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NUCLEAR REGULATORY COMMISSION

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BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

In the Matter of	)	
	)	Docket Nos. 50-329-OM
CONSUMERS POWER COMPANY	)	50-330 OM
	)	50-329-OL
(Midland Plant, Units 1 and 2)	)	50-330 OL

CERTIFICATE OF SERVICE

I, David E Barth, one of the attorneys for Consumers Power Company, hereby certify that copies of "Testimony concerning Sinclair Contention 3" were served upon all persons shown in the attached service list by deposit in the United States mail, first class, this 24th day of January 1983.

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CONSUMERS POWER TESTIMONY
CONCERNING SINCLAIR CONTENTION 3

Our names are David R Anderson, David T Perry and Gerald B Slade. The following testimony deals with Sinclair Contention 3, regarding the potential for water hammer at the Midland Nuclear Power Station. The Contention alleges that because of an anomoly in the design of the internal auxiliary feedwater ring in Babcock & Wilcox steam generators, the Midland Station is especially susceptible to water hammer. The contention goes on to allege that the Midland SER is defective because it fails to address the three recommendations of the NRC Staff's draft assessment of the generic task associated with water hammer phenomena.

Summary

Based upon a thorough review of available literature associated with water hammer phenomena in nuclear power plants (including NUREG CR-2781), and of relevant design and operating features of the Midland Nuclear Power Station, I conclude that Sinclair Contention 3 lacks factual basis. Although the contention correctly observes the problems that have been identified with the auxiliary feedwater headers in Babcock & Wilcox plants, the contention ignores a design change presently being implemented at the Midland Station which should totally eliminate this problem. Thus, there is nothing which distinguishes Midland from the other plants permitted to operate by the NRC pending final resolution of the water hammer issue. The Staff's conclusion in the SER, that Midland can be operated without undue risk to the public safety because of water hammer, is supported by studies and operating experience. These indicate there is little risk of damage in PWR's due to potential water hammer concerns. In any event, the three recommendations cited in this contention are being met at the Midland Plant.

TESTIMONY OF
DAVID R ANDERSON

My current position within Bechtel is Resident Assistant Project Engineer for Midland Project. My responsibilities include technical, schedule and administrative review of Mechanical/Nuclear, Civil, Architectural and HVAC resident engineering groups at Midland jobsite. My educational and employment background are given in detail in the attached resume. The following is a summary of my educational and employment background.

I graduated from University of Illinois in 1969 with a Bachelors Degree in Mechanical Engineering. After graduation I joined Bechtel Corporation and worked as a controls engineer, startup engineer and mechanical design engineer on several nuclear projects. In early 1973 I transferred to the Midland Project and progressed through various assignments as a mechanical design engineer, mechanical group leader, assistant mechanical group supervisor, mechanical group supervisor to my present Assistant Project Engineer position which I obtained in mid 1981.

TESTIMONY OF
DAVID T PERRY

My present position within the Midland Project organization is - Section Head of the Mechanical/Nuclear Section in Design Production. In that capacity, my responsibilities include reviewing and implementing approved designs in the Mechanical and Nuclear areas. My educational and employment background are given in detail in the attached resume. The following is a summary of my educational and employment background:

I graduated from Penn State in 1969 with a Bachelors Degree in Aeronautical Engineering. After graduation, I joined Westinghouse Electric Corporation and worked in the Nuclear Energy Systems Group. While with Westinghouse, I worked in both the secondary and primary systems engineering group responsible for the Westinghouse input and design of various systems on a number of plants. Also, during this time I worked as a Startup Engineer at Indian Point Unit 2.

In 1977, I joined Commonwealth Associates to work on the Erie Nuclear Plant. While at Commonwealth, I was appointed Mechanical Supervising Engineer responsible for the Mechanical Design of the Erie Nuclear Plant. In 1979, after the Erie Plant was placed on hold, my association with Midland began. I was loaned from Commonwealth to work on Midland as an interface between Project Engineering and the Nuclear Safety Task Force. In 1980, I accepted an offer from Consumers for my present position. I am also a registered Professional Engineer in the State of Michigan.

TESTIMONY OF
GERALD B SLADE

My name is Gerald B Slade. My present position with Consumers Power Company is as Assistant Site Manager of the Midland Project. At the time of fuel load the organization will change such that I will be the General Manager at the Midland Plant. My testimony regarding the potential for water hammer at the Midland Nuclear Power Plant, from Sinclair Contention 3, follows a brief summary of my experience.

I was graduated from Michigan Technological University in 1965 with a Bachelor of Science Degree in Mechanical Engineering. In 1967, I was graduated from Purdue University with a Master of Science Degree in Nuclear Engineering and joined the US Army Corps of Engineers as a Second Lieutenant in an Advanced Research Group which primarily reviewed advanced concepts of reactor design for potential applications to Army use.

In 1969 I joined Consumers Power Company, where from 1969 to 1972 I assisted in performance of pre-operational and hot functional testing, and training of the initial licensed operators at the Palisades Nuclear Power Plant. This included duties performed as acting shift supervisor prior to core loading as well as performing the duties of a shift test engineer during the initial start-up test program. From 1972 to 1973, I was Reactor Engineer at Palisades and assisted in developing plans and procedures for Palisades Initial Power Escalation Testing. From 1973 to 1975, I organized and directed the technical department as the Technical Superintendent at Palisades. During 1975 to 1976, I was the Operations Superintendent and directed the activities of Palisades' Operations, Chemistry, and Training Departments.

In 1976 through 1978, I was moved to the Midland Project as Operations Superintendent where I prepared and implemented plans for staffing up the Midland Plant. In 1978, I was promoted to the Operations and Maintenance Superintendent position at Midland until 1980 when I was named the Assistant Site Manager (Plant Superintendent) on the Midland Project, where I am continuing efforts to assure that the Midland Plant is ready for operation.

A detailed chronology of my experience and education as of this date is attached.

Water hammer has been defined as a change in pressure of a fluid in a closed conduit caused by a change in fluid velocity. The water hammer phenomena was studied by an NRC Consultant during 1981 and 1982. In a report detailing the results of this study (NUREG/CR-2781), the Consultant indicated that the frequency and severity of water hammer in pressurized water reactors is low. According to the study, none of the 40 non-steam generator related water hammer events in pressurized water reactors disabled a safety system or train, had an adverse safety effect, or placed the plant in a faulted or emergency condition. In addition, the NRC Staff determined, at SER Page C-7, that operating experience has shown that the once through steam generator design, the type used at Midland, is not susceptible to the steam/water hammer events that have occured in Westinghouse and Combustion Engineering steam generator designs using a "top" feed ring design. I agree with this conclusion, for the reasons explained on pages 12-15 below. The sole basis given in the contention for distinguishing Midland from other plants now operating relates to observed problems with internal auxiliary feedwater headers. This reason

disappears, however, upon consideration of a design change, now implemented, replacing the internal feed ring with an external one.

Interim NRC Staff publications on water hammer have made certain recommendations with regard to minimizing potential water hammer incidents in pressurized water reactors. Included among those recommendations are the three that are cited in the contention. These proposals have not been adopted by the NRC as formal requirements. Nonetheless, the Midland Station meets all three recommendations. Specifically, the Midland Station design has taken into account potential water hammer problems in various systems, includes or will include operating procedures to prevent water hammer events, and will include provision in preoperational testing to minimize the incidence of water hammer. The discussion which follows demonstrates how these proposals are being implemented at Midland and addresses features generic to the entire plant, as well as those specific to certain systems.

Generic Features

Features generic in the Midland design reduce the likelihood or mitigate the consequences of three types of water hammer, these are: (1) void formation, (2) slug formation and (3) water hammer events due to component operation.

The first type of water hammer, void formation, occurs when water piping systems are not properly vented during filling or pump start-up operations. When the pumps are started on empty or partially empty systems, large dynamic forces could occur as the water front impacts on elbows, tees, or other changes in direction or restrictions in an empty piping system or as it impacts a stationary slug of water in a partially filled system. Air pockets or void cavities can also develop from inadvertent draining of the piping or

when piping is subjected to very low pressures. The second type of water hammer, slug formation, can occur in steam pipe lines that are inadequately drained. It can also occur under certain conditions when steam comes into contact with subcooled water where the steam rapidly condenses allowing water, and possibly steam, to rush into the void. This latter type of water hammer is generally found in steam generators and is addressed in the following section.

Water hammer events generated by component operation are a third type encountered in power plant systems. These consist of pressure waves that are transmitted through a piping system as a result of a sudden change in fluid flow. Pumps starting, or valves opening or closing, are normal, expected events that cause pressure waves to move through a system. Under certain conditions, however, the flow may be stopped suddenly, causing a vapor cavity (known as column separation) which would subsequently collapse, generating high pressures. These types of transients are, in general, anticipated and provided for in the design of systems.

There are design features in the Midland power plant piping systems that function to mitigate water hammer. Some of these features are incorporated through usual engineering practice and are included in various Bechtel Engineering Standard Design manuals and recommended Design Guides. Piping system elements that are considered in the Midland design include:

- Proper venting and draining of piping
- Provision for sloping and drainage of steam lines
- Proper routing of piping to minimize air entrapment, particularly suction piping.

There are two types of vents and drains utilized, operating and nonoperating. Operating vents and drains are necessary in the normal operation of the plant.

Nonoperating vents and drains are used in initial filling of system and/or for maintenance. In addition to the above design features, Midland as a PWR, is built such that a majority of the safety systems are located below the safety systems water sources, as noted in NUREG/CR-2781. This physical arrangement will prevent inadvertent draining of the piping systems. There are a few cases at Midland where the water source of safety-related piping is below system piping. These instances will be discussed later with regard to particular systems.

Although no specific systematic review for water hammer is employed, the Midland project design organization utilizes a number of checks and reviews as part of the design process, to ensure that adequate engineering designs have been followed, and to comply with ANSI N45.2.11. Under engineering design procedures, each initial design is required to be checked by a separate, qualified engineer. The design is then reviewed by all affected disciplines. The group supervisor for the issuing group then reviews and accepts the design. After that, the design is reviewed and approved by the chief engineer of the issuing group. Finally, the project engineer approves the design for issuance. If, at any stage in the design process, it is determined that potential for harmful water hammer may exist in a given system, an evaluation is performed. The need for this evaluation may be indicated by the designer's own experience or by industry operating experience which indicates water hammer may be expected.

In addition, certain conditions may indicate the need for an evaluation. Some of the significant parameters include:

- Piping elevation, where voids can develop

- Speed of valve operation
- Pipe size and length
- Fluid velocity and compressibility
- Fluid (steam, air, water) two-phase flow

Safety or critical systems that have been evaluated or are undergoing evaluation because of an identified potential for water hammer are:

- Reactor coolant systems, where water hammer has resulted from pressurizer pressure relief valve operation.
- Main Steam System, where turbine stop valves have induced steam hammer events.
- Component cooling water system, where there is rapid valve operation.
- Reactor building spray system, where portions of the piping system are empty prior to starting the system.
- Service water system, where piping elevations in the reactor building are sufficiently high to establish void formation.

Auxiliary feedwater system where there is rapid turbine startup.

These evaluations, in some instances, confirm that the design of the system is such that water hammer would not adversely affect its function. In other instances, necessary alterations are identified to minimize the possibility of water hammer occurrence. In still other cases, detailed stress analyses are carried out to determine a system's capability to withstand water hammer forces.

To ensure successful and safe operation of the plant, information useful to the testing and operations staff is communicated from the design organization. Design information available to the test and operational personnel include the functional system description; procurement and operating technical specifications; piping and instrumentation drawings (P&ID); and vendor manuals

to name a few. The functional system description describes the system and the equipment and explains how it is intended to function. Vendor manuals provide specific information from manufacturers of specific equipment. Procurement and operating technical specifications provide information, or specific equipment and system operating limitations. The P&ID and other drawings provide system details on the components and instrumentation expected to be used during operation. This information is used in drawing up operating procedures and maintenance procedures.

Preoperational Testing and Operating Procedures

During operation at the Midland Plant we will minimize the occurrence of water hammer events by addressing the operational aspects of water hammer as follows:

First, the test program (including preoperational testing), as discussed in Chapter 14 of the FSAR, will verify that systems, components and structures have been properly constructed and perform in accordance with design criteria. More specifically, Test Abstract 14A.1.82, Piping Vibration Monitoring Porgram, commits to testing which verifies safety related piping systems exhibit vibrations within design limits during various transients. The AFW system will be monitored for water hammer during this testing for the following testing transients:

- Test Abstract 14A.1.64 - Pre-core Load Hot Functional Testing, Test Method 3.10 - Simulated trip of all four Reactor Coolant Pumps and a trip of both main feedwater pumps.

- Test Abstract 14A.4.8 - Loss of Offsite Power Test. This is the first test scheduled during the Power Ascension Test Program which initiates AFW. It is performed at 15% reactor power, as indicated in FSAR Table 14.2-4.

- Test Abstract 14A.4.22 - Natural Circulation Testing. The ability to establish and maintain Natural Circulation without offsite power will be demonstrated during this testing. AFW will be actuated as part of the test.

All testing performed during the test program is conducted 'ng detailed test procedures. Normal operating procedures are used where applicable and to the extent practical during the test program to verify their adequacy. In addition, trained operating personnel will participate in the test program activities.

Deficiencies discovered during the test program are reported individually and noted in the test summary of the test procedure. All deficiencies are transformed to Corrective Action Reports (CAR), which require satisfactory evaluation and disposition prior to system acceptance. All CAR's are tracked via the Master Punchlist.

A ha...ful water hammer is a deficiency. Any significant water hammer experienced during the test program is, therefore, documented, evaluated and dispositioned via the CAR process prior to final system acceptance.

Second, training for the unlicensed and licensed operating personnel includes the causes of water hammer and operational practices to reduce or preclude water hammer events.

All unlicensed Auxiliary Operator (AO) personnel hired after January 1, 1983 will have their experience reviewed on a person-by-person basis. Those whose

experience is deemed to not include two years of commercial experience will participate in a 10 week training course lead by CPCo certified instructors. The course addresses, among other items, the generic causes and means of preventing water hammer, as well as general behavior of fluids, fluid flow and interaction between different phases of a fluid (such as between steam and subcooled water) which can lead to water hammer. Prior to being qualified to operate plant equipment, the AO candidate must also participate in an on-the-job training program which includes demonstrating to a Shift Supervisor that he has the requisite knowledge to safely and correctly operate the system. The AO qualification program is controlled by Midland Plant procedure OPS 1358.2.

Other unlicensed Auxiliary Operator (AO) personnel hired before January 1, 1983, have had two years experience at either nuclear or fossil fuel plants. Knowledge of operational practices to reduce water hammer is assumed by virtue of this experience. This experience is reviewed on a person-by-person basis and if additional training is deemed necessary, it will be given to the personnel.

Reactor Operator and Senior Reactor Operator License candidates (including those from the AO ranks) also participate in a fundamentals course (different than that previously mentioned) which also includes generic discussions of the causes of water hammer and operational practices to avoid it. In addition, license personnel also attend a systems training class of approximately 10-13 weeks in length which covers the Midland Plant on a system-by-system basis. These classes are being taught by previouly licensed personnel from other operating power plants. Operational practices to avoid water hammer are discussed in the system lecture for those systems deemed prone to water hammer

by the lecturer (such as assuring steam supply lines to steam driven equipment are properly drained and warmed prior to admitting steam to standby equipment).

Third, the system and plant operating procedures will be written to take into account good operating practices, to the extent practicable, to minimize water hammer by assuring that (1) systems are filled and vented correctly, (2) steam systems are warmed in a slow, controlled manner and (3) where included, active components designed to mitigate water hammer operate properly. Examples of systems covered by such operating procedures to be written or revised include:

1. The Main and Auxiliary Feedwater Systems

2. The Reactor Coolant System

3. The Main Steam System

4. The Decay Heat Removal System

5. ECCS Systems - Low Pressure Injection (Decay Heat Removal)

   - High Pressure Injection (Makeup and Purification)

   - Core Flood System

6. Auxiliary Cooling Water Systems - Service Water System

   - Component Cooling Water System

7. Reactor Building Spray System

As an example, the Midland system operating procedures for service water presently include instructions to verify that the venting device is energized upon pump start, even though it is an automatic feature. In addition, general procedures for overall Plant coordination are being written which will provide instructions for evolutions where many systems are used at once (such as Plant heat-up or cooldown evolutions). Plant procedures presently existing for ECCS Systems will be reviewed and revised as necessary by fuel load to assure they include instructions for filling and venting or other instructions deemed necessary to preclude water hammer.

Midland Plant procedures governing restoration to service of Operating Technical Specification related equipment will direct shift personnel to include instructions to fill and vent systems where equipment has been drained due to maintenance operations prior to declaring the equipment "operable".

And finally, fourth, significant events of water hammer at other nuclear plants will be evaluated as part of Midland's Nuclear Operating Experience review process. If similar conditions are determined to exist at Midland, changes deemed necessary will be made to operator training, plant operating procedures, or system configurations as feasible to mitigate the potential at Midland.

Analyses of Water Hammer In Specific Systems

I. Water Hammer in Steam Generators Systems

A. Water Hammer Description

Two problems have been reported in connection with steam generators. The first problem involves a slug formation water hammer phenomenon

peculiar to Westinghouse and Combustion Engineering Steam Generators. These have common main and auxiliary feedwater connections to the steam generator which is used during emergency operation. Midland has a separate connection for auxiliary feedwater during emergencies and is not susceptible to this type. The second problem is not a water hammer, but involves a sequence of events which can cause damage to internal steam generator feeder headers. Both of these are addressed below.

Problem 1

The water hammer described under this heading is the water slugging which has occurred in the Westinghouse and Combustion Engineering steam generators. Figure 3, which is attached, depicts this phenomenon as it was observed in a Westinghouse plant. Sketch (a) of Figure 3 shows the initial step which occurs after a plant trip when the water level in the steam generator falls below the feed water ring, and the ring header begins to drain. As the feedwater ring drains, steam from the steam generator back-fills into the feedwater ring. The auxiliary feedwater is then brought into the feedwater ring and the colder auxiliary feedwater causes the steam to condense at the steam/water interface. As this steam condenses, steam from the steam generator flows into the feedwater ring replacing the condensed steam. Under certain conditions, surface waves are formed by the steam flowing counter to the water flow and the ensuing waves could result in a water seal at the feedwater ring, as depicted in Sketch (b) of Figure 3.

The water seal causes a steam volume to be trapped in the feed line. The trapped volume of steam continues to condense, causing a slug of water to be propelled down the feed line by steam generator pressure resulting in high pressure as the slug impacts the incoming water column. If conditions are right, feedwater will again move down the feed line towards the ring, while surface waves formed in the feed ring may create another seal and repeat the process.

It was determined through tests, both laboratory and in plants, that the slugging was dependent on auxiliary feedwater flow rate (ie, with a slow enough flow, a water seal wouldn't form since the water level in the feedpipe and ring would be too low to form a wave large enough to create a seal). It was also determined that the length of feed line subject to draining contributed significantly to the amplitude of the pressure pulses.

The plants which recorded this type of water hammer have been Westinghouse or Combustion Engineering Plants which have a feedwater ring similar to that depicted in Figure 2. This figure shows an internal feedwater ring which has holes drilled in the bottom of the ring for distribution of flow. The holes on the bottom of the ring header result in the draining of the header when the ring is uncovered. Also on these plants the feedwater line had a long, horizontal run before the connection to the steam generator as shown in Figure 1. In addition, these plants utilized the main feedwater distribution ring as an injection point for auxiliary feedwater during an emergency which caused the cold water interface resulting in steam condensation.

The Midland design is unlike that used in Westinghouse and Combustion plants. The main feedwater and auxiliary feedwater utilize separate connections to the steam generator, which eliminates the cold water interface in the feedwater pipe. Also, the auxiliary feedwater piping is installed such that the connection on the steam generator is the highest point on the discharge piping and there is only a short length of small-diameter piping which could drain into the steam generator. Both main and auxiliary feedwater utilize an external distribution header with distribution pipes rising from the external header to the steam generator connection. This eliminates the cold auxiliary feedwater from being introduced through the main feedwater piping during an emergency actuation and maintains the header full of water. Figure 4 shows the arrangement of the auxiliary feedwater header on Midland.

Auxiliary feedwater can be supplied to the main feedwater system during startup of the plant. Water hammer would not be expected during this operating condition because the main feedwater header will be maintained full of water because of the design of the external header.

As stated in SER Page C-7, operating experience with the once through design (used at Midland) has shown that it is not susceptible to the steam/water hammer events that have occurred in Westinghouse and Combustion Engineering steam generator designs, using a "top" feedring design.

Problem 2

Plants which are similar to Midland did have a problem with the internal auxiliary feedwater distribution header. The headers were found to be distorted, (ie caved inward). This distortion occurs when the cold auxiliary feedwater enters the header rapidly condensing the steam. This rapid condensing creates a void (negative pressure) within the header, which steam from the steam generator attempts to fill. But the existing holes in the header do not allow influx of a sufficient supply of steam in quickly enough to prevent a negative pressure (on the order of 200 psi below steam generator pressure) from building up within the header. This pressure differential is sufficient to distort the header inward.

The increasing pressure which accompanied the water hammer on the Westinghouse type feed ring has not been found on the B&W auxiliary feedwater header. The lack of increase in pressure was probably due to the absence of a mechanism to form a slug of water, or the slug of water was dissipated by the geometry of the internal ring.

Like the operating B&W plants, Midland is abandoning the internal auxiliary feedwater header and installing an external header. Attached is Figure 4 which depicts the new arrangement. The external header has been used on certain operating B&W plants without any damage as a result of water hammer.

Also, the operating B&W plants which have made this modification are being required by the NRC to conduct water hammer tests. These test results will be available prior to operation of the Midland units,

and any modifications required based on these results will be incorporated.

B. Safety Significance

The slug formation variety of water hammer described above has caused movement of piping, which has resulted in damage to the piping or damage to the piping supports. The most serious damage reported occurred on one project when a main feedwater line cracked as a result of the slugging. The plants which were susceptible to this water hammer event have been modified to minimize it and tested to assure the modifications were sufficient. Midland, as operating experience has shown, will not be susceptible to this type of water hammer.

Since the B&W auxillary feedwater header has been modified, there is no safety significance currently anticipated to Midland from problem 2, described above.

II. Feedwater System

A. System Description

The Midland feedwater system is similar to many that exist on plants currently in operation. The Midland feedwater system, as described in Chapter 10 of the FSAR, consist of booster pumps, feedwater pumps, feedwater heaters, piping and valves. There are three sets of control valves used to control flow in the feedwater system. A small one inch valve is used during heat up of the plant. A six inch bypass around the main control valve is used during startup to

about 15-20 percent power and the main feedwater control valve is used during power operation. The bypass and main control valve are controlled by the B&W designed ICS system. The feedwater system has been designed to permit complete filling (no voids) by placing vents at the system high points.

B. Water Hammer Evaluation

The major cause of water hammer events in the feedwater system, as identified by NUREG/CR-2781, is feedwater control valve instability, which is a component-operation type water hammer. All of the events which list feedwater control valve instability as the cause occurred in Westinghouse plants. The majority of these events were experienced on plants without a pump speed control system. The remaining of these events occurred at Zion, which does have variable speed feedwater pumps, as does Midland. The transients incurred there resulted in no damage to the system, and were only noticable by the noise. The specific cause of the water hammer at Zion, which has been attributed to valve instability, is not certain. This is because the corrective action that was taken at Zion, which apparantly alleviated the water hammer occurrences, was indicative of a steam generator water hammer (i.e. limiting flow), and not valve instability.

At Midland, the feedwater valves have been supplied by B&W, which also supplies a feedwater pump speed control system. The feedwater pump's speed is controlled by pressure drop across the feedwater valve. A 35 psi pressure drop is maintained across the valve. With

this speed control system, the feedwater valves can be adequately controlled to eliminate instabilities. At full load the valve would be about 6[illegible]% open. With 35 psi differential pressure across the valve, the flow in the feedwater system would not respond too quickly to changes in valve position (ie, a small change in valve position would not result in a large flow change). Therefore, valve instabilities would not be expected. If a problem did arise, it could be taken care of by adjusting the valve pressure drop.

There are also two other sets of valves used to control feedwater flow on Midland's system. A small one inch valve is used to ensure a continuous flow to the steam generator during plant heat up. No major problem with this valve is expected since velocities in the feedwater system will be very low. The second valve is controlled by the ICS and there have been no water hammer events attributed to this valve. The velocities in this system will also be low.

Only one hammer event involving the feedwater system has been reported in connection with B&W Plants. A valve, which is used to allow recycled feedwater to flow from the feedwater system to the condenser, was opened, as permitted by design. This allowed fluid from the steam generator to flow into this line and create a water hammer as the fluid flashed. On Midland, under the present design, this recycle valve is designed to be closed when the feedwater isolation valves to the steam generator are opened. The only time this line will be used is during plant startup when chemistry conditions require the recycling of flow for cleanup. And at these times, the steam generator will be isolated from this line.

C. Safety Significance

The concern of water hammer occurring in the feedwater system is high because of the number of events. However, the events reported are almost exclusively on Westinghouse plants. Only one event was reported for a B&W plant. And even in the plants that did experience problems, the damage was limited to supports, insulation, instrument tubing, and other minor items which did not result in an unsafe situation. Based on the above discussions, water hammer in the feedwater system of the Midland Plant is not considered a safety problem.

III. Reactor Coolant System

A. System Description

The pressurizer, which is attached to the reactor coolant system, has been involved in some slug formation type of water hammer events at other plants. The pressurizer is utilized to control the reactor coolant system pressure. Electric heaters are used to increase the temperature and pressure, and a spray system from the discharge of the reactor coolant pumps is used to decrease pressure by cooling the pressurizer. Safety and relief valves are mounted on the pressurizer to prevent system overpressurization. All of the reported water hammers have been associated with the discharge piping from these safety and relief valves.

The discharge of the valves is combined at the outlets and utilizing a common line, is routed to a relief tank; water hammer could occur in this line.

B. Water Hammer Evaluation

The discharge piping for the pressurizer safety and relief valves has experienced damage due to hydraulically induced forces. The majority of the plants which experienced damage have loop seals (water seals) upstream of the pressurizer safety valves. The water is propelled from the loop, down the pipe as a slug of water when the valve opens. Midland does not have a loop seal and will not have water hammer caused by a loop seal. However, the piping may still be subjected to large forces because of anticipated discharge fluid conditions.

Pressure transients in relief piping have been studied by EPRI in an industry program in which Midland was represented, as identified in Responses to Post-TMI 2 Issues and Events, Item II.D.1. EPRI has developed a computer program which provides forcing functions for use in the stress analysis of the piping system to assure the piping will withstand encountered pressures. The Midland system is currently being analyzed and forcing functions are being developed. Any modifications which this analysis shows to be necessary will be designed and installed.

C. Safety Significance

In view of the above considerations, water hammer in this system will not be a problem at Midland. The potential for water hammer is being considered and included in the design of the system.

IV. Main Steam System

A. System Description

The main steam system supplies steam to the main turbine, auxiliary feedwater pump turbine, process steam, main feedwater pump turbine, and other users. A detailed description is presented in FSAR Chapter 10.

The water hammers reported for the main steam system have been mainly caused by rapid valve closures, a component-operation type water hammer. There are valves in the system such as main steam isolation, process steam isolation, and turbine stop valves that close quickly. The quick closure could cause a water hammer, the force of which is dependent on the flow rate through the valves at the time of closure. Another water hammer of the slug formation type has also been reported in exhaust line from an auxiliary feedwater pump turbine.

B. Water Hammer Evaluation

The Midland main steam system has been analyzed for the forces that would occur on closure of the main turbine stop valves. The closure of the turbine stop valves would result in the worst anticipated

transient. These reaction forces have been factored into the design of the piping supports.

The reported water hammer, in NUREG/CR-2781, in the exhaust line from the auxiliary feedwater pump turbine was caused by accumulation of water in the turbine exhaust line from an external source. At Midland, the turbine exhaust line is sloped to a drain which automatically drains through a trap.

The auxiliary feedwater pump steam system will be analyzed for forces that will occur due to water slug formation during startup. These reaction forces will be factored into design of piping supports.

C. Safety Significance

The water hammers reported in NUREG/CR-2781 that have occurred at operating plants have not resulted in an unsafe condition, and only minor damage to hangars and supports was reported. The Midland systems will be designed to prevent or mitigate the effects of these water hammers which have occurred in the main steam piping.

V. Decay Heat Removal

A. System Description

The decay heat removal system is used during plant start-up, shutdown, refueling and loss of coolant accidents. The system design is discussed in FSAR Chapter 6.

B. Water Hammer Evaluation

The reported cause of this water hammer event in NUREG/CR-2781 was the occurrence of voids in pump discharge lines, which is a void-type water hammer.

During the design process at Midland, the pipe routing is reviewed and vents are placed at the high points of the system to vent out the gaseous voids. The Decay Heat Removal Pumps and the connection to the reactor coolant system are located in a manner so the system piping is below the borated water storage tank. This feature aids in preventing an inadvertant draining of the piping. For these reasons, the majority of the line voiding problems that have occurred on BWR plants will not occur on Midland Plant's System.

C. Safety Significance

The event reported (NUREG/CR-2781) for the decay heat removal system did not result in any unsafe condition. Because of the design features on Midland, the decay heat system should not be susceptible to water hammer events.

VI. ECCS Injection Systems

A. System Description

The ECCS system includes the core flood, high pressure injection and low pressure injection systems. The system is described in FSAR Chapter 6.

B. Water Hammer Evaluation

The major cause of water hammers reported, in NUREG/CR-2781, in this system is produced by flow into voided lines and improper venting. Other water hammers have been caused by poor operating procedures or surveillance testing procedures.

The Midland design features for the ECCS are the same as those discussed for the decay heat removal system. Pipe routing and venting criteria are used to avoid a water hammer event. Operating and testing procedures will take into account past experience with water hammer in this system, as discussed in CPCo Responses to NRC Staff Questions 211.41 and 211.134 (a copy of these responses is attached to this testimory).

C. Safety Significance

The safety significance of water hammer in these systems is high as discussed in NUREG/CR-2781, even though no safety system or train was disabled as a result. However, as explained above, Midland's design features, and operating and testing procedures, will ensure a low probability of an event.

VII. Cooling Water Systems

A. System Description

The systems at Midland include service water and component cooling water. These systems are described in FSAR Chapter 9.

B. Water Hammer Evaluation

The service water system has a suction source below the elevation of the discharge piping and as a result must be considered susceptible to water hammer because of inadvertent voiding. The service water systems currently include automatic venting device to minimize water hammer potential during pump startup. The remainder of the cooling water systems use surge tanks which maintain the system full of water.

Recently, as a result of this knowledge and experiences at another Bechtel plant, the service water system at Midland was further evaluated for water hammer potential. It was decided to study in more detail the piping arrangement from the reactor building air coolers, the piping most likely to experience water hammer because of draining the service water system. This review is currently in progress. The phenomenon of concern is water column separation which could result in this line if a service water pump is started after the trip of an operating pump. Further information is being gathered through tests at another plant. The results of this testing will be factored into any Midland design modifications that may be required.

The component cooling water system is also being reviewed for void formation and fast-valve closure water hammer. This is a result of potential water hammer effects associated with various hydraulic transients as a result of seismic or pipe rupture effects on various portions of the component cooling water system.

C. Safety Significance

The potential for water hammer is recognized in the Midland cooling water systems. The analyses, when complete, will be factored into Midland design and procedures, if necessary, to ensure that Midland can be operated safely.

VIII. Reactor Building Spray

A. System Description

The reactor building spray system is actuated after a loss of coolant accident. This system is described in Chapter 6 of the FSAR. The system is maintained partially empty and water hammer is a concern when the system is started, and flow is discharged into voided lines.

B. Water Hammer Evaluation

NUREG/CR-2781 describes a slug formation type of water hammer which has occurred in other plants. The potential for water hammer in this system has been recognized and various design provisions have been included in the system design as described in chapter 6 of the FSAR. Finalization of systems design is currently in process and any required modification will be included in system design.

C. Safety Significance

The potential for water hammer is recognized for reactor building spray system. The analysis, when complete, will be factored into the Midland design to insure that Midland can be operated safely.

CONCLUSION

In conclusion, upon completion of the actions committed to and identified above, we believe that Midland can be operated without undue risk to public safety because of water hammer.

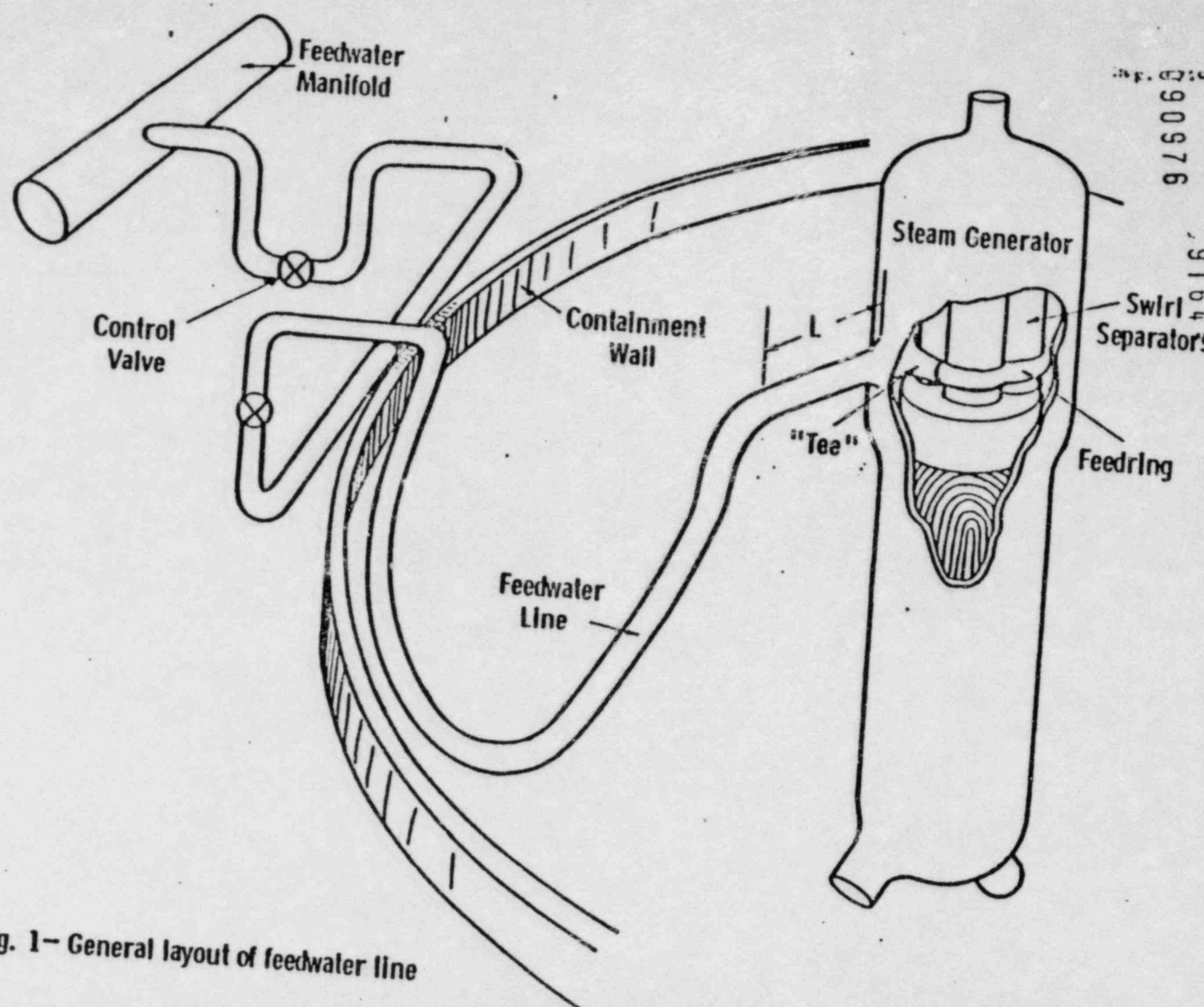

Fig. 1– General layout of feedwater line

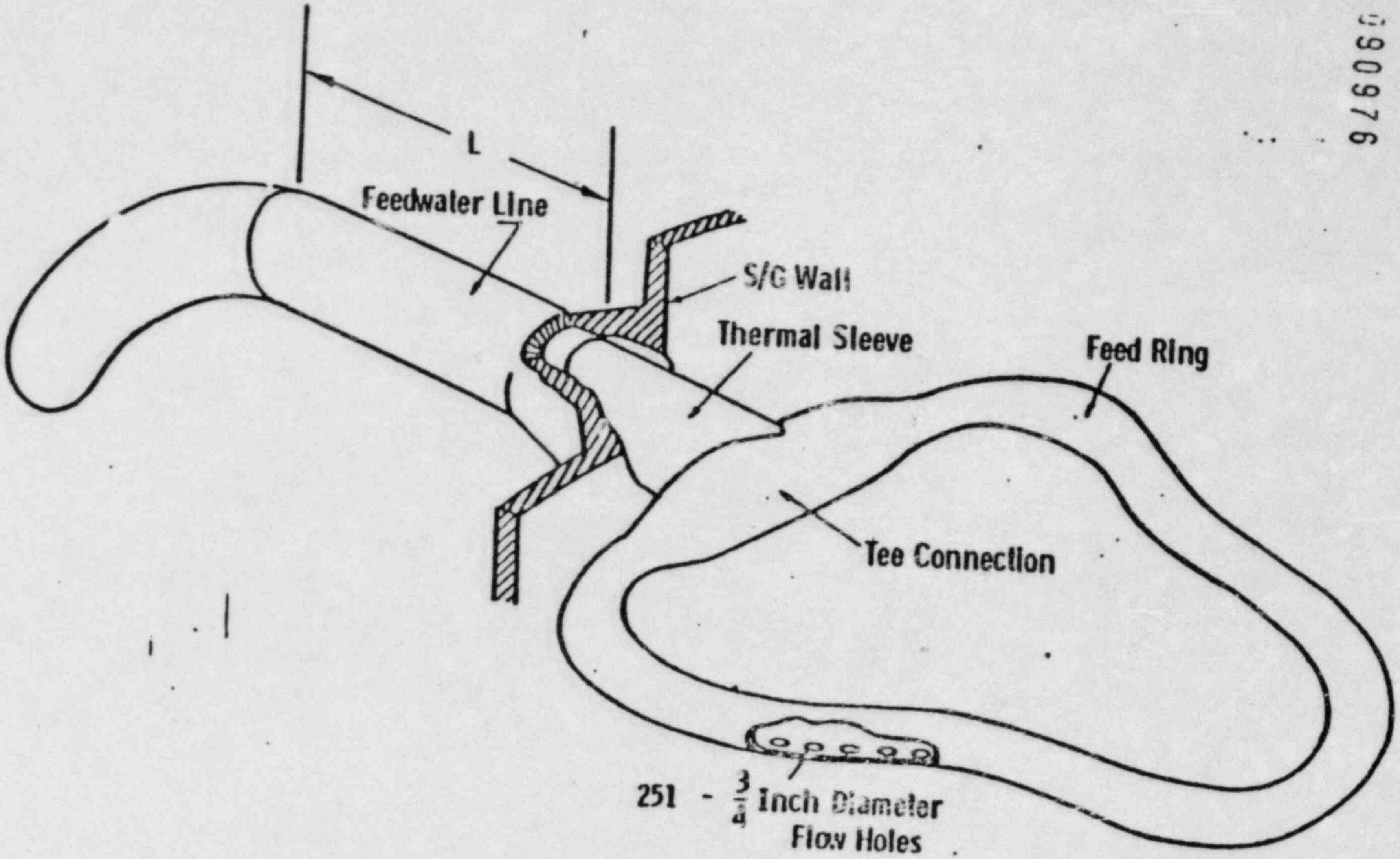

Fig. 2— Feedring assembly

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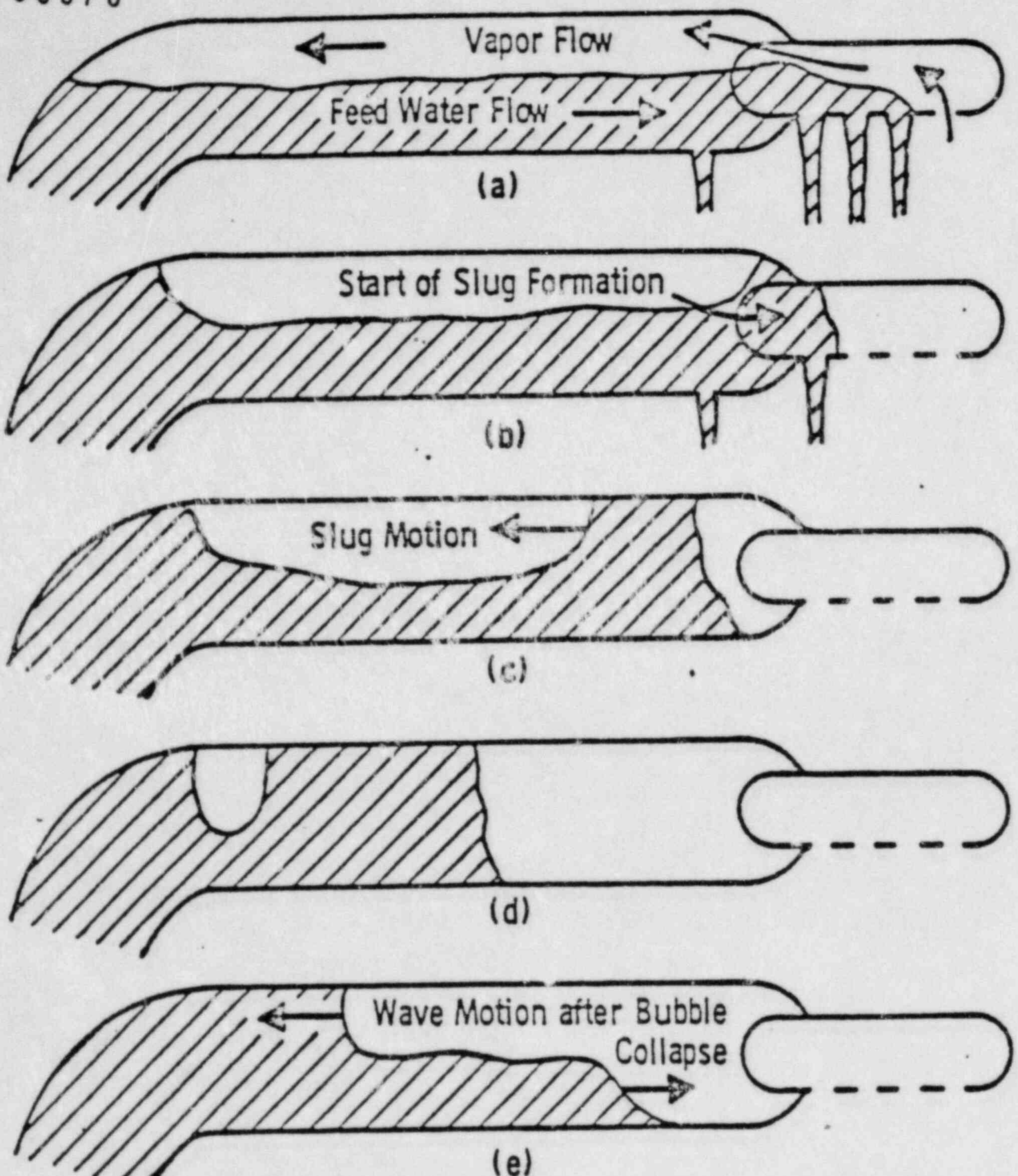

Fig. 3 — Schematic representation of slugging mechanism

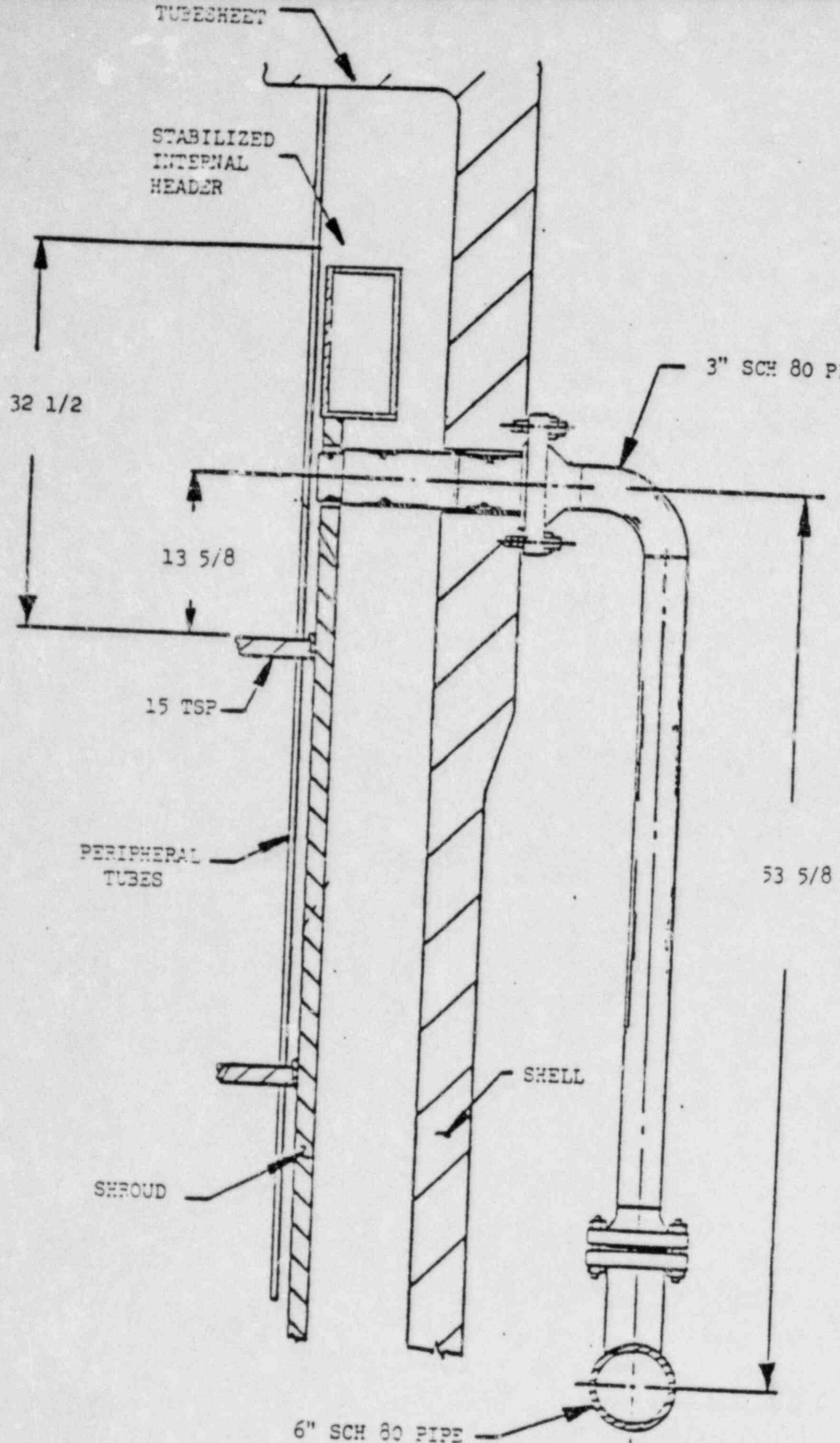

FIGURE 4

AUXILIARY FEEDWATER HEADER

Question 211.41 (6.3.2.5)

Discuss the provisions and precautions of assuring proper system filling and venting of ECCS to minimize the potential for water hammer and air binding. Address piping and pump casing venting provisions, accessibility, and surveillance frequencies.

Response

Proper filling and venting is necessary to minimize water hammer and air binding in the emergency core cooling system (ECCS).

The location and design of ECCS piping requires that special precautions be taken to ensure proper filling and venting of the ECCS. Adequate pump casing vents and high point vents exist in the low- and high-pressure injection systems. Two methods may be used to ensure proper filling and venting in the ECCS after maintenance and certain operational mode changes. 9

1. Actual operation of the system after manual venting

2. Manual venting using installed vent valves

These methods will be addressed in the individual operating procedures for the systems in the ECCS.

During normal operation (reactor coolant system 2,155 psig), T_{ave} 579F and 100% reactor power), the decay heat removal pumps are aligned to the borated water storage tank (BWST) such that their suction pressure is essentially constant. Once this system is aligned in this manner and vented it will not require periodic surveillance to ensure that the system remains properly filled and vented. Likewise the three makeup pumps will usually be aligned to a source of constant pressure. Once they are aligned and vented they will not require periodic surveillance to ensure they are properly filled and vented.

Changes in system line up will be done using approved procedures, which address the venting requirements to ensure a properly vented system under all operating condition.

All system piping and pump casing vents are accessible except under certain accident conditions.

Question 211.134 (6.3.2.5, Chap 16) (RSP)

The response to Question 211.41 does not satisfactorily address the concern for proper ECCS filling and venting. The response states that the methods will be addressed in the individual operating procedures for the systems in the ECCS. We require that periodic verification of fully vented ECCS piping and pump casings be included in the Midland technical specifications.

Response

Periodic verification of fully vented ECCS piping and pump casings will not be included in the Midland plant technical specifications for the following reasons: 15

1. Borated water storage tank (BWST) head is constantly applied to DHR and spray pumps during operation. The HPI pump supplying makeup (redundant HPI pump) is running. Therefore, a problem does not exist.

2. Inservice testing of all ECCAS pumps is performed at a monthly frequency under technical specification surveillance requirements. The fluid supply to the pumps will be via their normal ECCS flowpath except for the HPI pumps, which are normally tested using their operational makeup flowpath.

3. After a system is opened for maintenance, approved safety return to service procedures addressing filling and venting will be used. Also, the inservice testing addressed above will be performed prior to placing the system in service.

For these reasons, it is our position that adding venting requirements to the technical specifications will in no way increase the reliability of the safety systems to perform their functions.

AFFIDAVIT OF DAVID R. ANDERSON

I, David R. Anderson, am an Assistant Resident Project Engineer on the Midland Project. I am a co-author of "Consumers Power Testimony concerning Sinclair Contention 3", which is true and correct to the best of my knowledge and belief.

Signed ____________________

Sworn and subscribed before me this 21 day of January, 1983.

____

Notary Public

BEVERLY A. GROSS, Notary Public
WASHTENAW COUNTY - MICHIGAN
MY COMMISSION EXPIRES 10-[illegible]-86

My Commission Expires ____________________

AFFIDAVIT OF DAVID T PERRY

I, David T Perry, am the Section Head of the Mechanical/Nuclear Section in Design Production. I am a co-author of "Consumers Power Testimony concerning Sinclair Contention 3", which is true and correct to the best of my knowledge and belief.

Signed David T. Perry

Sworn and subscribed before me this 21st day of January, 1983.

Pamela J Griffin
Notary Public

My Commission Expires Sept 8, 1984

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AFFIDAVIT OF GERALD B SLADE

I, Gerald B Slade, am the Assistant Site Manager of the Midland Project. I am a co-author of "Consumers Power Testimony concerning Sinclair Contention 3", which is true and correct to the best of my knowledge and belief.

Signed [signature]

Sworn and subscribed before me this 24th day of January, 1983.

Pamela J. Guffin
Notary Public

My Commission Expires Sept 8, 1984

BECHTEL POWER CORPORATION - PERSONAL RESUME

NAME DAVID (DAVE) R. ANDERSON DATE January 1983

CLASSIFICATION Resident Assistant Project Engineer

ORGANIZATION & LOCATION AAPD

Midland Jobsite

BIRTH DATE 09/02/46 CITIZENSHIP U.S.A.

ORIGINAL BECHTEL EMPLOYMENT DATE 06/23/69

RE-EMPLOYMENT DATE(S) --

NAME OF SPOUSE Bonita (Bonnie)

CHILDREN'S BIRTH DATES 09/25/71, 03/11/73

PHOTO DATE -- MILITARY SERVICE & RANK --

EDUCATION AND PROFESSIONAL DEVELOPMENT PROGRAMS

DEGREE, CERTIFICATE, ETC	SCHOOL	MAJOR	DATE
BS	University of Illinois	Mechanical Engineering	1969
--	Bechtel	Nuclear Power Plant Course	1971
--	Bechtel	Electrical Utility Systems	1973
--	Bechtel	Nuclear Power Plant Course	1975
--	Bechtel	Basic Supervisory Training	1980
--	Quality College	Executive Quality Course	1981

OTHER SIGNIFICANT INFORMATION

PERSONAL & FAMILY:

General health excellent; family enjoys travel.

0369L

SPECIAL INTERESTS:

Golf, racketball, bowling, woodworking, and remodeling.

ACHIEVEMENTS:

President, BEC Ann Arbor, 1976.

ASPIRATIONS:

To obtain an overseas assignment. Major goal is project management.

WORK HISTORY

DATES FROM	DATES TO	COMPANY, DIVISION, OR DEPARTMENT: LOCATION AND SUPERIOR	POSITION HELD, SUMMARY OF RESPONSIBILITIES, AND SIGNIFICANT ACCOMPLISHMENTS
6/69	10/69	BC San Francisco, CA J. Conquer	Junior instrument engineer: responsible for miscellaneous instrument design and instrument procurement.
10/69	3/71	BC Minneapolis, MN J. Murphy W. Balodis	Startup engineer: responsible for preoperational preparation and various system startups.
3/71	12/73	BPC, SFPD San Francisco, CA Ann Arbor, MI J. Vance J. Hurley	Engineer: responsible for system design and equipment procurement.
12/73	9/75	BPC, SFPD Ann Arbor, MI T. Vanvick	Mechanical turbine group leader: coordinated group efforts.
9/75	4/78	BPC, SFPD Ann Arbor, MI T. Vanvick	Deputy group supervisor: assisted with technical coordination and review of mechanical group activities.
4/78	5/81	BPC, SFPD Ann Arbor, MI R. Castleberry L. Curtis	Group supervisor: responsible for coordination and technical review of mechanical group activities.

WORK HISTORY

DATES FROM	TO	COMPANY, DIVISION, OR DEPARTMENT: LOCATION AND SUPERIOR	POSITION HELD, SUMMARY OF RESPONSIBILITIES, AND SIGNIFICANT ACCOMPLISHMENTS
5/81	2/82	BPC, AAPD Ann Arbor, MI L. Curtis E. Hughes	Assistant project engineer: provided project direction, including technical, schedule, and administrative review of mechanical, nuclear, control systems, and plant design activities.
2/82	Present	BPC, AAPD Midland, MI L. Curtis P. Corcoran	Resident assistant project engineer: provide project direction, including technical, schedule, and administrative review of heating, ventilation, and air conditioning, mechanical, architectural, and civil resident groups. Also designated deputy resident project engineer and resident engineering quality improvement coordinator.

RESUME

NAME: David T Perry

EDUCATION:

Penn State, University Park, PA			
9-65 to 9-69	BS	Engineering	
Carnegie Mellon		Major in Fluid Mechanics	
74-75		Power Engineering	

EXPERIENCE:

1980 Accepted a position with Consumers Power as Section Head for the Midland Project Mechanical/Nuclear Group.

1979 The Erie Project was placed on hold and I was loaned to Consumers Power Midland Project as an interface between the Project Organization and the Nuclear Safety Task Force. The responsibilities included reviewing and causing to be implemented the approved recommendations which were issued by the Task Force.

1978 Assigned as Mechanical Supervisor for the Mechanical Engineering Group on Erie. Responsible for all aspects of the Mechanical System Design.

1977 Joined Commonwealth Associates on the Erie Nuclear Project as Group Leader for Plant System in the Mechanical Engineering Group. Responsible for Fire Protection, Service Water, Component Cooling Water, Drainage, and other service systems. Promoted to Systems Engineering Group Leader responsible for design of all the Mechanical Group Systems including HVAC, Plants Service Systems, and the Power Generation Systems.

1975 Transfered to the Fluid Systems Application Group. Responsible for the primary systems design including residual heat removal, chemical and volume control, ECCS, Liquid and Gaseous Radwaste and Boron Recovery on the following plants:

1. Marble Hill
2. Byron
3. Braidwood
4. SNUPPS

1974 The following responsibility was added:

Provide interface between Westinghouse Research Center and Water Reactor Divisions, on work the Research Center was doing on the feedwater line water hammer.

1973 Added following lead responsibility requiring broader scope:

a. Korea Electric - Ko-Ri Unit I.

b. Assigned responsibility for writing the Fluid Systems Design II policies and procedures. These procedures are required for compliance with 10 CFR 50.

c. Authored the Westinghouse Steam Systems Design Manual WCAP-7451. This manual provides guidance on Secondary Plant design and highlights the Westinghouse criteria.

1972 Assigned lead responsibility for following new plants:

a. Duke Power Company - Catawba Units I and II.

b. Texas Utility Service - Comanche Peak Units I and II.

c. Worked with the Westinghouse Reference Plant Group to develop conceptual designs for the plant secondary systems.

1971 Assigned lead responsibility for following plants:

a. Consolidated Edison - Indian Point Units II and III.

b. American Electric Power - Donald C Cook Units I and II

c. Duke Power Company - McGuire Units I and II.

d. Puerto Rico Water Resources Authority - Aguirre Unit I.

e. Platform Mounted Nuclear Plant. Worked on conceptual design of power generation systems including layouts, costing, feasibility, systems descriptions, and proposal information.

1969-75 Engineer in Steam Systems Engineering Group in Westinghouse PWR Systems Division. Steam Systems Engineering is responsible for providing secondary plant criteria as required by the NSSS and ascertaining that the plant design complies with the criteria.

1969-70 Assisting on (IPP) Indian Point Plant, (AEP) Donald Cook Plant, and (DAP) McGuire Plant. Took a six month field assignment working at Indian Point Site as a Startup Engineer.

RESUME

NAME: Gerald B Slade

Education and Training

1965:	Bachelor of Science in Mechanical Engineering: Michigan Technological University, Houghton, Michigan
1967:	Master of Science in Nuclear Engineering: Purdue University, West Lafayette, Indiana
	Engineer Officer Basic Course, Fort Belvoir, Virginia
1968:	Nuclear Plant Engineer Course, Fort Belvoir, Virginia
1973:	Formal training program for Senior Reactor Operator License, Consumers Power Company's Palisades Nuclear Plant
1974:	Productive Listening Management Course, Consumers Power Company - 10 hours
1975:	QA Program Indoctrination Course, Consumers Power Company - 16 hours
	Maintenance Management Improvement Program, Consumers Power Company - 12 hours
1976:	Effective Reading Course, Consumers Power Company - 14 hours
1977:	Monetary Control/Budget Course, Consumers Power Company - 16 hours
	Human Aspects of Management Course, Consumers Power Company - 40 hours
	Effective Management Course, Consumers Power Company - 40 hours
1978:	B&W Nuclear Power Plant Operations for Management Course, Babcock & Wilcox Company, Lynchburg, Virginia
	Managerial Economics Course, Consumers Power Company - 40 hours
1979:	Public Speaking Skills Course, Millar and Millar, Inc, and Central Michigan University - 45 hours
	Labor Law Course for Nonlawyers, University of Wisconsin-Milwaukee, Wisconsin - 16 hours

1980: Management of Managers Program, University of Michigan, Ann Arbor, Michigan - 36 hours

Utility Startup Workshop, NUS, Atlanta, Georgia - 28 hours

Experience

1965: Design Engineer, Hull and Suspension Department, US Army Tank Automotive Center - worked on minor design projects

1967: General Engineer Analytical Computer Division US Army Tank Automotive Center - worked on analog computer simulation of ride characteristics for army vehicles

1967-1969: Second Lieutenant, US Army Corps of Engineers - performed as Technical Operations Officer in the Advanced Research Group of the Army Engineers Reactors Group. Primarily involved with reviewing advanced reactor design concepts for potential applications in the Army.

1969-1972: General Engineer, Palisades Nuclear Plant, Consumers Power Company - assisted in performance of preoperational and hot functional testing. Performed as acting shift supervisor prior to core loading. Performed as shift test engineer for initial startup testing. Assisted in the training of the initial licensed operators.

1972-1973: Reactor Engineer, Palisades Nuclear Plant - followed core burnup for Cycle I fuel; assisted in developing procedures and plans for initial power escalation tests

1973-1975: Technical Superintendent, Palisades Nuclear Plant - organized and directed a new technical department

1975-1976: Operations Superintendent, Palisades Nuclear Plant - directed the activities of the plant operations staff, chemistry staff, and training department

1976-1978: Operations Superintendent, Midland Nuclear Power Plant - Prepared and started implementing staffing plans for the Midland Plant

1978-1980: Operations and Maintenance Superintendent, Midland Nuclear Plant - responsible for planning, organizing, hiring, and coordinating activities of maintenance, operating, chemistry, and health physics departments to prepare for plant operation

1980-Present: Plant Superintendent, Midland Nuclear Plant - responsible for preparing for plant operation