# SAFETY ANALYSIS REPORT

# SYSTEM 21 MODIFICATION PROGRAM

# FORT ST. VRAIN NUCLEAR GENERATING STATION

# PUBLIC SERVICE COMPANY OF COLORADO


Prepared by:
Proto-Power Management Corporation
Groton, Connecticut 06340



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# SAFETY ANALYSIS REPORT

# SYSTEM 21 MODIFICATION PROGRAM

## 1.0 INTRODUCTION

The Helium Circulator Auxiliary System (System 21) includes the buffer helium, bearing water, and helium recovery systems. The System 21 Modification Program divides the existing common supply buffer helium system into two separate buffer helium loops such that the Helium Circulator Auxiliary System will be comprised of two separate and independent buffer helium/bearing water loops. Each buffer helium/bearing water loop will serve two helium circulators in a primary coolant loop.

The objective of the System 21 Modification Program is to provide separate and independent buffer helium loops such that a pressure or flow transient, system rupture, equipment failure or power loss in one loop will not affect the operation of the circulators served by the other loop. In addition, other modifications are being incorporated which are directed toward improving system responsiveness, operability, reliability, availablity and maintainability. Attachments A and B provide functional descriptions of the existing and modified systems, respectively.

This report describes the design of the modified Helium Circulator Auxiliary System and evaluates the effect of the design changes on plant performance and safety.

## 2.0 OBJECTIVES AND PERFORMANCE CRITERIA

The objectives and performance criteria of the System 21 Modification Program are as follows:

- To provide two separate and independent buffer helium loops such that a pressure or flow transient, system rupture, equipment failure or power loss in one loop will not affect the operation of the helium circulators served by the other loop.

- To decouple the buffer helium system from the helium recovery system such that the direct path for accidental release of primary coolant via the buffer helium dryer and low pressure separator has been eliminated.

- To provide for early detection of primary coolant entering the buffer helium system.

- To prevent or minimize reoccurance of prior incidents which resulted in release of primary coolant to the environment due to malfunction of the Helium Circulator Auxiliary System.

- To incorporate control changes which will minimize the occurrence of pressure and flow transients in the individual buffer helium loops that have resulted in moisture injection into the prestressed concrete reactor vessel (PCRV) or release of primary coolant from the PCRV, and to mitigate the effect of those transients that do occur.

- To incorporate changes which are directed toward improving system availability and reliability.

## 3.0 DESIGN DESCRIPTION

### 3.1 Separate and Independent Loops

The following changes are directed toward providing separate and independent buffer helium loops, with each loop serving the two helium circulators in a primary coolant loop, such that a malfunction in one buffer helium/bearing water loop will not affect the operation of the other buffer helium/bearing water loop:

- Duplication of Buffer Helium Piping/Components

  Piping and components between the existing buffer helium recirculators and buffer helium supply to each helium circulator are being duplicated to provide two separate and independent buffer helium loops.

- Duplication of Buffer Helium Makeup Piping

  Purified helium makeup supply lines and valving from the helium purification system and helium storage system are being modified to allow buffer helium makeup to either buffer helium loop independently of the other buffer helium loop.

- Electrical Separation

  Electrical power and control bus supplies to all electrical components and system instrumentation affected by the modification program are assigned to be consistent with the two loop functional separation criteria (i.e., separate and independent loops) of the system.

- Separation of Helium Recovery System Piping

  Although a single low pressure separator is being retained for the reasons discussed in Attachment B, the helium recovery system is being modified to allow the helium which is recovered in the low pressure separator to be returned to either buffer helium loop independently.

### 3.2 Buffer Helium System/Helium Recovery System Decoupling

The design of new buffer helium dryers in each loop will allow decoupling of the buffer helium system from the helium recovery system. The new dryers will be designed to regenerate at the operating pressure of the buffer helium system. This eliminates the existing purge line to the low pressure separator and the direct path for potential release of primary coolant.

### 3.3 Early Detection of Radioactive Contamination

Radiation detection instrumentation is being added to the buffer helium return piping of each helium circulator's high pressure separator to provide for early indication of radioactive contamination and identification of the specific helium circulator(s) involved.

## 3.4 Other System Modifications

The following system design modifications, which are part of the System 21 Modification Program, are directed toward improving system performance; minimizing the occurrence of and mitigating the effects of pressure and flow transients in buffer helium; and improving system reliability and availability.

### 3.4.1 Low Pressure Separator-Turbine Water Drain Tank Bypass

A bypass line has been added to allow the steam/water drain flow to be temporarily diverted to the turbine water drain tank during reactor shutdown (i.e., during removal of decay heat from the reactor core). This will facilitate maintenance of the low pressure separator without requiring system shutdown.

### 3.4.2 Buffer Helium Dryer Cross-Connects

Valved cross-connect lines have been added to allow one buffer helium dryer to serve both buffer helium loops or to allow the dryer in one buffer helium loop to serve the other buffer helium loop in the event of a malfunction of one buffer helium dryer. Use of the cross-connect lines will be limited to low power operation (i.e., less than two percent power level) or to reactor shutdown conditions in order to maintain a flow of dry buffer helium to the operating helium circulator(s).

### 3.4.3 Simplification of Low Pressure Separator Instrumentation

The water level instrumentation in the low pressure separator has been consolidated and redesigned for simplicity, to increase reliability, and to facilitate improved instrument calibration.

### 3.4.4. Addition of Coalescing Filters

The modified buffer helium system will use a coalescing filter upstream of each buffer helium dryer. Coalescing filters remove entrained liquid water from a gas stream more effectively than the existing knock-out pot and will, therefore, reduce water carryover to the dryer, thus improving overall system performance.

### 3.4.5 Buffer Helium Supply Pressure Control Modification

In the modified system design, the buffer helium supply flow control valves will be relocated from their present locations in each helium circulator buffer supply line to the buffer helium makeup line from the helium purification system, as described in Attachment B. The modified system also eliminates the buffer helium makeup pressure control valves in the

helium purification system. These modifications are directed toward improving the capability of the buffer helium system to respond to pressure and flow transients.

### 3.4.6 High Pressure Separator Drain Line Modification

A check valve has been added in the drain line from each high pressure separator upstream of the connection to each helium circulator main drain line. This will preclude flow reversal in the high pressure separator water drain under abnormal conditions.

### 3.4.7 Buffer Helium Recirculator Automatic Initiation

Automatic start of the standby helium recirculator in each buffer helium loop will be based on low differential pressure across the operating recirculator rather than low recirculator flow rate. This will improve the response of the buffer helium system to pressure and flow transients.

### 3.4.8 Buffer Helium Recirculator Differential Pressure Control

Provisions for manual control of buffer helium recirculator differential pressure regulation have been added. This will improve flow control of the buffer helium system during conditions such as refueling operation.

### 3.4.9 Helium Recovery System Discharge to Buffer Helium

The helium recovery system discharge will be directed into the bearing water surge tank in lieu of the buffer helium system piping downstream of the helium recirculator. This will preclude the accidental introduction of water into the buffer helium piping, in the event of a malfunction in the helium recovery system.

## 3.5 Overpressure Protection

The methods of pressure relief protection which were addressed in discussions between Public Service Company of Colorado and the Nuclear Regulatory Commission on August 21, 1979 and subsequently incorporated into the system design have been retained in the modified system design.

## 3.6 Systems and Components Not Affected by the System 21 Modification Program

The design, function, and operation of the following portions of the Helium Circulator Auiliary System and associated systems are not directly affected by the System 21 Modification Program:

- Bearing Water System, including Backup Bearing Water

- Helium Circulator Steam/Water Drains
- Turbine Water System and the Nitrogen Pressurization System
- Plant Protective System (PPS)
- Circulator Speed Control System

# 4.0 PERFORMANCE EVALUATION

## 4.1 Introduction

The function of the buffer helium system is to provide a controlled interface between primary coolant and bearing water at the helium circulator shafts in order to prevent both the release of primary coolant from the prestressed concrete reactor vessel (PCRV) and the injection of bearing water into the PCRV. The following performance evaluation addresses how the system modifications improve the capability of the system to perform its function under normal operating conditions and to minimize the impact of a malfunction or failure on system operation. Specifically, the evaluation addresses how the system modifications serve ..

1) prevent the loss of normal system function;

2) mitigate the consequences of a system malfunction or failure; and

3) accommodate the conditions which will exist following a system malfunction or failure.

Other modifications, which are not directly related to the ability of the system to perform its function but are directed toward improving overall system reliability and availability, are also addressed.

## 4.2 Preventing the Loss of System Function

The following system design changes improve system control and the ability to respond to system pressure and flow transients and, thus, are directed toward enhancing normal system function:

### 4.2.1 Buffer Helium Supply Pressure Control

This modification provides for regulation of buffer helium flow to each helium circulator by regulating the amount of buffer helium makeup flow from the helium purification system. The existing system first regulates the pressure of the buffer helium makeup from the helium purification system and then, downstream of the makeup connection, buffer helium flow to each helium circulator is regulated. This change improves the system response to transient conditions during which pressures and flows increase in the buffer helium system by:

1) allowing helium to be vented from the system through the helium circulator upper labyrinth into the PCRV to compensate for changes in system pressure and volume without the restriction imposed by the buffer helium supply flow control valves, and

2) automatically restricting the external source of helium into the buffer helium system from the helium purification system without significantly affecting the existing

systems responsiveness to decreasing pressure and flow transients in which case the external source of makeup helium is automatically increased.

Computer models developed for the modified system have demonstrated that this change significantly improves the capability of the modified system to respond without loss of normal buffer helium flow during system transient conditions (e.g., transfer to backup bearing water, scrams, helium circulator trips, and turbine trips), without affecting normal operation and control of the system.

4.2.2 Standby Recirculator Auto-Start Control

This modification provides for automatically starting the standby helium recirculator in each loop on low differential pressure across the operating recirculator in lieu of low recirculator flow. The change enhances the system response to pressure and flow transients by improving the control of the pressure differential between buffer supply and buffer return.

4.2.3 Recirculator Differential Pressure Control

This modification allows the operator to manually control the recirculator differential pressure in each buffer helium loop. This will improve system flow control and stability during plant conditions, such as refueling, without affecting the programmed automatic differential pressure control which is employed during normal operation.

4.3 Mitigating the Consequences of a Malfunction

The following system design changes are directed toward mitigating the effects of a system malfunction or failure:

4.3.1 Separate Buffer Helium Loops

Separation of the buffer helium system into two (2) loops, by itself, provides the most significant improvement in mitigating the consequences of a system malfunction or failure. All buffer helium system control functions and piping have been duplicated where commonality existed to provide complete separation of the buffer helium loops. Any malfunction or failure will be limited in its effects to operation of the corresponding two helium circulators in one primary coolant loop. The helium circulators served by the affected buffer helium loop could be shut down and sealed, while allowing continued operation of the remaining two helium circulators to permit an orderly plant shutdown.

In separating the buffer helium system, consideration has been given to common interfaces with other systems. Where appropriate, (such as the interface between the buffer helium system and the helium purification system) duplication of interfacing controls and piping and the use of

check valves and remote controlled isolation valves have been incorporated into the design to ensure that a single failure will not affect the operation of both buffer helium loops.

4.3.2 Separation of Buffer Helium Makeup Control

Associated with the separate buffer helium loops are flow control valves which regulate the supply of makeup helium from both the helium purification system and the helium storage system (the backup supply). These control valves and associated piping independently control helium makeup to each buffer helium loop. This design ensures that a malfunction of one flow control valve in one buffer helium loop will not affect the operation of both buffer helium loops. Remote controlled isolation valves and check valves have been incorporated into the design to ensure that:

1) a pipe rupture in the purification system or helium storage system will not result in depressurization of either buffer helium loop; and

2) a pipe rupture in one buffer helium loop will not result in depressurization of the other buffer helium loop.

4.3.3 Separation of Electrical Bus Assignments

Electrical and instrumentation and control components in each buffer helium/bearing water loop have been assigned to separate buses to ensure that a loss of power to one bus will not affect the operation of the helium circulators in both primary coolant loops. Attachment B describes the criteria for assignment of electrical buses.

4.3.4 Separation of Helium Recovery System

Each helium recovery compressor in the modified system discharges to the bearing water surge tank in its respective loop. As in the existing system, one helium recovery compressor is normally operating and the second helium recovery compressor serves as a standby. The standby compressor is automatically started on a high pressure signal in the low pressure separator. Unlike the existing system which returns all of the recovered helium to the common portion of the helium recovery system, all of the recovered helium in the modified system is returned to a single loop of the buffer helium system. The specific loop to which the recovered helium is returned will depend upon which helium recovery compressor is operating. The amount of recovered helium (which varies depending on power level) is small, less than one percent of the total helium flow to the helium circulators served by a buffer helium loop. Thus, the addition or loss of recovered helium to a buffer

helium loop will not affect the operation of the buffer helium loop.

The two helium recovery compressor discharges are not cross connected. In this manner, any malfunction in one helium recovery compressor or buffer helium loop will not affect operation of the other helium recovery compressor or its associated buffer helium loop. In addition, by directing the compressor discharge to the bearing water surge tank, any water carryover, such as that resulting from a compressor cooler failure or knockout pot level control malfunction, will not affect the normal helium gas flow performance in the buffer helium dryer and its supply header.

In the event that both helium recovery compressors are inoperable, or the helium recovery compressor associated with a single operating buffer helium loop is inoperable, the modified helium recovery system has provision to vent the low pressure separator via the reactor plant exhaust system. The radiation detector on the low pressure separator water drain will automatically isolate the vent path in the event of radioactive contamination in the low pressure separator.

A relief valve on the discharge of each helium recovery compressor is set sufficiently low to precluce continued discharge of recovered helium to an isolated buffer helium loop.

### 4.3.5 Dryer Regeneration at Buffer Helium System Pressure

The use of buffer helium dryers that are regenerated at system operating pressure eliminates the need to direct the dryer purge flow to the low pressure separator and thus decouples a direct path from the high pressure buffer helium system to the low pressure portion of the helium recovery system. Elimination of this path removes both the potential for depressurization of the buffer helium system and the direct path for radioactive contamination of the low pressure separa' r with the potential for release of radioactivity in the event that the buffer helium system becomes contaminated.

### 4.3.6 Radiation Detection

The modified system incorporates radiation detectors in the buffer helium return piping at each high pressure separator to provide an alarm and early indication of the presence of primary coolant accidently in the buffer helium system. These alarms will identify to the operator the source of contamination (i.e., which helium circulator(s)). The operator can take immediate action to correct the situation or to shutdown and seal the corresponding helium circulator(s).

Operator action aided by this instrumentation will minimize the spread of contamination which may enter the buffer helium system.

4.3.7 Check Valves in the High Pressure Separator Drain Lines

Check valves will be added in the drain line from each high pressure separator. These valves prevent bearing drain water from backing up into the high pressure separator in the event that a malfunction causes bearing water system main drain pressure to temporarily exceed the buffer helium return pressure in the high pressure separator.

## 4.4 Accommodating a System Malfunction

Although the system design modifications are primarily directed toward preventing system transients and mitigating the consequences of a malfunction, the modifications also improve the ability to accommodate the degraded conditions which may exist following a system malfunction.

### 4.4.1 Separation of the Buffer Helium System

In the event of a malfunction or failure in one buffer helium/bearing water loop, the modified two-loop system will allow the affected helium circulators in one primary coolant loop to be shutdown and sealed to prevent the release of primary coolant or ingress of bearing water into the PCRV. Normal operation of the helium circulators in the other loop can be maintained to effect an orderly plant shutdown and decay heat removal until the malfunction can be corrected and the affected loop restored to normal operation.

### 4.4.2 Early Detection of Radioactivity

Installation of radiation detectors on the piping downstream of the high pressure separators will provide early indication of the source and location of primary coolant entering the buffer helium system and will facilitate timely action to minimize the contamination level. The modified system design provides for isolation of the contamination within the helium circulator auxiliary system thereby preventing the release of radioactivity from the plant and potential contamination of interfacing systems. With normal system operation, approximately 50% of buffer helium flow is constantly returned to the PCRV with a corresponding fraction of clean makeup helium added back to the system.

Accidental radioactivity in one loop will, therefore, be followed by corrective self cleanup action. This, coupled with decay of short lived nuclides, will reduce buffer helium radioactivity levels to approximately one per cent of initial levels within one hour.

4.4.3 Safe Shutdown Function

None of the system modifications reduce or affect the capability of the buffer helium system to perform its safe shutdown function (i.e., to maintain the pressure integrity of the bearing water system) as established by the Fort St. Vrain FSAR. This fact is addressed in detail in the Safety Analysis below.

4.5 Changes for Maintainability, Reliability, Availability and Performance

The following modifications are not directly related to preventing the loss of system function or mitigating the effects of a malfunction, but are directed toward improving the overall system maintainability, reliability and availability and toward improving system performance.

4.5.1 Coalescing Filters

Coalescing filters were added upstream of the buffer helium dryers to improve system performance by reducing the potential for entrained moisture carryover into the dryer units.

4.5.2 Low Pressure Separator Bypass Line

A bypass line has been added to allow the stream/water drain flow to be temporarily directed to the turbine water drain tank to permit maintenance of the low pressure separator and associated piping and instrumentation. The line is intended to be used only with the reactor shut down while operating helium circulators for decay heat removal. The line does not affect normal operation of the system or the ability to utilize the turbine water system for safe shutdown.

4.5.3 Buffer Helium Cross-Connect Lines

Cross-connect lines have been provided between the buffer helium loops upstream and downstream of the dryers and in the dryer regeneration piping. These lines will be isolated with locked-shut valves during power operation. The cross-connect lines will be used only during low power operation or reactor shutdown to allow one buffer helium dryer to serve both buffer helium loops or to allow the dryer in one buffer helium loop to serve the other buffer helium loop in the event of a malfunction of one buffer helium dryer.

4.5.4 Simplification of Low Pressure Separator Instrumentation

The existing low pressure separator level control instrumentation utilizes five primary sensing devices (two level

switches, one electronic level transmitter, and two pneumatic level controllers) to perform twelve separate indication, alarm and control functions. To facilitate calibration and to improve reliability, the instrumentation associated with the low pressure separator has been redesigned to utilize only two primary sensing devices (two electronic level transmitters). The modification primarily affects only the method of sensing tank level and does not affect the basic functions performed or the methods of controlling tank level.

# 5.0 SAFETY ANALYSIS

## 5.1 Introduction

The Helium Circulator Auxiliary System modifications have been reviewed on an individual and overall basis to evaluate potential effects on plant safety. It is concluded that the modifications do not: (1) increase the probability of occurrences or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the Safety Analysis Report; (2) create a possibility for an accident or malfunction of a different type than any evaluated previously in the Safety Analysis Report; or (3) reduce the margin of safety as defined in the basis for any technical specification.

## 5.2 Consideration of Accidents Previously Evaluated

### 5.2.1 Design Basis

#### 5.2.1.1 Overall

The Fort St. Vrain Safety Analysis is presented in Section XIV of the FSAR. The relevance of the Helium Circulator Auxiliary System to that safety analysis is the importance of the system to safe shutdown cooling of the reactor core. The FSAR demonstrates that safe shutdown cooling can be accomplished with operation of a single helium circulator. Therefore, operation of a helium circulator is the overall design basis that determines the design basis of the Helium Circulator Auxiliary System.

#### 5.2.1.2 Bearing Water System

Section 4.2.2.3.7 of the FSAR states that bearing water supply is vital to the continued operation of the helium circulators. Therefore, system functionality is the design basis of the bearing water system. Although the System 21 Mo[illegible]ication Program does not affect the bearing water system, the design basis of the bearing water system, combined with its inherent relationship with the buffer helium system, establishes the design basis of the buffer helium system.

#### 5.2.1.3 Buffer Helium System

Section 4.2.2.3.7 of the FSAR states that buffer helium is not required insofar as continued operation of the helium circulators is concerned. However, the pressure boundary integrity of the buffer helium system is necessary to maintain the pressure integrity of the bearing water surge tank, which is essential to the operaton of the bearing water system for safe shutdown cooling. Therefore, the design basis

for the buffer helium system is to maintain the pressure integrity of the system and is not related to functionality.

5.2.1.4 Helium Recovery System

The helium recovery system does not perform any safety related function and, therefore, has no design basis related to safety.

5.2.1.5 Other Systems

The System 21 Modification Program does not involve changes to other safety related systems, such as the Plant Protective System and Turbine Water System, which are associated with the Helium Circulator Auxiliary System, nor do the modifications affect the ability of these interfacing systems to perform their intended safe shutdown functions.

5.2.2 Design Considerations

The following design considerations relate to the design basis of the buffer helium system (i.e., maintaining system pressure boundary integrity for safe shutdown) and have been incorporated into the design modifications.

5.2.2.1 Seismic

Piping and Component Support:

All piping and component support structures of the buffer helium system, which are being added or modified as a result of the system design changes, are designed to meet the Fort St. Vrain seismic design criteria, as identified in the response to FSAR Question 5.11.

Equipment Qualification:

Equipment specifications for components being procured to support the modifications of the buffer helium system include requirements for seismic qualification consistent with the Fort St. Vrain seismic design criteria, as identified in the FSAR, and existing plant design standards for seismic qualification of equipment.

5.2.2.2 Environmental

Piping and Component Supports:

All materials for piping, piping components, and associated support structures, which are being added

or modified as a result of the modifications, have been selected to ensure that the pressure integrity of the buffer helium system will be maintained when subjected to the environmental conditions following a steam line rupture, consistent with the response to FSAR Question 6.1.

Equipment:

Where applicable, the equipment specifications for the components being procured for the buffer helium system modifications specify environmental conditions following a steam line rupture consistent with the response to FSAR Question 6.1, and require that the suppliers certify that the equipment will perform its safety function when subjected to these environmental conditions.

5.2.2.3 Pipe Rupture

Buffer Helium System:

Separation of the existing buffer helium system into two individual system loops will significantly reduce to potential of a single missile or other accident from affecting the pressure integrity of both buffer helium loops.

Existing system design features, such as check valves and remote or automatic operated valves whose functions are directed toward mitigating the effects of a pipe rupture, have been retained in the modified design.

Interfacing Systems:

The portions of the helium recovery system and helium purification system, which connect to the buffer helium system, are not designed to retain their pressure boundary under accident conditions (i.e., seismic and environmental). To ensure that a pipe rupture in these systems will not degrade the pressure boundary integrity of the buffer helium system, a check valve, in series with a remote operated on-off valve, is used in the connecting system piping.

The check valve will respond immediately to a pipe rupture in the connecting pipe to preclude sudden depressurization of the buffer helium loop. The remote operated on-off valve can then be used to ensure isolation from the pipe rupture. These valves are being designed and qualified to be functional during and following accident conditions. The portion of the connecting piping containing these valves

is being designed to maintain pressure integrity during a seismic or environmental event.

5.2.3 Conclusion

Existing design bases have been utilized for the System 21 Modification Program. Safe shutdown cooling of the reactor core has not been compromised by these modifications. It is concluded that these modifications do not increase the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the Safety Analysis Report (Section XIV of the FSAR).

5.3 Consideration of Potential New Concerns

Each of the modifications being made to the Helium Circulator Auxiliary System has been reviewed with respect to its potential for initiating new safety concerns which have not been previously evaluated in the FSAR Safety Analysis. The modifications do not affect the design intent or overall function of the buffer helium system or other associated systems, and all existing plant design criteria have been met.

It is concluded that these modifications do not create the possibility for an accident of a different type than any evaluated previously in the Safety Analysis Report.

5.4 Margin of Safety

It is concluded that the system modifications do not affect the limiting conditions for helium circulator operation and, as such, do not reduce the margin of safety as defined in the basis for any plant technical specifications.

## 6.0 EFFECT OF SYSTEM 21 MODIFICATION PROGRAM ON TECHNICAL SPECIFICATIONS AND FSAR

### 6.1 Technical Specifications

The System 21 Modification Program does not require any change to the Fort St. Vrain Technical Specifications.

### 6.2 FSAR

The System 21 Modification Program does warrant revision to the FSAR. The required revisions are predominantly narrative in nature, affecting the descriptive portion of system operation and component design and do not affect the general FSAR design basis or safety analysis.

## 7.0 CONCLUSION

Based on the safety and performance evaluations summarized in this Safety Report, it is concluded that the System 21 Modification Program:

- improves the ability of the Helium Circulator Auxiliary System to mitigate the consequences of a system malfunction or accident without adversely affecting the safety of the plant or risk to the health and safety of the public.

- significantly adds to the reliability and availability of the Helium Circulator Auxiliary System.

- does not increase the probability of occurrences or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the Safety Analysis Report, does not create a possibility for an accident or malfunction of a different type than any evaluated previously in the Safety Analysis Report, and does not reduce the margin of safety as defined in the basis for any technical specification.

## ATTACHMENT A

## FUNCTIONAL DESCRIPTION

## EXISTING HELIUM CIRCULATOR AUXILIARY SYSTEM

### INTRODUCTION

This Attachment describes the general function of the existing Helium Circulator Auxiliary System as it relates to the System 21 Modification Program.

### GENERAL FUNCTION

Helium circulators are utilized to circulate helium inside the prestressed concrete reactor vessel (PCRV) in order to transfer heat from the reactor core to the steam generators and secondary coolant system. Each helium circulator consists of a single stage axial flow compressor, located inside the PCRV primary system boundary, normally driven by a single stage axial flow steam turbine, located outside of the PCRV primary system boundary. A vertical circulator shaft, supported by a water lubricated bearing system, penetrates the PCRV primary system boundary to connect the compressor and steam turbine. There are four (4) helium circulators, two assigned to each primary coolant loop.

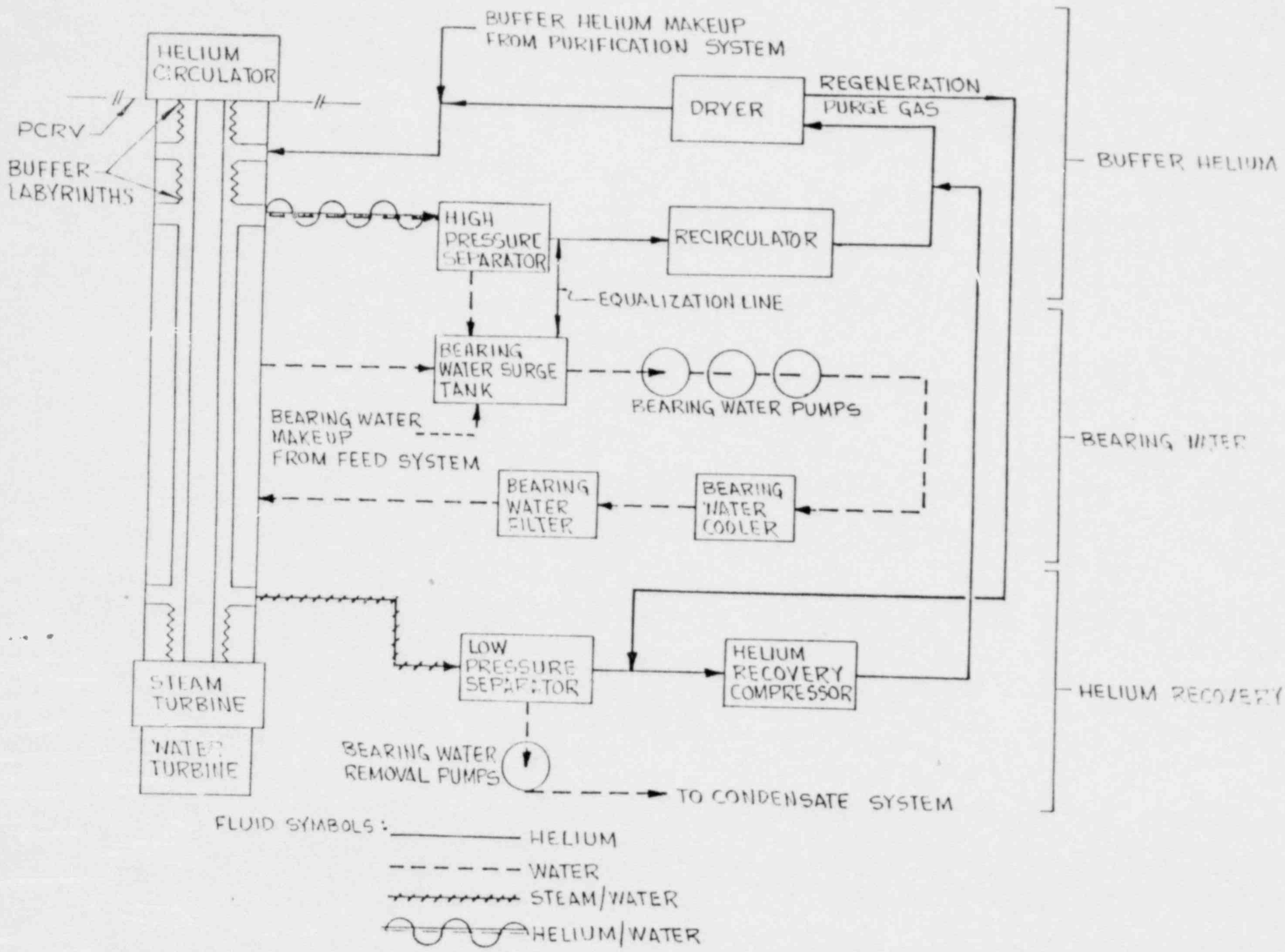
The bearing water portion of the Helium Circulator Auxiliary System provides a supply of high pressure water for helium circulator bearing lubrication. The buffer helium portion of the Helium Circulator Auxiliary System provides a supply of purified buffer helium to prevent both the in-leakage of bearing water into the PCRV and the out-leakage of primary coolant from the PCRV past the helium circulator shaft seals.

The helium recovery portion of the Helium Circulator Auxiliary System recovers helium which degasses from the helium circulators steam/water drains. These sub-system inter-functional relationships are shown in Figure 1.

### BUFFER HELIUM SYSTEM

Each helium circulator requires approximately 7.4 acfm (200 lbs. per hour at full primary system pressure) buffer helium flow. Approximately half of this amount enters the PCRV through the helium circulator upper buffer labyrinth. The remaining half flows through the helium circulator lower buffer labyrinth and is directed to the helium circulator's high pressure separator which separates bearing water carried over from the helium circulator. Each helium circulator is instrumented to measure the differential pressure between the buffer helium supply pressure to the buffer labyrinths and the pressure at a point at approximately the middle of the lower buffer labyrinth. This difference, referred to as the buffer mid-buffer $\Delta P$, is important to system operation. Under normal conditions, the flow of clean buffer helium through the lower buffer labyrinth creates approximately 30 to 40 inches of water $\Delta P$ in

FIGURE I EXISTING HELIUM CIRCULATOR AUXILIARY SYSTEM



the positive direction at full reactor pressure. A "negative" buffer mid-buffer $\Delta P$ is indicative of bearing water flowing up through the buffer labyrinths and entering the PCRV. A higher than normal positive buffer mid-buffer $\Delta P$ is indicative of either a higher than normal buffer helium return flow through the helium circulator lower buffer labyrinth or of primary coolant exiting from the PCRV and flowing down through the buffer labyrinths into the buffer helium system.

Buffer helium leaving helium circulators A and B (primary coolant Loop I) is combined into a single header and recompressed by one of two buffer helium recirculators (one operating, one on standby). See Figure 2. Similarly, buffer helium leaving helium circulators C and D (primary coolant Loop II) is combined into a single header and recompressed by one of two buffer helium recirculators. The existing buffer helium system then combines the buffer helium return flow from all four helium circulators into a single header and passes this flow through a single helium dryer. The buffer helium dryer removes water vapor from the buffer helium that has been returned from the helium circulators. Otherwise, water vapor would be carried along with the buffer helium that flows up the helium circulators' labyrinths into the PCRV.

Makeup flow from the helium purification system (to replace the buffer helium which had entered the PCRV through the helium circulator's upper labyrinth) enters the common system at the buffer helium dryer outlet. The common piping is then split into four separate headers, each servicing a single helium circulator.

HELIUM RECOVERY SYSTEM

The existing helium recovery system is shown in Figure 3. The major source of helium flow into this system is produced from the regeneration purge gas of the existing helium dryer. The design of this dryer requires that the desiccant beds be regenerated with helium at low (approximately atmospheric) pressure. This low pressure purge gas flow is directed to the low pressure separator and then returned to the buffer helium system via the helium recovery compressors. The helium recovery system also recovers the helium which is off-gassed from the helium circulator steam water drain flow entering the low pressure separator.

Normally, one helium recovery compressor is operated to return the recovered helium to the inlet of the buffer helium dryer. The second helium recovery compressor serves as a standby in the event that the operating compressor malfunctions or additional capacity to remove abnormal quantities of helium from the low pressure separator is required.

BEARING WATER SYSTEM

The bearing water system is also an integral part of the Helium Circulator Auxiliary System. As shown in Figure 4, the existing bearing water system is presently divided into two separate and independent loops (except for both bearing water loops equalization lines dependance on a common buffer helium system), with each loop servicing two helium circulators. In as much as this portion of the system currently is physically divided into two separate loops, the bearing water system will not be directly involved with the System 21 Modification Program and will not be discussed in detail in this Attachment.

FIGURE 2 EXISTING BUFFER HELIUM SYSTEM

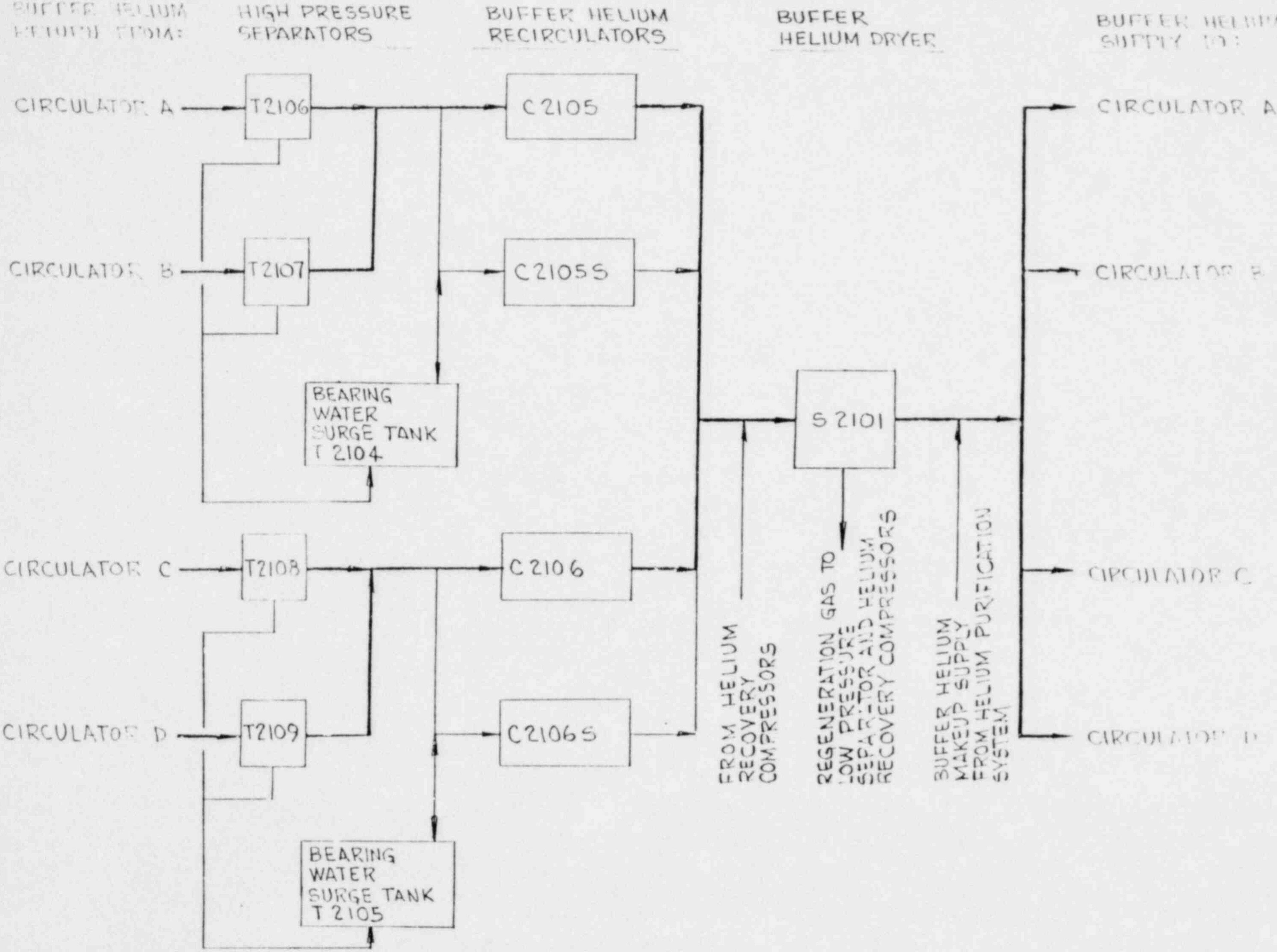


FIGURE 3 EXISTING HELIUM RECOVERY SYSTEM

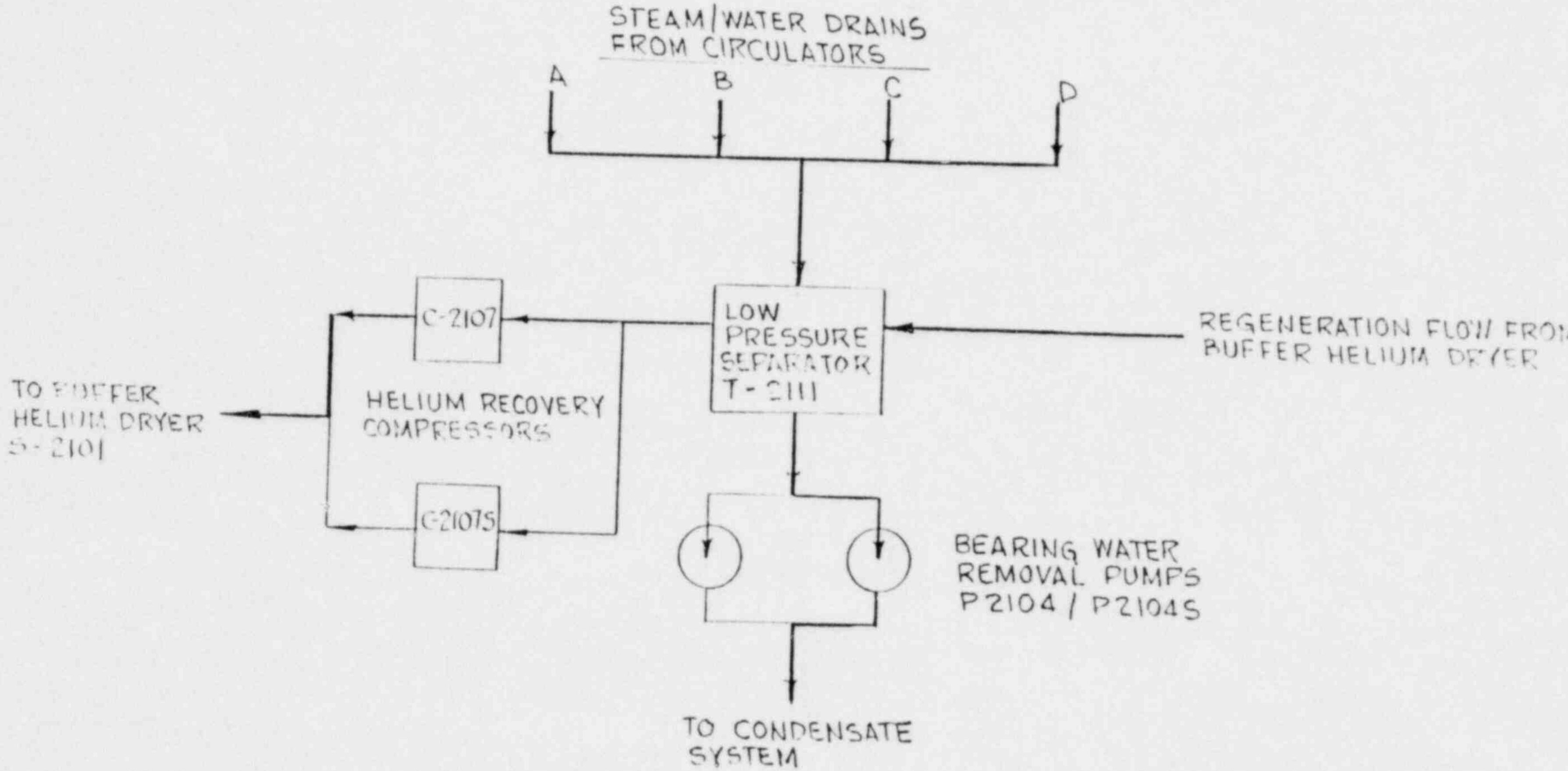


FIGURE 4 EXISTING BEARING WATER SYSTEM

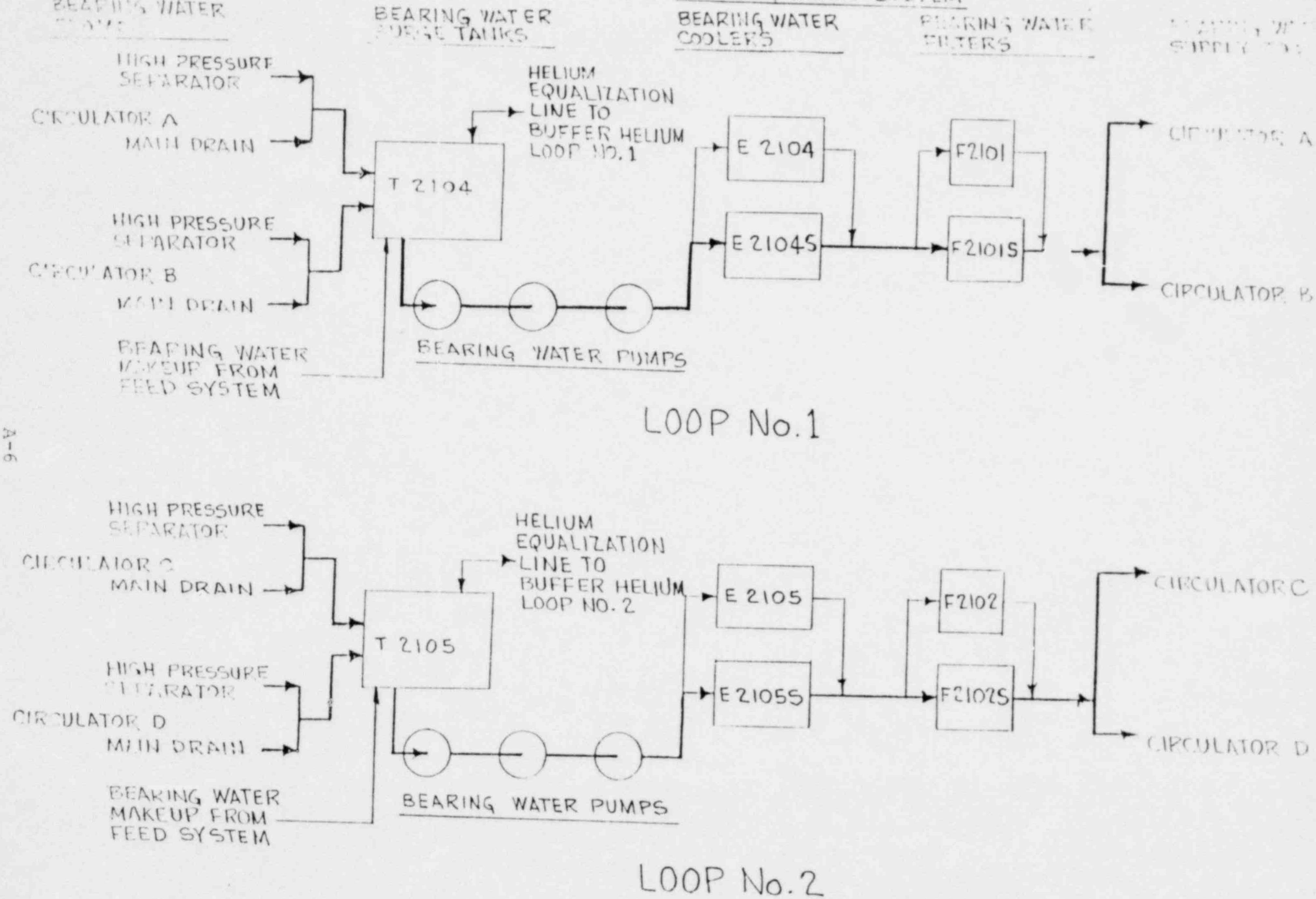


Figure 4 shows that there is a physical system connection between the loops of the bearing water system and the buffer helium system. The gas space in each bearing water surge tank is connected to the buffer helium system at the helium recirculator suction via a pressure equalization line which maintains a relative pressure between the buffer helium system and bearing water system.

RADIATION DETECTION SYSTEM

The existing system has a radiation detector and alarm on the low pressure separator water drain. Reactor coolant, which enters the buffer helium system is absorbed into the bearing water and enters the low pressure separator via the helium circulator steam water drains. As this water leaves the low pressure separator, the dissolved primary coolant will actuate the high radiation alarm.

PLANT PROTECTIVE SYSTEM

Although not a part of the Helium Circulator Auxiliary System, a portion of the Plant Protective System consists of the instrumentation and controls required to initiate automatic corrective actions associated with the operation of the helium circulator. These actions are directed toward reducing plant power and shutting down reactor plant equipment and are designed to override the plant operator and the normal plant controls. The Plant Protective System monitors, as one particular function, buffer mid-buffer $\Delta P$.

The Plant Protective System initiates a programmed helium circulator shutdown on a sustained (i.e., more than 3 seconds to eliminate erroneous signals due to transitory occurrances) high positive or negative buffer mid-buffer $\Delta P$. This signal is inhibited in the Plant Protective System such that if one helium circulator in a primary coolant loop trips, automatic shutdown of the second helium circualtor is prevented. This is intended to prevent a primary coolant loop shutdown in the event that some transient momentarily affects both helium circulators. Sine manual shutdown of the second circulator is not inhibited by the Plant Protective System, the system allows the operator to take positive action, as appropriate, to effect a primary coolant loop shutdown.

ATTACHMENT B

FUNCTIONAL DESCRIPTION

MODIFIED HELIUM CIRCULATOR AUXILIARY SYSTEM

INTRODUCTION

This Attachment describes the general function of the modified Helium Circulator Auxiliary System as it relates to the System 21 Modification Program.

GENERAL FUNCTION

The general functions of the modified Helium Circulator Auxiliary System are unchanged from that of the existing system, which is described in Attachment A to the Safety Analysis Report for the System 21 Modification Program.

BUFFER HELIUM SYSTEM

The modified Buffer Helium System is as shown in Figure 1. Each primary coolant loop, containing two helium circulators, will be serviced by a separate and independent buffer helium loop. With separate and independent buffer helium loops, a flow or pressure upset, system rupture, equipment failure, or power loss in one buffer helium loop will not affect the other buffer helium loop from performing its intended function for the associated two helium circulators. The following changes have been incorporated in order to achieve separate and independent buffer helium loops:

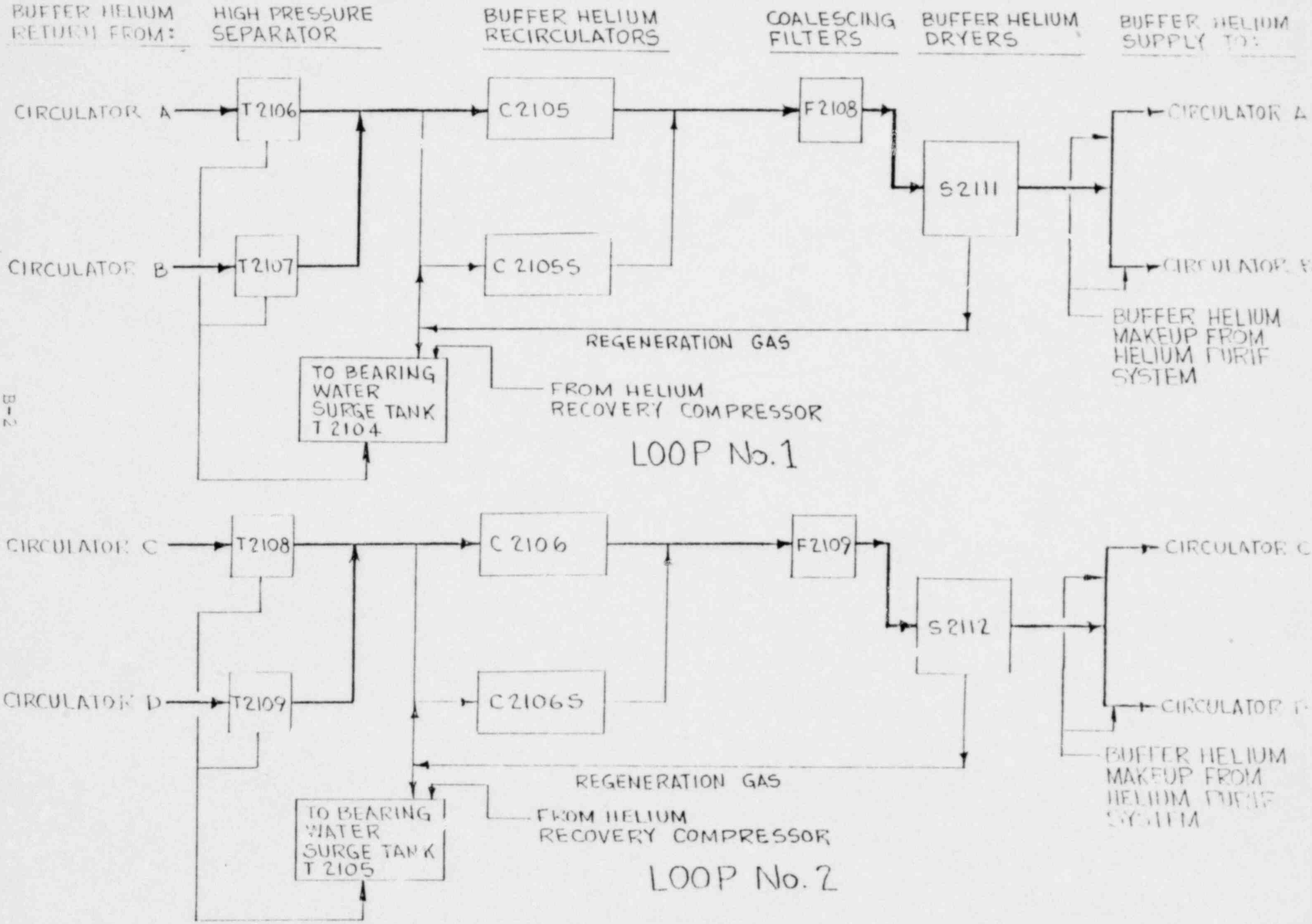
- Piping and components in the common portion of the existing system (between the helium recirculators and buffer helium supply) have been duplicated. Most significantly, a new buffer helium dryer has been added to each loop.

- Separate and independent purified helium supply lines have been provided to each buffer helium supply loop from the helium purification system and helium storage system for buffer helium makeup.

- Electrical power and control bus assignments for electrical components and system instrumentation affected by the modification program have been assigned to be consistent with the system's functional separation criteria, i.e., separate and independent loops. Thus, loss of a bus which supplies power to the equipment or controls in one buffer helium loop will not affect the operation of the helium circulators in the other loop.

To improve system performance and availability, the following changes have also been incorporated:

FIGURE 1 MODIFIED BUFFER HELIUM SYSTEM



- A coalescing filter has been located upstream of each buffer helium dryer, as opposed to the existing design which contains a knockout pot upstream of the buffer helium dryer. The purpose of both the coalescing filter and knockout pot is to remove entrained liquid water from the helium stream which may be carried over from the buffer helium recirculators. A coalescing filter performs this function more efficiently than a knockout pot and will, therefore, improve overall system performance. As with the existing knockout pot, the coalescing filter will contain an integral reservoir for collection of the water removed from the buffer helium and the reservoir will be automatically drained on level control to the bearing water surge tank.

- Valved lines have been included to allow the buffer helium loops to be cross-connected at the buffer helium dryer inlet, outlet and regeneration piping during low power operation or reactor shutdown. During power operation, these cross-connects will be locked shut. In the event of a dryer malfunction, these cross-connects will permit one buffer helium dryer to serve both buffer helium loops or to allow the dryer in one buffer helium loop to serve the other buffer helium loop. Dry buffer helium can then be supplied to the operating helium circulators during repair of the malfunctioned dryer while precluding excessive moisture from entering the PCRV which would otherwise occur if the malfunctioned dryer were simply bypassed.

- Check valves have been added to the drain line of each high pressure separator. This will prevent bearing water from backing up into the high pressure separator during pressure transients.

- Buffer helium makeup flow from the helium purification system will be regulated to provide the required buffer helium flow to each helium circulator, in lieu of first regulating buffer helium makeup pressure from the helium purification system and then, downstream of the makeup connection, regulating buffer helium flow to each helium ciculator. This modified buffer helium supply flow control scheme is shown in Figure 2. Also, the standby helium recirculator will automatically start on low differential pressure across the operating recirculator in lieu of low flow. These changes will considerably improve the system's response during transient conditions.

- Manual control of the recirculator differential pressure will be added to improve system flow control during conditions such as refueling.

The significant functional change in the buffer helium system relates to the new buffer helium dryers and their ability to regenerate at system operating pressure as discussed below. The basic system operational concept has not been changed. Minor changes in the operation of the system have been made consistent with the buffer helium loop separation, the method of controlling buffer helium makeup flow, and the addition of equipment.

## HELIUM RECOVERY SYSTEM

The modified helium recovery system is as shown in Figure 3. In the modified design, the only source of helium into the system is the off-gassed helium from the bearing water in the steam water drains. The buffer helium dryers will regenerate at buffer helium system operating pressure, as shown in Figure 1 and, therefore, not return the regeneration purge gas to the low pressure separator. In this manner, the low pressure portion of the helium recovery system has been decoupled from the high pressure buffer helium system.

A single low pressure separator has been retained in the modified helium recovery system. The decision to utilize a single low pressure separator in conjunction with two buffer helium/bearing water loops is based on the following rationale:

- The low pressure separator operates at atmosphere pressure and, as such, is well below the normal operating pressure of the buffer helium and bearing water systems. This pressure differential will ensure that a pressure transient in the low pressure separator, will not affect operation of either buffer helium/bearing water loop.

- The system modifications have eliminated the direct flow path between the buffer helium dryer and low pressure separator. These modifications also preclude cross-flow between the loops of the buffer helium system.

- The low pressure separator is a passive component which operates at approximately atmospheric pressure. Therefore, its potential for failure is low.

FIGURE 2 MODIFIED BUFFER HELIUM SUPPLY FLOW CONTROL SCHEME

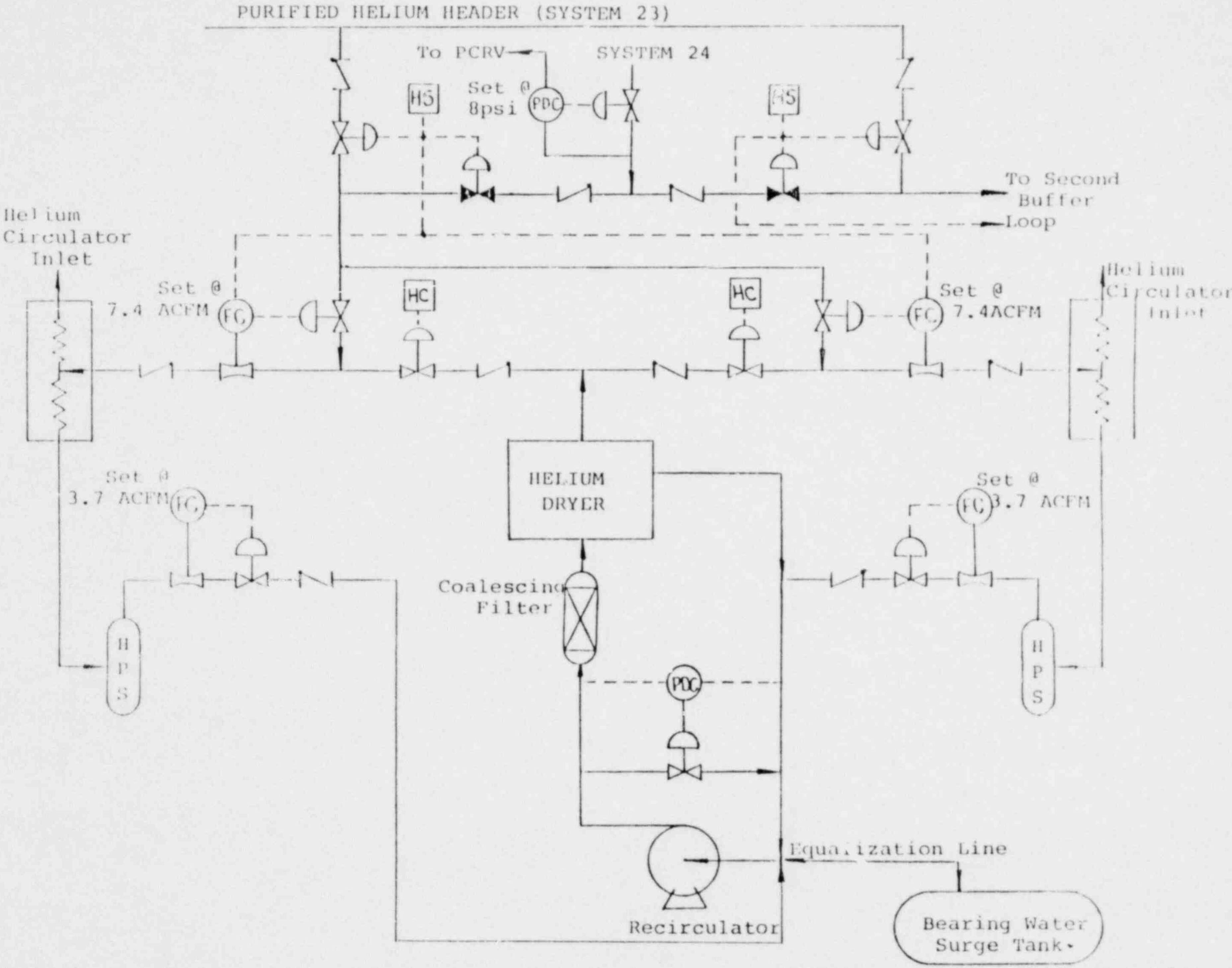
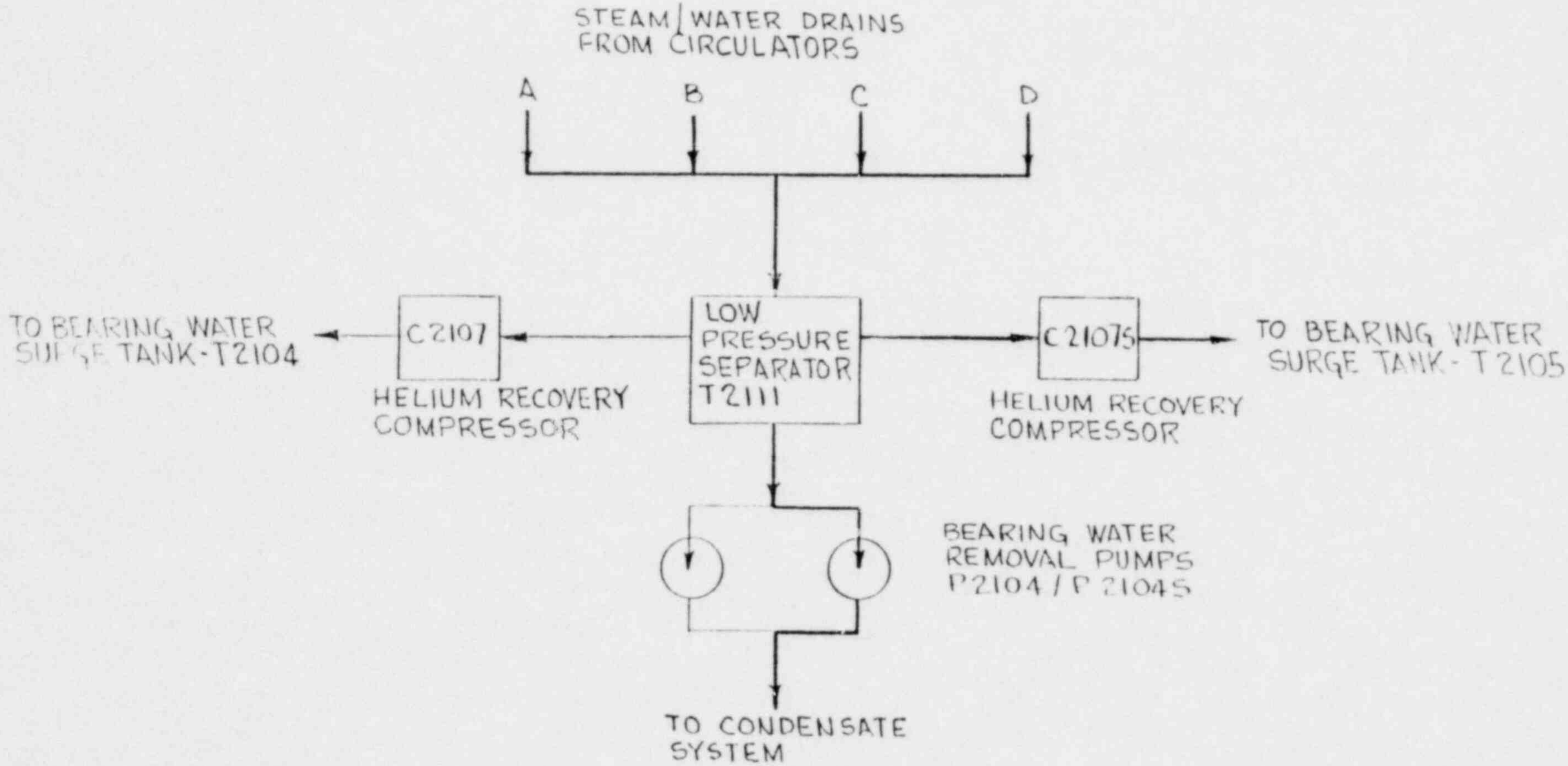


FIGURE 3 MODIFIED HELIUM RECOVERY SYSTEM



- The low pressure separator does not perform any safety functions.
- The addition of a separate and independant low pressure separator would result in unnecessary complexity of the helium recovery system and associated turbine water and nitrogen pressurization systems.

Other major components in the existing helium recovery system have also been retained and no new major components have been added. The changes incorporated into the helium recovery system, as a result of the System 21 Modification Program, are as follows:

- All of the recovered helium will be returned to a single buffer helium loop, the particular loop depending on the operating helium recovery compressor. Like the existing system, the modified system will normally operate one helium recovery compressor with the second compressor serving as a standby.
- The operating helium recovery compressor will discharge into the gas space of the associated loop's bearing water surge tank. This will minimize the effect on the buffer helium system should any water be carried over from the helium recovery system (such as that which would result from a compressor intercooler failure or knockout pot level control malfunction).
- Piping has been added to allow flow intended for the low pressure separator to be bypassed to the turbine water drain tank. This will allow the low pressure separator to be isolated and removed from service should maintenance on the tank be required. Due to the interfunctional relationship between the turbine water drain tank, low pressure separator and nitrogen pressurization system (which is intended for use when feedwater is utilized to drive the helium circulators), this bypass line will only be used during shutdown conditions.
- The low pressure separator water level control instrumentation has been consolidated and redesigned to improve reliability and maintainability. The five primary sensing devices (two level switches, one electronic level transmitter and two pneumatic level controllers) used in the existing system have been consolidated into two electronic level transmitters. The basic functions performed by the sensing devices and the methods of controlling tank water level have not changed.

BEARING WATER SYSTEM

In as much as the existing bearing water system is currently comprised of two separate and independent loops, no changes are required to this system for the System 21 Modification Program.

RADIATION DETECTION

The modified Helium Circulator Auxiliary System will include radiation instrumentation at the buffer helium return piping of each helium circulator to permit early detection of radioactive contamination and indication of the specific helium circulator(s) that are providing the escape path for the

primary coolant. This instrumentation will be external to the buffer helium system piping and, therefore, will not be a system pressure boundary.

Early detection of radioactive contamination and knowledge of the source path will facilitate orderly system operation and will enable appropriate operator action to be taken to minimize the extent of the contamination. If deemed appropriate, the operator can take action to shut down and seal the affected helium circulators and isolate the affected buffer helium/bearing water loop. If necessary, an orderly shutdown may proceed with the two operating helium circulators, with all primary coolant contained.

PLANT PROTECTIVE SYSTEM

The System 21 Modification Program does not change the design or operation of the Plant Protective System. A transient in one of the buffer helium/bearing water loops which results in a sustained (i.e., more than 3 seconds) high positive or negative buffer mid-buffer $\Delta P$ on both helium circulators will automatically trip one of the helium circulators. Automatic tripping of the second circulator in that loop will be inhibited by the Plant Protective System. If the reactor operator determines that the transient is severe and will be sustained, manual tripping of the second helium circulator and shutdown of that Helium Circulator Auxiliary System and primary/secondary coolant loop would be appropriate. The non-affected buffer helium/bearing water/helium recovery loop could then be used for safe and orderly plant shutdown.

Retaining the existing PPS logic will minimize the number of loop shutdowns which could be initiated by transient perturbations in the Helium Circulator Auxiliary System, while allowing complete shutdown of the affected loop in the event of a system malfunction.

COMPONENTS

The major components for the System 21 Modification Program are the buffer helium dryers. Unlike the existing buffer helium dryers, the new dryers will be regenerated at system operating pressure and, as Figure 1 shows, regeneration purge gas will be returned to the suction of the buffer helium recirculators. The existing dryer returns regeneration purge gas to the low pressure separator. The regeneration scheme of the new dryers allows the low pressure portion of the helium recovery system to be decoupled from the high pressure buffer helium system.

The pressure vessels of the existing buffer helium dryer were procured to Class C, Section III of the 1968 edition of the ASME boiler and pressure vessel code which, in essence, invoked the requirements of Section VIII of the ASME Code for materials, design, fabrication, inspection and testing. The pressure vessels of the new dryers are being procured to the requirements of Section VIII of the ASME Boiler and Pressure Code, 1977 Edition with Addenda through Winter 1979. A detailed engineering evaluation of these Code requirements has been performed and it has been concluded that the new dryers will satisfy the FSAR commitment which requires that modifications or replacements of plant systems or equipment result in installation of components that are equal to or better than that originally installed.

In addition, a coalescing filter is being utilized upstream of each buffer helium dryer, in lieu of a knock-out pot, to improve overall system performance. A coalescing filter will remove entrained liquid water from the gas stream more effectively than a knock-out pot. These filters are also being procured to the requirements of Section VIII of the ASME Boiler and Pressure Vessel Code, 1977Ed from with Addenda through Winter 1979.