
AF-4020,4021,4022,4023	MDAFWP Discharge MOVs

PARAMETER	VALUE	REFER TO
SUPPORTING DESIGN REQUIREMENTS		
1. Stroke Time		3.4.1
Nominal Stroke Time	15 sec	
2. Operating Differential Pressure		3.4.2
Specified Design D/P	1560 psid	
Design Basis Maximum D/P		
• Opening D/P	1376 psid	
• Closing D/P	1288 psid	
3. Control Signals		3.4.3
Automatic Open to affected unit	Open	
Automatic Shut to unaffected unit	Shut	
Remote-Manual	Open/Shut	
4. Design Code	Unspecified	9.6.94 4.2
OTHER DESIGN INFORMATION		
5. Valve Position		3.4.4
Normal Position	Shut	
Fail Position (Loss of Power)	As-Is	
6. Power Supply Requirements	Safeguards Supply	3.4.5
Voltage Level		
• Nominal	460 VAC	
• Minimum	364 VAC	
7. Size	3 inch	9.6.94
8. Material	Carbon Steel valve Stellite trim	9.6.94