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TABLE OF CONTENTS

0318

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LIST OF TABLES

LIST OF FIGURES

11 RADIOACTIVE WASTES AND RADIATION PROTECTION

11.1 RADIOACTIVE WASTES

11.1.1 DESIGN BASES

11.1.1.1 Performance Objectives

The Radioactive Waste System is designed to provide controlled handling and disposal of liquid, gaseous, and solid wastes from the Davis-Besse Nuclear Power Station. The principal design criterion is to insure that station personnel and the general public are protected against exposure to radioactive material in accordance with the regulations of 10 CFR 20.

11.1.1.2 Sources and Quantities of Radioactive Wastes

The various types of radioactive wastes to be handled are:

- a. Liquid Wastes
  - i. Clean liquid waste
  - ii. Miscellaneous liquid waste
  - iii. Detergent waste

- b. Gaseous Waste
  - i. Hydrogenated waste gases
  - ii. Aerated waste gases

- c. Solid Wastes

The major sources of clean liquid waste are bleed-off of the reactor coolant during a reduction in reactor coolant boron concentration, an increase in coolant volume due to heat-up of the reactor system, and partial replacement of reactor coolant prior to refueling.

Liquid wastes other than from the reactor coolant system are considered as detergent wastes and as miscellaneous wastes and are collected separately. The detergent wastes may contain oil and detergents.

The sources of these wastes include:

- a. Sample system drains

- b. Decontamination area drains

- c. Spent fuel storage area drains

- d. Equipment drains

- e. Low point piping drains

- f. Containment sump

- g. Auxiliary Building Sumps

h. Component cooling system drains

i. Boric acid preparation area drains

j. Laundry and hot showers

1 The sources of gaseous wastes are expected to be reactor system vents, equipment and tank vents, purging from the sampling system, the degasifier, the make-up tank, and the evaporators. There are also large quantities of displaced cover gases that may be radioactive.

The sources of solid wastes are expected to be spent demineralizer resins, filter elements and/or pre-coat material, contaminated equipment, and paper, rags, plastic sheeting, etc. used in decontamination and contamination control.

The estimated volumes of radioactive wastes generated during station operation are listed in Table 11-1.

11.1.1.3 Waste Activity

Activity accumulation in the reactor coolant system and associated waste handling equipment has been determined on the basis of fission product leakage through clad defects in 1 percent of the fuel. The activity levels were computed assuming full power operation of 2772 MWt for two core cycles with no defective fuel followed by operation over the third core cycle with 1 percent defective fuel. The pins that fail are assumed to have been in the core which operated for a 460-day first cycle and a 310-day second cycle at power of 2772 MWt with 2/3 of the power produced by U-235 and 1/3 by Pu-239.

The quantity of fission products released to the reactor coolant during steady state operation is based on the use of "escape rate coefficients" (sec^{-1}) as determined from experiments involving purposely defected fuel elements (References 1, 2, 3, 4). Values of the escape rate coefficients used in the calculations are shown in Table 11-2.

Calculations of the activity released from the fuel were performed with a digital computer code which solves the differential equations for a five-member radioactive chain for buildup in the fuel, release to the coolant, removal from the coolant by decay,purification and bleed. Continuous reactor coolant purification at a rate of one reactor system volume per day was used with a zero removal efficiency for Kr, Cs, Y, Mo, and Xe, and a 99 percent removal efficiency for all other nuclides. Activity levels are relatively insensitive to small changes in demineralizer efficiencies, e.g., use of 90 percent instead of 99 percent would result in only about 10 percent increase in the coolant activity. Removal by bleed occurs only during the first 253 days of a cycle. After this time, (when the boron concentration is below 180 PPM) deborating demineralizers are used to further reduce the boron concentration.

The activity of important fission product nuclides (except tritium) are shown in Table 11-3 at various times during the third cycle in which the core continues to operate at 2772 MWt.

Reactor coolant bleed is taken from the downstream side of the purification demineralizers. It is assumed to have the same activity concentration as the reactor coolant reduced by the decontamination factor of the purification demineralizers.

Gaseous activity is generated by the evolution of radioactive gases from the liquids as they are processed through the degasifier and to a lesser extent as they are stored in tanks throughout the station. The degasifier and these tanks are vented to the gaseous radwaste system. The activity of the gases is dependent on the liquid activity.

Since it is not practical to remove tritium from the reactor coolant and it has a half life of 12.3 years, the concentration will continue to build up during the life of the station assuming recycling of the coolant. The three significant sources of tritium are ternary fission, the boron reactions, and productions from the lithium used in the pH control agent. Thirty percent of the tritium produced by fission is conservatively assumed to diffuse through the clad. The boron concentration decreases with operating time as shown in Section 3 and the lithium is held at a constant 2ppm of 99.9% ^{7}Li and 0.1% ^{6}Li. The tritium thus produced is diluted over 39,540 ft^3, the volume of systems used to process and store reactor coolant, and the water loss is assumed to be zero during the life of the station. Table 11-4 shows the tritium concentration buildup during the first cycle and at the end of each succeeding cycle.

In actual practice tritium concentration will never reach the levels in Table 11-4 for several reasons. Only a small percentage of tritium is expected to diffuse through the zircalloy fuel element cladding. Some of the reactor coolant will be mixed with the refueling water. Finally some of the processed waste will be discharged into the discharge water system.

Radioactive Waste Quantities Table 11-1

	Waste Source	Quantity per Year	Assumptions and Comments
	Liquid Waste		
	Reactor Coolant System		
	Start-Up Expansion	96,000 gal	4 cold start-ups
	Start-Up Dilution	146,000 gal	2 cold start-ups at beginning of life, and 1 cold start-up at 100 and 200 full (ultimate) power days, respectively
		72,000 gal	2 hot start-ups at peak xenon at 100 and 200 full power days, respectively
8	Lifetime Shim Bleed	195,000 gal	Dilution from 1230 to 50 ppm boron
	System Drain (Refueling)	61,400 gal	Drain to level of outlet nozzles
	System Drain (Maintenance)	84,000 gal	Incl. drain of 1 steam generator
	Sampling and Laboratory	3,000 gal	12 samples per wk at 5 gal per sample
3	Demineralizer Sluice	4,500 gal	2 ft^3/ft^3 resin
8	Regeneration Wastes	15,000 gal	20 ft^3/ft^3 resin
	Area Washdowns	110,000 gal	5 gpm hose, 1 hr per day
	Miscellaneous System Leakage	45,000 gal	5 gph leakage
	Showers and Laundry	155,000 gal	10 showers per day at 30 gal per shower. 120 gpd laundry
	Gaseous Waste		
	Off-Gas from Reactor Coolant System	3,400 ft^3	Degas at 40 cc H_2 per liter concentration
	Off-Gas from Liquid Sampling	120 ft^3	Degas at 40 cc H_2 per liter concentration
	Off-Gas from Makeup Tank	900 ft^3	Vent once per year
	Off-Gas from Pressurizer	60 ft^3	Vent once per year

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324

Waste Source	Quantity per Year	Assumptions and Comments	
Solid Waste			
Demineralizer Resin	300 ft^3	Resin replacement once per year	1
Miscellaneous (filter Elements, Clothing, Rags, Etc.)	900 ft^3	1-1/2 55-gal drum per week plus 300 ft^3 per refueling period	

Table 11-2

Escape Rate Coefficients for Fission Product Release

Element	Escape Rate Coefficient, sec^{-1}
Xe	1.0×10^{-7}
Kr	1.0×10^{-7}
I	2.0×10^{-8}
Br	2.0×10^{-8}
Cs	2.0×10^{-8}
Rb	2.0×10^{-8}
Mo	4.0×10^{-9}
Te	4.0×10^{-9}
Sr	2.0×10^{-10}
Ba	2.0×10^{-10}
Zr	1.0×10^{-11}
Ce and Other Rare Earths	1.0×10^{-11}

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TABLE 11-3

REACTOR COOLANT ACTIVITY, μc/ml
BASED ON 1% DEFECTIVE FUEL

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Isotope	Half-Life	Third Cycle Operating Time, effective full power days 50	100	150	200	253	275	310
Kr 85m	4.36 h	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Kr 85	10.57 y	7.1	10.7	11.9	10.7	7.7	8.6	10.0
Kr 87	78 m	.94	.94	.94	.94	.94	.94	.94
Kr 88	2.77 h	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Rb 88	17.8 m	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Sr 89	53 d	.041	.044	.044	.045	.045	.045	.045
Sr 90	28 y	.0031	.0033	.0035	.0037	.0039	.0039	.0041
Sr 91	9.7 h	.052	.052	.052	.052	.052	.052	.052
Sr 92	2.6 h	.019	.019	.019	.019	.019	.019	.019
Y 90	64.8 h	.13	.29	.46	.64	.83	.91	1.05
Y 91	58.3 d	.12	.18	.19	.21	.17	.21	.25
Mo99	68 h	6.0	5.9	5.9	5.9	5.8	6.0	6.0
Xe 131m	12 d	2.1	2.5	2.5	2.4	2.2	2.5	2.7
Xe 133m	2.3 d	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Xe 133	5.27 d	270.	270.	270.	270.	259.	280.	280.
Xe 135m	15.6 m	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Xe 135	9.2 h	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Xe 138	17 m	.57	.57	.57	.57	.57	.57	.57
I 131	8 d	3.6	3.6	3.6	3.6	3.6	3.6	3.6
I 132	2.4 h	5.4	5.4	5.4	5.4	5.4	5.4	5.4
I 133	20.8 h	4.2	4.2	4.2	4.2	4.2	4.2	4.2
I 134	52.5 m	.56	.56	.56	.56	.56	.56	.56
I 135	6.68 h	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Cs 136	12.9 d	.72	.82	.82	.80	.73	.85	.90
Cs 137	27 y	16.	29.	37.	40.	35.	41.	53.
Cs 138	32.9 m	.82	.82	.82	.82	.82	.82	.82
Ba 137 m	2.6 m	15.	27.	35.	37.	31.	38.	47.
Ba 139	85 m	.091	.091	.091	.091	.091	.091	.091
Ba 140	12.8 d	.070	.073	.073	.073	.073	.073	.073
La 140	40.5 h	.024	.024	.024	.024	.024	.024	.024
Ce 144	290 d	.0029	.0029	.0030	.0030	.0031	.0031	.0031

Table 11-4

Tritium Activity in Reactor Coolant with Bleed Recycled
Initial Cycle (433d)

	Time (days)	Ternary Fission uc/ml	Boron Activation uc/ml	2 ppm Li uc/ml	Total uc/ml
	1	.009	.0009	.0002	.01
	10	.09	.009	.002	.10
	50	.42	.04	.02	.48
8	100	.84	.08	.03	.95
	200	1.65	.14	.05	1.84
	300	2.46	.18	.07	2.71
	400	3.24	.20	.09	3.53
	433	3.51	.21	.10	3.82

Equilibrium Cycle (292d)

	End of Cycle #	Ternary Fission uc/ml	Boron Activation uc/ml	2 ppm Li uc/ml	Total uc/ml
	1	3.51	.21	.10	3.82
	2	5.4	.30	.16	5.86
	5	9.9	.53	.30	10.73
8	10	15.0	.79	.45	16.24
	20	21.3	1.1	.63	23.03
	30	24.6	1.3	.73	26.63
	40	26.7	1.4	.79	28.89

0328

11.1.1.4 Methods of Disposal

Four methods are defined in the treatment of the radioactive wastes.

a. The clean liquid wastes consist of liquids such as reactor coolant and fuel pool coolant, which are relatively low in chemical impurities and suspended solids content. Processing consists of degassing, storing, filtering, demineralizing and evaporating. The end products, concentrated boric acid and demineralized water, are normally stored for later reuse in the reactor cycle.

b. The dirty liquid wastes consist of liquids of largely varying types and origins such as radioactive laboratory drains, building sumps, and decontamination drains. These liquids are relatively high in chemical impurities and suspended solids content but low in radioactivity. Normal processing consists of storage and filtration, and, if necessary, evaporation. The end products are normally discharged from the plant, but the evaporator distillate may be reused. 1

c. The gaseous wastes consist of the discharges from all potentially radioactive systems. Processing consists of compression into decay tanks, retention for a period of 30-60 days, release through high efficiency filters, and discharge to the atmosphere through the station vent. 1

d. The solid wastes consist of all potentially radioactive solids wastes such as demineralizer resins, spent filter elements, clothing and rags. Processing consists of storage and packaging, as appropriate, for later off-site disposal.

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11.1.2 SYSTEM DESCRIPTION AND OPERATION

11.1.2.1 Liquid Waste System

The flow diagram of the Clean Liquid Radioactive Waste System is shown in Figure 11-1. The major source of clean liquid waste is the reactor coolant letdown that occurs during plant startups and dilution operations. Minor sources include leakoff, drain, and relief flows from valves and equipment inside the containment which contain reactor coolant. These smaller quantities are accumulated in the reactor coolant drain tank before processing.

Hydrogenated liquid wastes pumped from the reactor coolant drain tank and re-
leased from the makeup and purification system are sprayed into the
1 degasifier. The dissolved hydrogen and fission gases flash out of solution
and are sent to the Waste Gas Disposal System. The degasifier pump operation
is controlled automatically by a signal from a level controller. Pressure
and level instrumentation with alarms are provided on the degasifier to
inform the operator of any malfunction.

The liquid is pumped from the degasifier through a filter and a boron saturated
3 mixed bed ion exchange demineralizer to one of the two clean waste receiver
tanks. A nitrogen blanket in the tanks is automatically maintained above
atmospheric pressure to prevent air in-leakage. This cover gas is released
to a waste gas collection header or into the other receiver tank when it
is displaced. No flashing occurs in these tanks, and any transfer
1 of hydrogen or fission gases from the liquid to the cover gas is by the slow
process of molecular diffusion. The wastes are then fed to an evaporator
where they are separated into their two reusable constituents: demineralized
water and concentrated boric acid. The distillate is passed through a
2 polishing demineralizer into one of two clean waste monitor tanks. From
here it is reused, recycled, or discharged. The concentrated boric acid is
sent to a concentrate storage tank from which it is taken to boric acid
storage for reuse, or routed to the miscellaneous liquid waste system for
further concentration prior to disposal.

At several points in this cycle, alternate flow paths are provided. These allow for the recirculation through, or the bypassing of, a demineralizer or evaporator. This flexibility, along with sampling at various stages in the cycle, permits the operator several options in insuring the adequate processing of the waste.

Near the end of core life, the coolant, instead of being processed by an evaporator, is diverted through a deborating demineralizer. Normally the flow is then directed back to the make-up tank but the option exists to pass it through part, or all, of the Clean Liquid Radwaste System.

A flow diagram of the Miscellaneous Liquid Radioactive Waste System is shown
in Figure 11.2. The major sources for this system are showers, laundry, area
washdowns, boric acid being disposed of, and any regeneration wastes. These,
1 depending on their composition, are collected in either the miscellaneous
or detergent waste drain tanks. The contents of these are then monitored
and may be released through filters directly to the discharge water
8 system. If further processing is required, the wastes are fed to an evaporator

and concentrated to 25% solids by weight. Neutralization of the evaporator
feed may be necessary in order to obtain this high concentration level. The
distillate goes to the miscellaneous waste monitor tank where a final check 1
on activity is made before storage for reuse or release to the discharge
water system. The evaporator bottoms are transferred to a concentrate 8
tank where they are stored prior to drumming for off-site disposal.

Before any liquid is released from a waste tank to the discharge water 8
system, a sample is taken and its level of activity is determined. If it does not meet established limits, it is recycled until it does. A final check is made on the waste as it is discharged through an in-line radiation monitor. If its activity exceeds preset values, an alarm is annunciated and isolation valves automatically shut off the discharge. Some mode of recycling is then necessitated. A record will be kept of both the amount and level of activity of all discharged effluent.

The valves in the inlet line to a waste tank are closed whenever the
tank is being discharged so that filling and discharging to the discharge 8
water system cannot be done simultaneously. This insures batch processing.

11.1.2.2 Gaseous Waste System

The Gaseous Waste System processes potentially radioactive hydrogenated and aerated waste gases. A diagram of the system is shown in Figure 11-3.

Sources of hydrogenated, radioactive waste gas include the reactor coolant drain tank, degasifier, the make-up tank and the quench tank.

Hydrogen and fission gases stripped in the degasifier and vented from other
tanks flow to the waste gas header and then to the waste gas surge tank. A 5
nitrogen blanket in this tank automatically maintains a slight positive
pressure in the system. The gases are then compressed into one of three 1
decay tanks, which are sized for 30-60 days holdup. A sample is removed from the tank and its activity level determined. If it is sufficiently low, the gases are discharged to the vent through a HEPA filter. If it is high, the gases are allowed to decay until future sampling shows that they are suitable for controlled release to the atmosphere.

The nitrogen cover gas displaced from the receiver tanks is also handled
by this system. Since it should have little activity, an effort is made to
keep it separate from the hydrogen and fission gases. This is done by
forming one of the compressors and tanks into a separate processing chain. 1
The cover gas that has been compressed can be reused or vented after 5
sampling. Should any significant contamination occur, then it must be
processed similarly to the normal hydrogenated waste. If only one compressor 1
is available at any time, all gases will be collected at a common header.

All released gases must pass a radiation monitoring system and if their activity exceeds a set point, an alarm is annunciated and the isolation valves in the discharge line will automatically close.

Aerated radioactive waste gases from the miscellaneous and detergent waste
drain tanks will be processed separately from the hydrogenated waste gases 5
to prevent the possibility of explosive mixtures. These low level gases are
simply collected and released to the vent.

11.1.2.3 Solid Waste System

Solid wastes are placed in ICC-approved containers appropriate for the waste material. Loaded containers are monitored for radiation levels and stored in a special area prior to shipment to an off-site disposal facility. Radioactive spent resins sluiced from demineralizers are collected and stored in the spent resin tank until a quantity sufficient for disposal is accumulated. The tank is sized for at least a one-year accumulation and is arranged with pumpout connections for resin transfer to a shipping cask for disposal. All soft solid wastes, such as contaminated clothing, rags, wiping towels, paper, gloves, and shoe coverings will be compressed into the containers by a baler. Hard solids such as wood, metal, glass, plastics, concrete and ceramics will be put into the containers without compressing. Items too large for the containers will be stored, packaged and disposed of as appropriate.

11.1.3 DESIGN EVALUATION

The possibility of an accidental release of activity from the radwaste system is minimized by reuse of much of the liquid wastes. Liquid and stored gaseous wastes are sampled prior to discharge to the environment.

Solid wastes are disposed of by licensed contractors in accordance with ICC regulations.

All liquid radioactive wastes flow to storage tanks prior to discharge to the environment and cannot be discharged to the environment by gravity (i.e., the effluent must be pumped out). All actuator operated valves which control the discharge of radioactive material into the environment fail in the closed position on loss of actuating force or signal.

Radioactive gases are continuously monitored during discharge in compliance with requirements of 10 CFR 20.

Standby units (pumps, ion exchangers, and compressors) permit continuous processing in the event of equipment failures or routine maintenance.

11.1.4 TESTS AND INSPECTIONS

Functional operational tests and inspections of the radioactive waste system will be made as required to insure performance consistent with the requirements of 10 CFR 20. Routine surveillance will be conducted for detection of system leaks. Radiation detectors and monitors will be periodically checked for calibration. Alarm circuits and automatic features of flow diversion for waste liquid and gaseous effluents will be periodically tested.

Each component is inspected and cleaned prior to installation into the system. Demineralized water is used to flush all portions of the system. Preoperational tests include calibration of instruments, testing of automatic controls, and verification of alarm set points. All flow paths are checked for capacity and mechanical operability. All pumps are run to demonstrate head and capacity.

11.1.5 CODES

The water processing system components are designed and fabricated in accordance with the following codes and standards:

a. Tanks (including demineralizers)

Tanks conform to Section VIII of the ASME Boiler and Pressure Vessel Code.

All wetted surfaces are fabricated of a corrosion resistant material.

b. Pumps

Pumps conform to the standards of the Hydraulic Institute and all wetted surfaces are fabricated of a corrosion resistant material.

Pump motors conform to standards of NEMA, IEEE, and USASI.

c. Piping and Valves

Piping and valves conform to code requirements for pressure piping. All pipes carrying radioactive waste are USASI B31.7, Class III piping. Piping systems, where required, are fabricated of corrosion resistant material.

11.2 RADIATION PROTECTION

11.2.1 RADIATION ZONING AND ACCESS CONTROL

The following list identifies the different zones used for the Davis-Besse Nuclear Power Station.

Designation	Design Dose Rate (mRem/h on a 40 h/week basis)	Description
A	≤ 0.5	Uncontrolled, unlimited access
B	≤ 2.5	Controlled, unlimited access. 40 h/week
C	≤ 15	Controlled, limited access for routine tasks
D	< 100	Controlled, limited access for short periods 2
E	> 100	Controlled occupancy for very short periods. Occupancy during emergencies. 1 Normally inaccessible. 2

0333

UNCONTROLLED areas are those that can be occupied by plant personnel or visitors on an unlimited time basis with a minimum probability of health hazard from radiation exposure.

CONTROLLED areas are those where higher radiation levels and/or radioactive contamination which have a greater probability of radiation health hazard to individuals can be expected. These areas can be entered only by individuals who have passed through the plant access control station. Normally, only individuals directly involved in the operation of the plant will be allowed to enter these areas.

LIMITED ACCESS areas are those that have radiation levels of less than 100 mrem/h and which can be entered either through open passages or unlocked doors. These areas are identified by radiation caution signs at strategic locations.

INACCESSIBLE areas are those where dose rates above 100 mrem/h can be expected. These areas are either blocked off completely or can be entered only through locked doors. Access is supervised from the access control station and the station control room.

In case of emergency, personnel will be able to use escape routes which involve the minimum exit time.

11.2.2 RADIATION SHIELDING

11.2.2.1 Design Bases

The basis for the shielding design for normal plant operation is the "Code of Federal Regulations," Title 10, Chapter 1, Part 20, entitled "Standards for Protection Against Radiation."

All areas of the plant are subject to these regulations. The areas are zoned according to their expected occupancy by plant personnel and radiation exposure levels under normal operating conditions.

The maximum whole body exposure for station personnel is 1.25 rem per calendar quarter. For the general public, the maximum dose is not more than 0.5 rem for one calendar year.

No individual will receive more than 25 rem of whole body exposure during the course of any accident, in accordance with 10 CFR 100. The control room is designed to limit whole body exposure to 5 rem during the course of the MHA. This provides an allowance for excursions into other areas of the station to attend to critical equipment.

11.2.2.1.1 Radiation Exposure of Materials and Components

No regulations similar to those established for the protection of individuals exist for materials and components. Materials are selected on the basis that radiation exposure will not cause significant changes in their physical properties which adversely affect their operation during the design life of the plant. Materials for equipment required to operate under accident conditions are selected on the basis of the additional exposure received.

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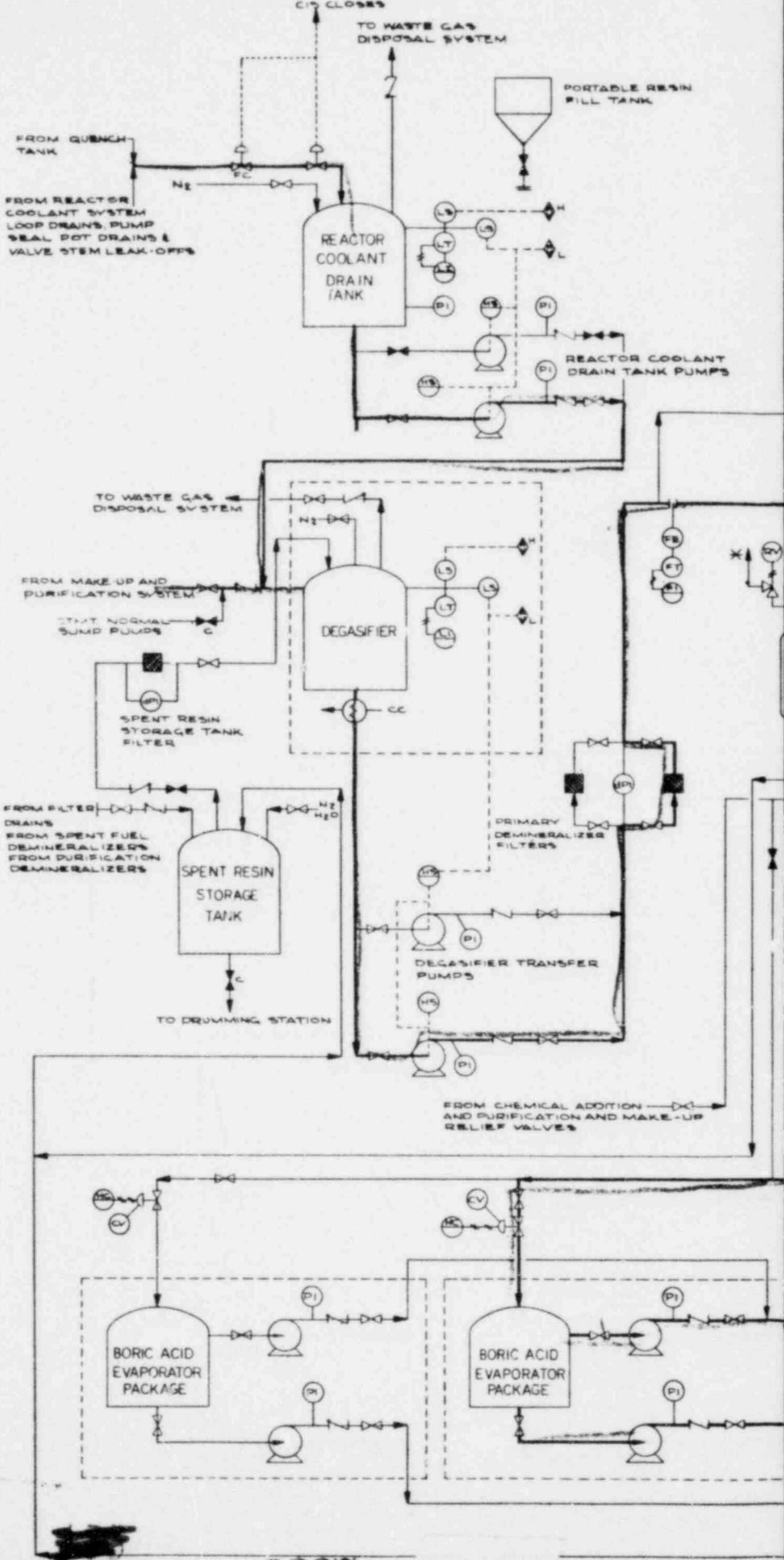
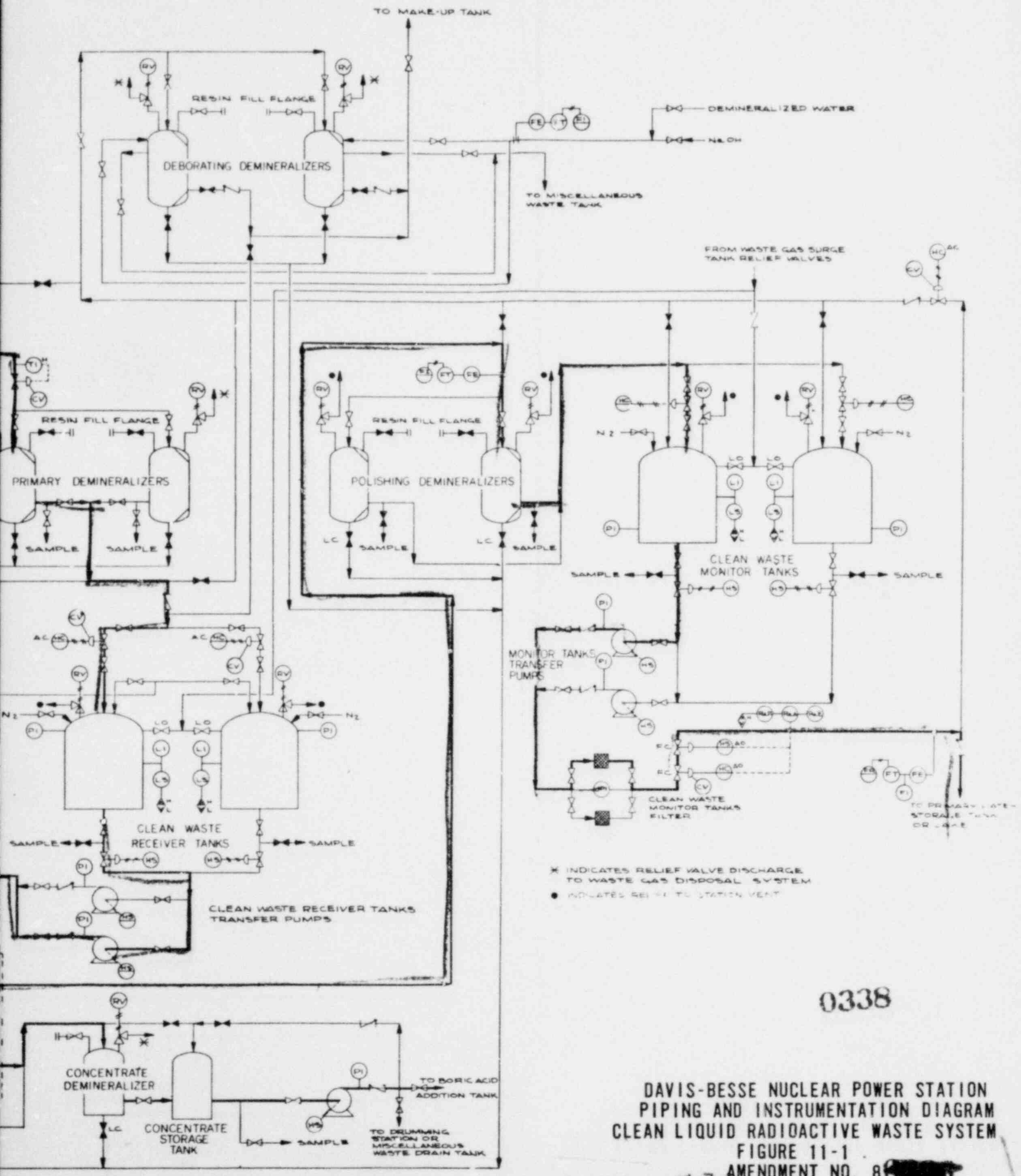

CIS CLOSES
TO WASTE GAS DISPOSAL SYSTEM
PORTABLE RESIN FILL TANK
FROM QUENCH TANK
FC
N2
FROM REACTOR COOLANT SYSTEM LOOP DRAINS, PUMP SEAL POT DRAINS & VALVE STEM LEAK-OFFS
REACTOR COOLANT DRAIN TANK
LS
LT
LI
PI
HS
H
L
REACTOR COOLANT DRAIN TANK PUMPS
TO WASTE GAS DISPOSAL SYSTEM
N2
FROM MAKE-UP AND PURIFICATION SYSTEM
CTMT. NORMAL SUMP PUMPS
C
DEGASIFIER
CC
SPENT RESIN STORAGE TANK FILTER
DPI
FB
FT
FI
RV
PRIMARY DEMINERALIZER FILTERS
FROM FILTER DRAINS
FROM SPENT FUEL DEMINERALIZERS
FROM PURIFICATION DEMINERALIZERS
N2
H2O
SPENT RESIN STORAGE TANK
TO DRUMMING STATION
DEGASIFIER TRANSFER PUMPS
FROM CHEMICAL ADDITION AND PURIFICATION AND MAKE-UP RELIEF VALVES
CV
HC
BORIC ACID EVAPORATOR PACKAGE
BORIC ACID EVAPORATOR PACKAGE



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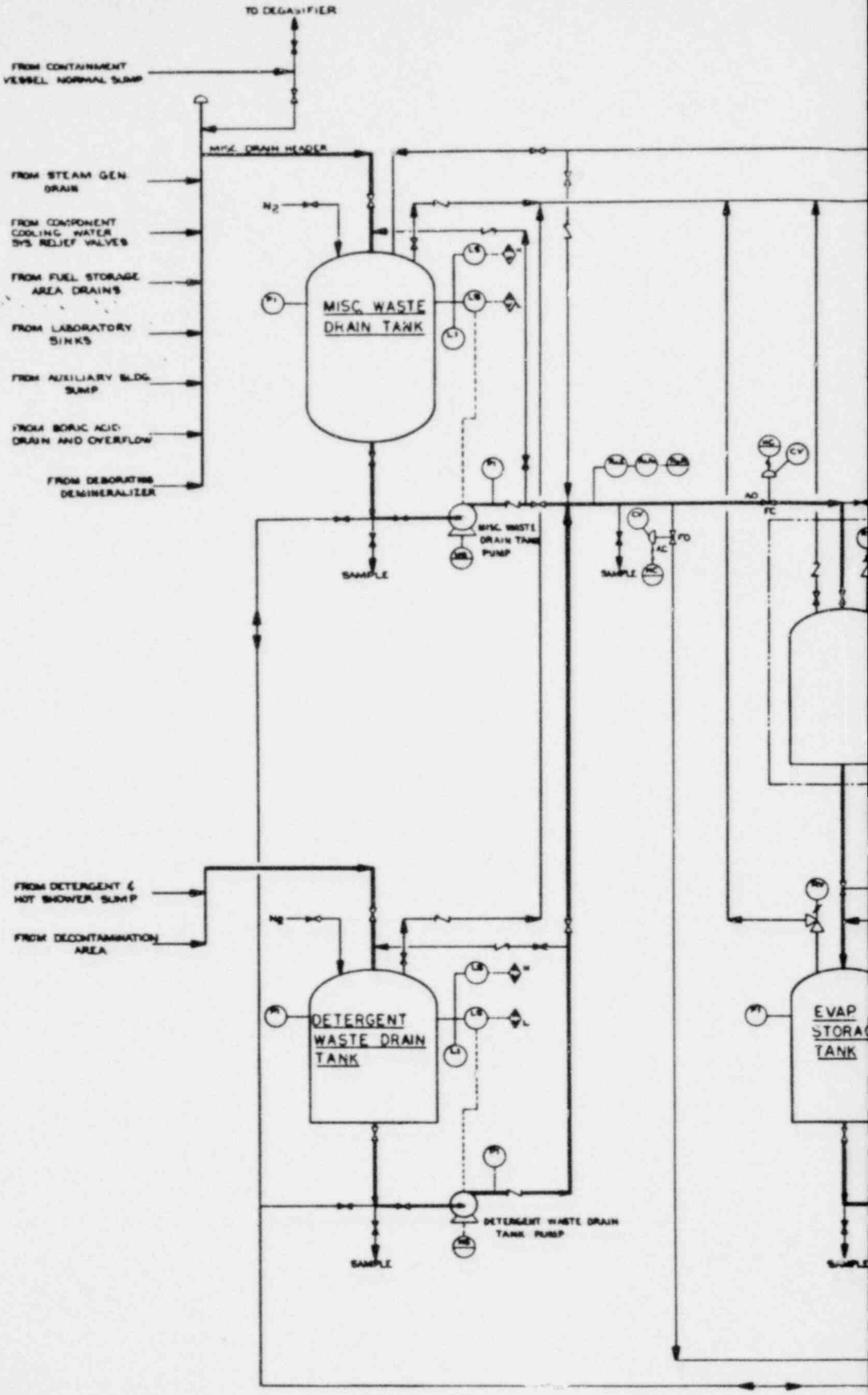
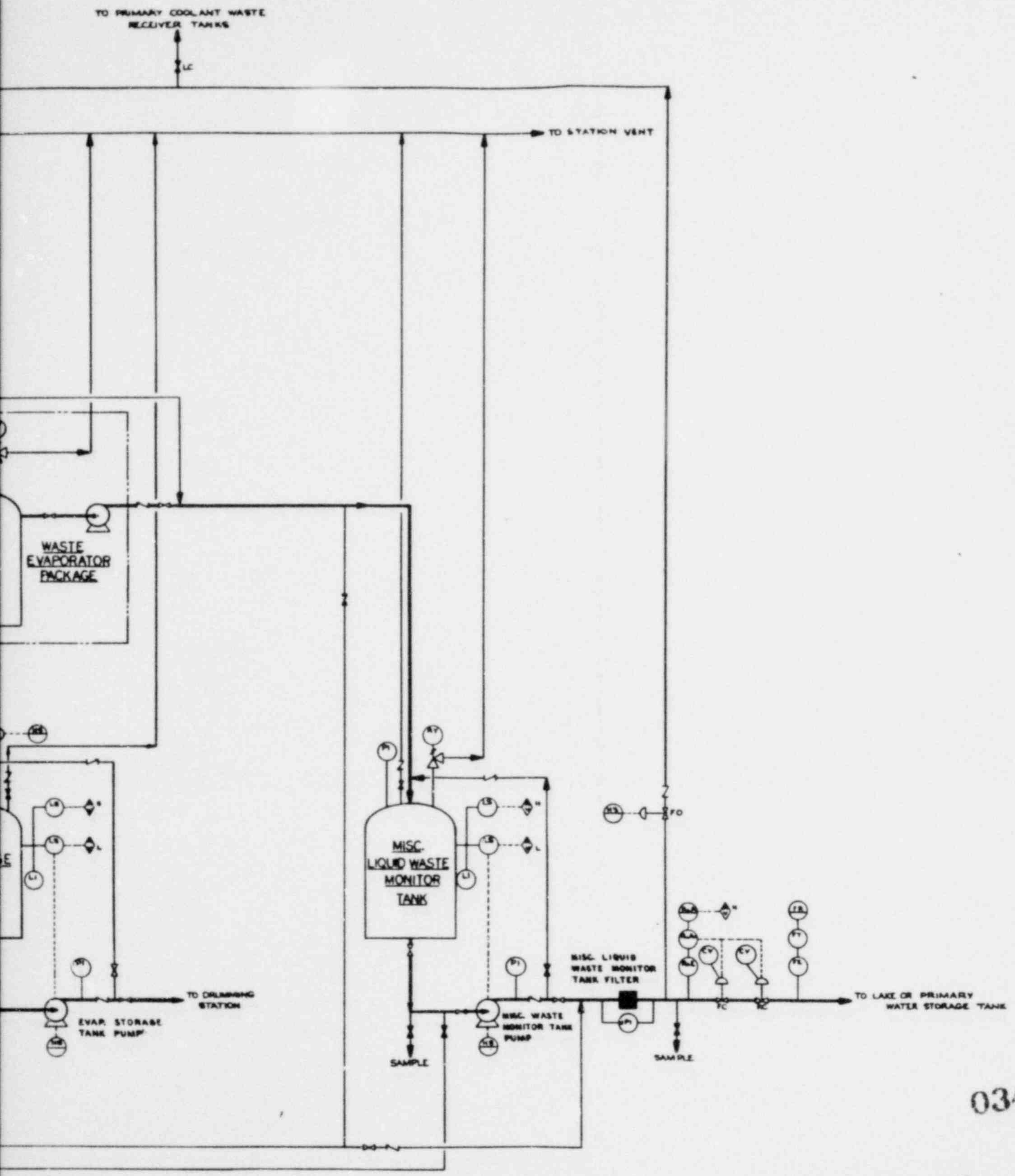
DAVIS-BESSE NUCLEAR POWER STATION
PIPING AND INSTRUMENTATION DIAGRAM
CLEAN LIQUID RADIOACTIVE WASTE SYSTEM
FIGURE 11-1
AMENDMENT NO. 8[redacted]


TO DEGASIFIER
FROM CONTAINMENT VESSEL NORMAL SUMP
MISC. DRAIN HEADER
FROM STEAM GEN. DRAIN
FROM COMPONENT COOLING WATER SYS RELIEF VALVES
FROM FUEL STORAGE AREA DRAINS
FROM LABORATORY SINKS
FROM AUXILIARY BLDG. SUMP
FROM BORIC ACID DRAIN AND OVERFLOW
FROM DEBORATING DEMINERALIZER
N_2
MISC. WASTE DRAIN TANK
LI
CV
AO
FC
FO
AC
MISC. WASTE DRAIN TANK PUMP
SAMPLE
SAMPLE
FROM DETERGENT & HOT SHOWER SUMP
FROM DECONTAMINATION AREA
N_2
DETERGENT WASTE DRAIN TANK
LI
DETERGENT WASTE DRAIN TANK PUMP
SAMPLE
EVAP STORAG
TANK
SAMPLE

0339



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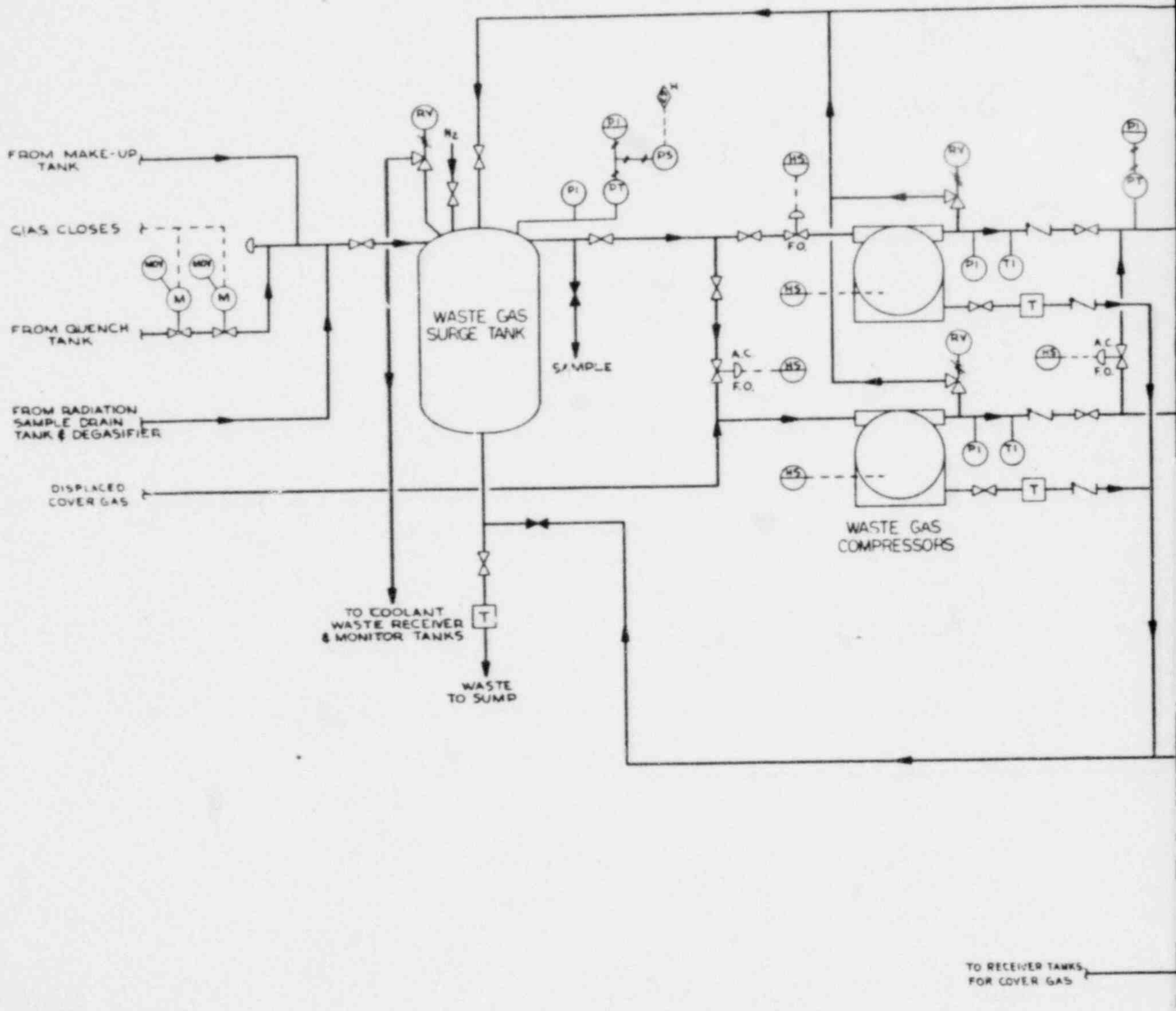
ISSUED FOR PSAR AMEND.#3
ISSUED FOR PSAR AMEND.#2 2-11-70
ISSUED FOR PSAR AMEND.#1 12-9-69

DAVIS-BESSE NUCLEAR POWER STATION
MISCELLANEOUS LIQUID
RADIOACTIVE WASTE SYSTEM

FIGURE II-2
AMENDMENT NO. 3



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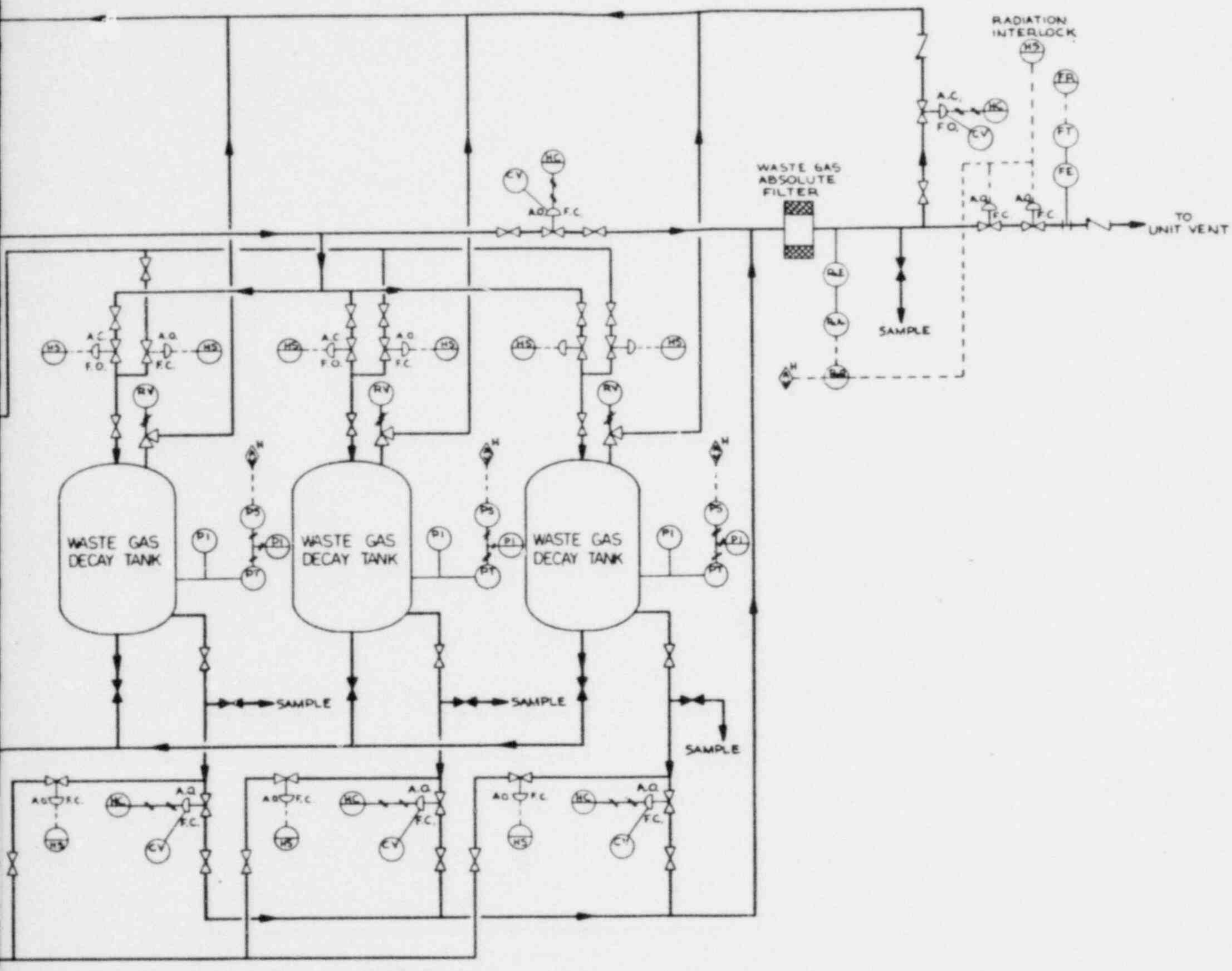
[redacted]



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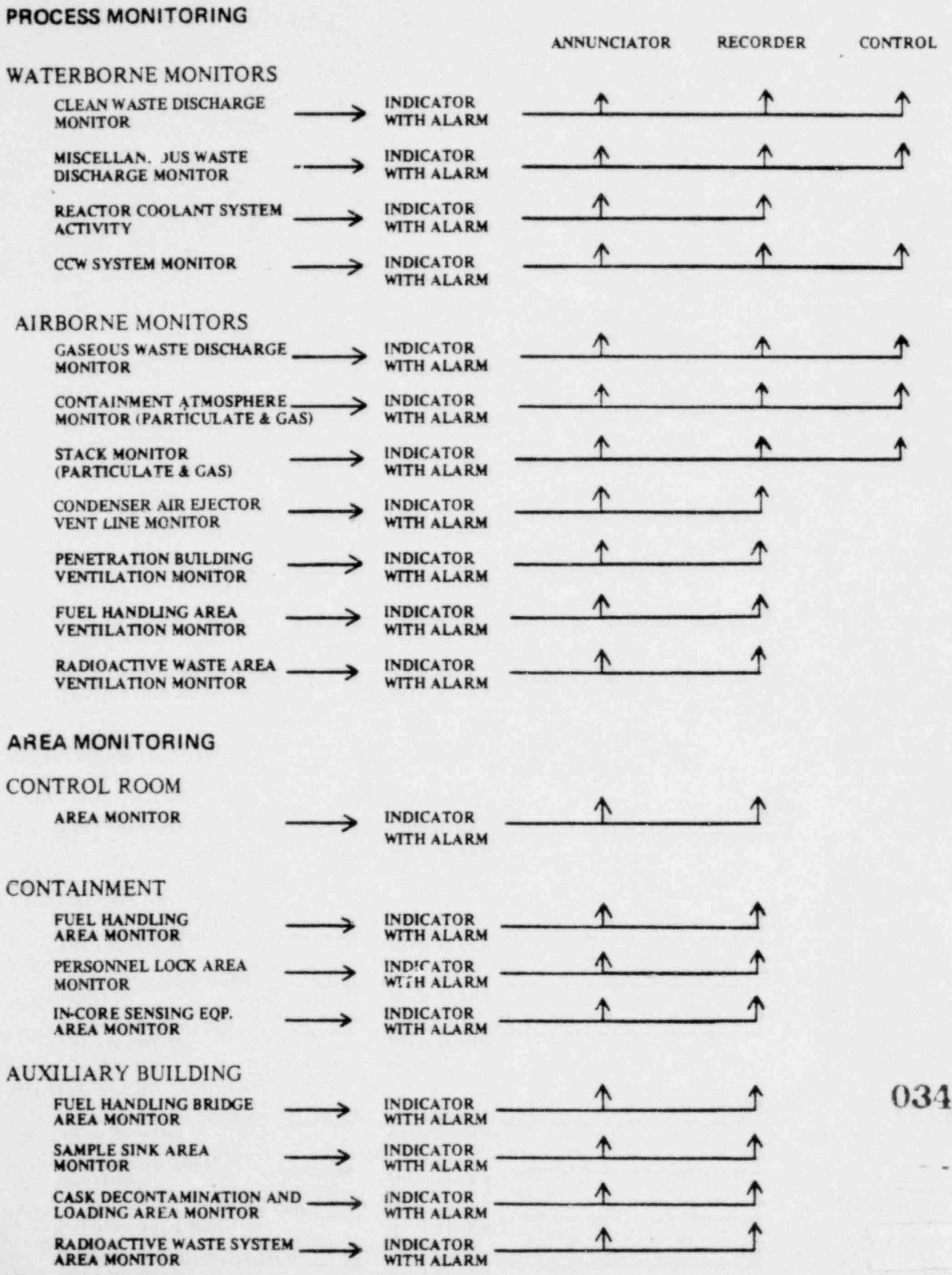
DAVIS-BESSE NUCLEAR POWER STATION
WASTE GAS SYSTEM
FIGURE 11-3
AMENDMENT NO. 3



PROCESS MONITORING

WATERBORNE MONITORS

		ANNUNCIATOR	RECORDER	CONTROL
CLEAN WASTE DISCHARGE MONITOR	→ INDICATOR WITH ALARM	↑	↑	↑
MISCELLANEOUS WASTE DISCHARGE MONITOR	→ INDICATOR WITH ALARM	↑	↑	↑
REACTOR COOLANT SYSTEM ACTIVITY	→ INDICATOR WITH ALARM	↑	↑	
CCW SYSTEM MONITOR	→ INDICATOR WITH ALARM	↑	↑	↑

AIRBORNE MONITORS

		ANNUNCIATOR	RECORDER	CONTROL
GASEOUS WASTE DISCHARGE MONITOR	→ INDICATOR WITH ALARM	↑	↑	↑
CONTAINMENT ATMOSPHERE MONITOR (PARTICULATE & GAS)	→ INDICATOR WITH ALARM	↑	↑	↑
STACK MONITOR (PARTICULATE & GAS)	→ INDICATOR WITH ALARM	↑	↑	↑
CONDENSER AIR EJECTOR VENT LINE MONITOR	→ INDICATOR WITH ALARM	↑	↑	
PENETRATION BUILDING VENTILATION MONITOR	→ INDICATOR WITH ALARM	↑	↑	
FUEL HANDLING AREA VENTILATION MONITOR	→ INDICATOR WITH ALARM	↑	↑	
RADIOACTIVE WASTE AREA VENTILATION MONITOR	→ INDICATOR WITH ALARM	↑	↑	

AREA MONITORING

CONTROL ROOM

		ANNUNCIATOR	RECORDER	CONTROL
AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	

CONTAINMENT

		ANNUNCIATOR	RECORDER	CONTROL
FUEL HANDLING AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	
PERSONNEL LOCK AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	
IN-CORE SENSING EQP. AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	

AUXILIARY BUILDING

		ANNUNCIATOR	RECORDER	CONTROL
FUEL HANDLING BRIDGE AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	
SAMPLE SINK AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	
CASK DECONTAMINATION AND LOADING AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	
RADIOACTIVE WASTE SYSTEM AREA MONITOR	→ INDICATOR WITH ALARM	↑	↑	

0343

DAVIS-BESSE NUCLEAR POWER STATION
PROCESS MONITORING
FIGURE 11-4
AMENDMENT NO. 6

11.2.2.1.2 General Design Considerations

The shielding design considers three conditions:

1. Full core power operation at 2772 MWt. This also includes shielding requirements for certain off-normal conditions such as the release of fission products from leaking fuel elements.

2. Shutdown. This condition deals mainly with the radioactivity from the subcritical reactor core, with radiation from spent fuel bundles during on-site transfer, and with the residual activity in the reactor coolant system and neutron-activated materials.

3. A hypothetical accident in which 100% of the noble gases, 50% of the halogens and 1% of the other fission products are released from the reactor core (TID 14844).

11.2.2.1.3 Specific Design Values

The material used for most of the station shield is ordinary concrete and concrete block with a bulk density of about 143 lb/ft^3. Only in a very few instances will steel or water be utilized as primary shielding materials.

11.2.2.2 General Descriptions and Evaluations

11.2.2.2.1 Shield Building

The shield building serves two main shielding purposes:

1. During operation, it shields the surrounding station structures and yard areas from radiation originating at the reactor vessel and the primary loop components. Together with additional shielding in the interior and in the walls of the containment vessel, the concrete shell will reduce radiation levels outside the shell to below 0.5 mrem/h in uncontrolled areas.

2. In the event of an accident, the shielding will reduce station and off-site radiation intensities, emitted directly from released fission products, to acceptable emergency levels. The concrete roof of the shield building will effectively reduce contributions due to sky shine.

11.2.2.2.2 Containment Vessel Interior

During operation, most areas inside the containment vessel are inaccessible because of dose rates greater than 100 mrem/h and contamination of the atmosphere by activation and/or fission products. The reactor vessel, which is the major radiation source, is surrounded by a heavy concrete biological shield. A concrete shield also surrounds equipment that carries reactor coolant water.

Inside the containment vessel, shielding is provided around the reactor internals storage pool. This shielding is designed for personnel protection during storage of activated reactor internals and for protection during transfer of spent fuel elements to the transfer tube.

11.2.2.2.3 Auxiliary Building

All radioactive areas can be reached through service corridors which will be entered from the access control station. For normal equipment operation, none of the high radiation areas need to be occupied since all manually operated valves of contaminated equipment will have reach rods which penetrate through the shield walls into the corridor or will have remote manual operators. Gages and other instruments which need visual checking from time to time can be inspected from the corridors or on the local or central control boards. The different systems are isolated from each other by individually shielded chambers. Systems can be isolated for maintenance or repair with no significant radiation interference from other systems.

Heavy concrete shielding is provided around the waste gas decay tanks wherever they are adjacent to access areas.

The counting room has been shielded in order to reduce background radiation as much as possible. For the room containing the ventilation system, concrete block is used to shield against radiation from the ventilation filters.

The relative closeness of fully accessible and uncontrolled areas requires especially heavy shielding for the area surrounding the spent fuel pool.

The control room has concrete shielding for those sides which are in direct line of sight with the shield building. The integrated whole body gamma dose inside the control room will be less than 5 rem over a period of 30 days following an MHA.

11.2.2.2.4 Turbine Building

The turbine building is fully accessible and uncontrolled with dose rates much less than 0.5 mrem/h during normal plant operation as well as during shutdown.

In the event of an MHA, access to the turbine building is controlled.

11.2.2.2.5 General Plant Yard Areas

The radiation shielding design of the shield building and auxiliary buildings protects all plant yard areas from excessive radiation exposure. All yard areas which are frequently occupied by plant personnel receive a radiation field of less than 0.5 mrem/h.

11.2.3 RADIATION MONITORING SYSTEM

11.2.3.1 Design Basis

The radiation monitoring system is designed to:

1. Continuously detect and record the level of radiation in the plant effluents released to the environment.

2. Provide operating personnel with a continuous indication and records of the gamma radiation levels in selected plant areas.

3. Protect operating personnel from exposure to excessive radiation levels or radioactive concentrations by alarm annunciation and in some cases automatic action of protective equipment in the event that such limits are exceeded.

To fulfill these design criteria the radiation monitoring system consists of interrelated subsystems as described in Figure 11.4. These are identified as the Airborne Radiation Monitoring System, Waterborne Radiation Monitoring System and Area Radiation Monitoring System.

11.2.3.2 Airborne Radiation Monitoring System

11.2.3.2.1 Stack Gas Monitors

A continuous sample is drawn from the stack via an isokinetic sample probe and activity is monitored by a beta-gamma air particulate monitor consisting of a detector and removable filter paper assembly and a gas gamma monitor. The sample is then returned to be discharged through the stack. Radioactivity is indicated and recorded in the main control room. An alarm is initiated upon the detection of activity above the specified limit and closure of the containment ventilation valves is initiated.

11.2.3.2.2 Containment Vessel Monitors

A continuous air sample is drawn from the containment vessel by an air particulate monitor consisting of a beta-gamma detector, removable filter paper assembly and a gas gamma monitor. Radioactivity is indicated and recorded in the main control room and an alarm and closure of the containment purge valves is initiated upon the detection of activity above the specified limit.

11.2.3.2.3 Waste Gas Monitor

This system consists of an off-line monitor which uses a gamma detector. The system continually indicates and records radioactivity in the gas and initiates an alarm in the control room if the specified activity level is exceeded. The system automatically closes the waste discharge header valve if an alarm situation does occur.

11.2.3.2.4 Condenser Air Ejector Monitor

The air ejector vents the non-condensable gases from the condenser to the stack. An off-gas monitoring system continuously monitors for the presence of radioactivity in the non-condensable gases which would indicate a primary to secondary leak in the steam generators. The sampler will be located in the air ejector vent line and consists of an off-line beta-gamma detector which will indicate and record in the main control room. An alarm will be initiated in the event that the radioactivity in the non-condensable gases exceeds a preset limit.

11.2.3.2.5 Ventilation Systems Monitors

The fuel handling, radwaste and penetration areas are ventilated. Each is equipped with a ventilation radiation monitoring system which records the activity levels in the vent ducts from each area and actuates an alarm in the control room when the activity levels reach a preset level.

11.2.3.3 Waterborne Radiation Monitoring Systems

11.2.3.3.1 Radwaste Liquid Monitoring System

The radwaste liquid monitor initiates an alarm and terminates the release of radwaste effluent when the activity level in the liquid effluent exceed a preset limit. An in-line monitor is placed on the waste discharge line. In the case of abnormally high radiation, the waste discharge valve will be closed.

11.2.3.3.2 Component Cooling Water System Monitors

This system has two beta-gamma monitors in the inlet lines to the CCWS pumps. Should the radioactivity level in the system rise above a preset limit, the atmospheric vent valve of the head tank is automatically closed. The system will then operate unvented with relief to the radioactive waste system for overpressure protection.

11.2.3.3.3 Reactor Coolant System Activity Monitor

This monitor will detect gross increases in the activity of the reactor coolant. It will measure activity in the letdown flow from the reactor coolant system into the makeup and purification system.

11.2.3.4 Area Radiation Monitoring System

This system consists of beta-gamma detectors placed at appropriate locations in the following areas:

a. One detector near the fuel handling bridge inside the containment.

b. Inside containment near the personnel access hatch.

c. Inside containment near in-core monitoring equipment.

d. Near fuel handling bridge in auxiliary building.

e. Auxiliary building near sample sink.

f. Auxiliary building cask decontamination and loading area.

g. Control room.

h. Radioactive waste system area.

i. Selected areas to be determined later, i.e., passageway, etc.

Readout for each detector will be provided in the control room. High radiation alarm signals for each detector will be furnished to the control room and to each detector location. Sources will be available to allow the overall system performance to be verified at regular intervals. Detector ranges will be determined depending upon the normal background at the detector locations and the expected radiation levels for abnormal conditions.

The multichannel area radiation monitoring system monitors the radiation intensity of areas in the plant where it is possible for operating personnel to be subject to abnormally high gamma radiation. The selection and number of points are coordinated with the plant access control so that operating personnel are not able to enter an unmonitored area in which they could be exposed to an excessive dose.

11.3 REFERENCES

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(2) Eichenberg, J. D., et al, Effects of Irradiation on Bulk UO_2, WAPD-183, October, 1957.

(3) Allison, G. M. and Robertson, R. F. S., The Behavior of Fission Products in Pressurized-Water Systems. A Review of Defect Tests on UO_2 Fuel Elements at Chalk River, AECL-1338, 1961.

(4) Allison, G. M. and Roe, H. K., The Release of Fission Gases & Iodines From Defected UO_2 Fuel Elements of Different Lengths, AECL-2206, June, 1965.