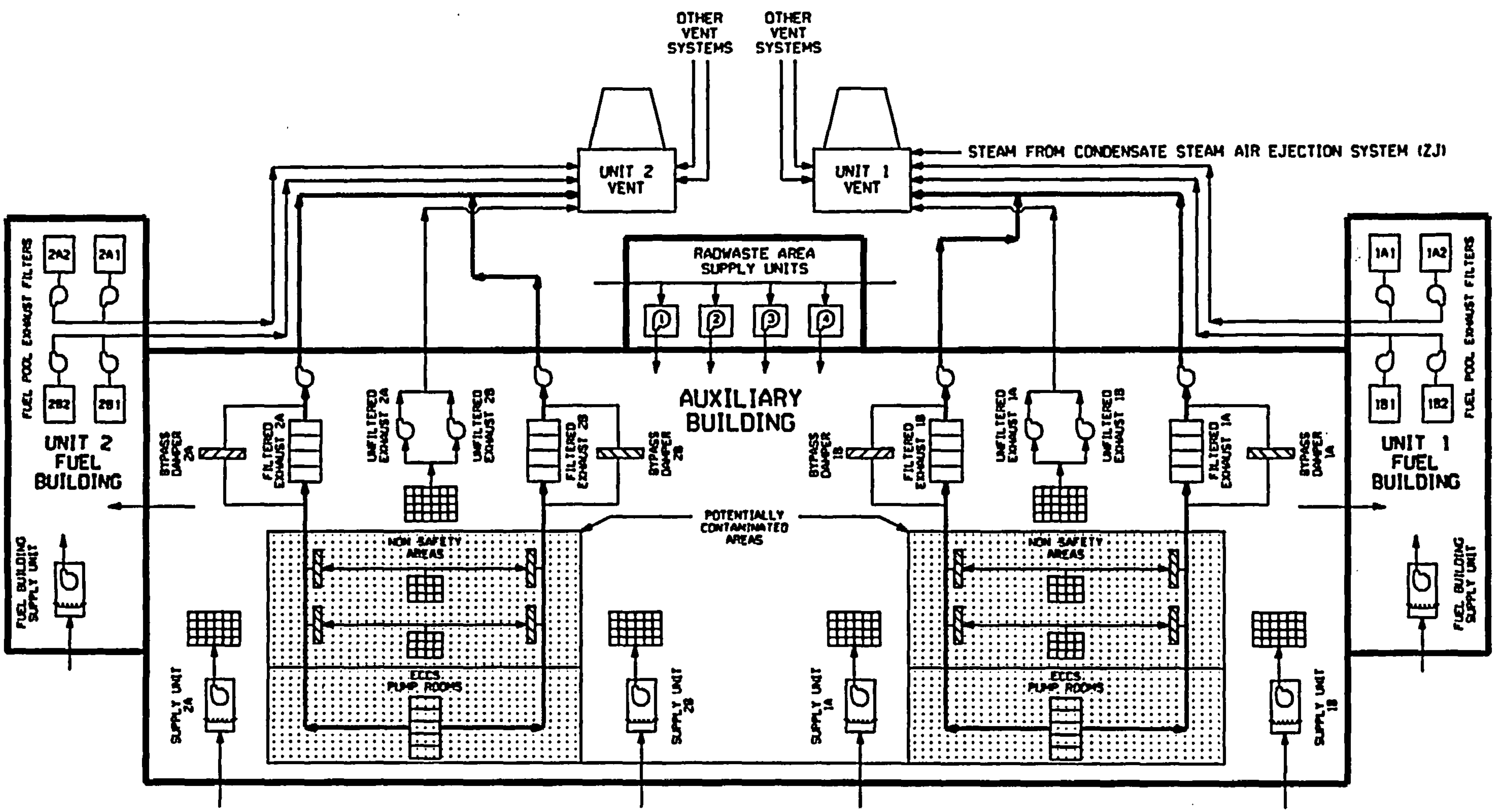
ATTACHMENT 1

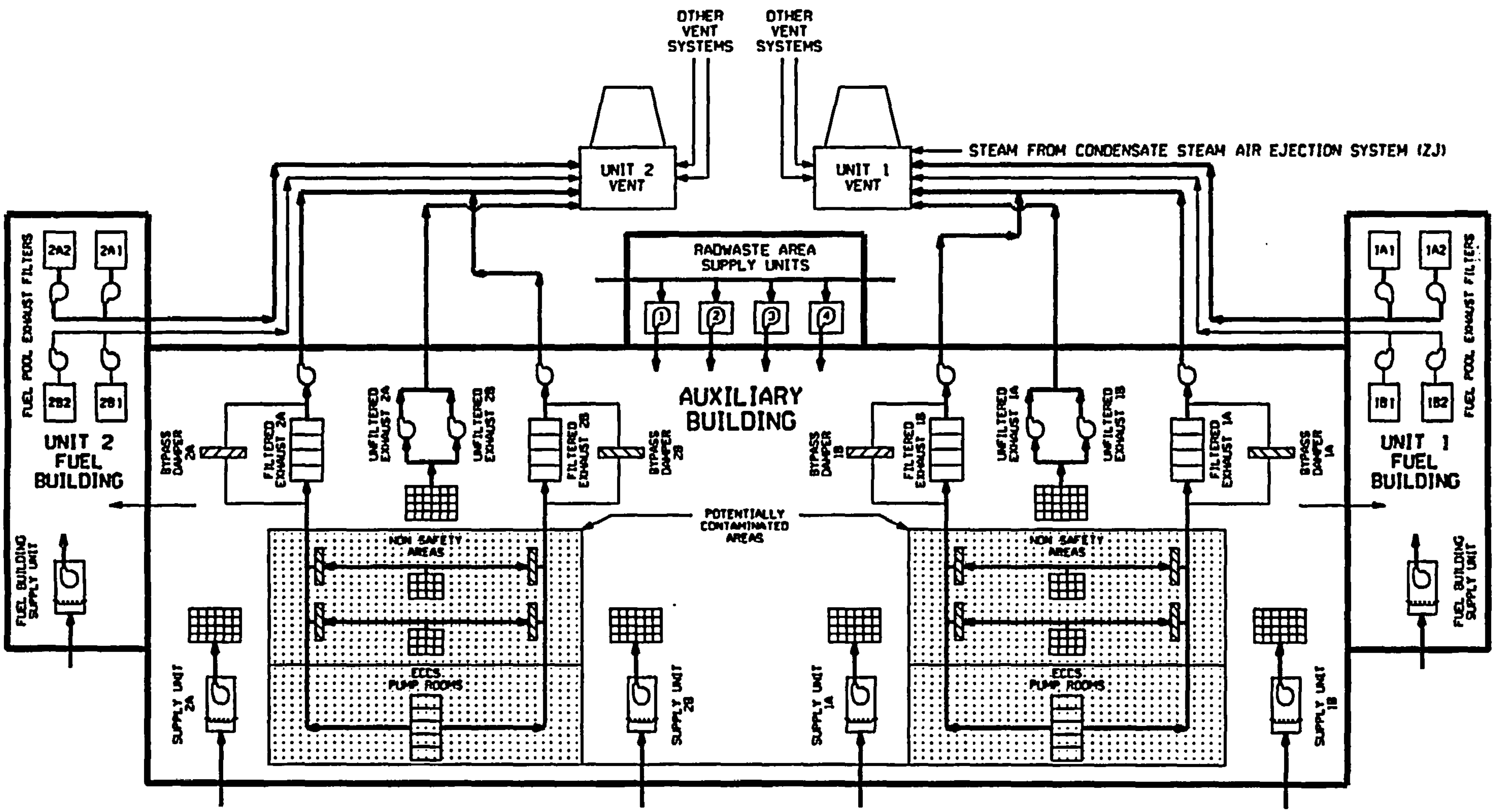
ACCIDENT ALIGNMENT



c:/sarosdm/userdir/JEFFREED.dgn Aug. 25, 1999 15:57:55

ATTACHMENT 2

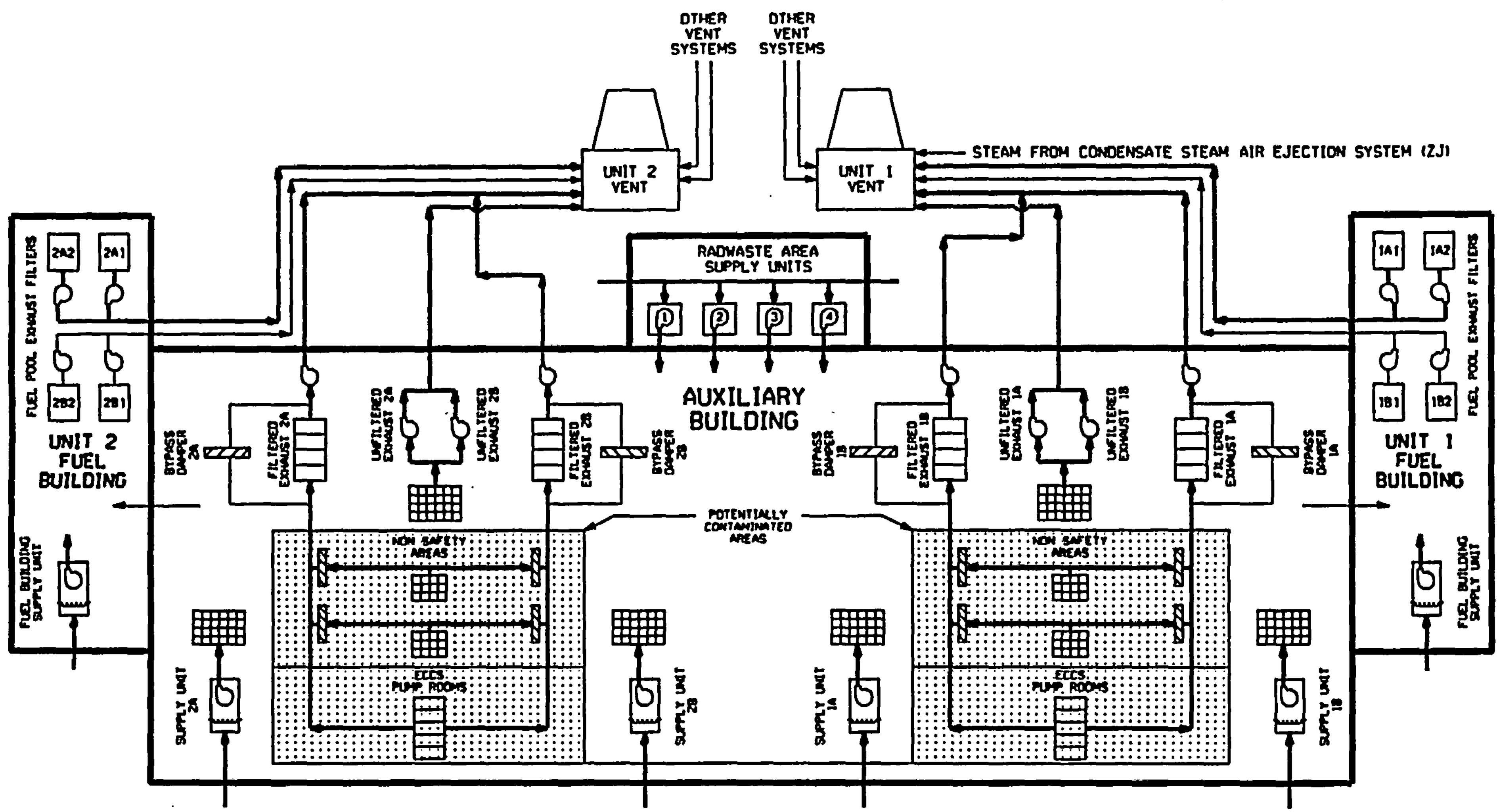
NORMAL ALIGNMENT



c:/sarosdm/userdir/JEFFREED.dgn Aug. 25, 1999 15:56:12

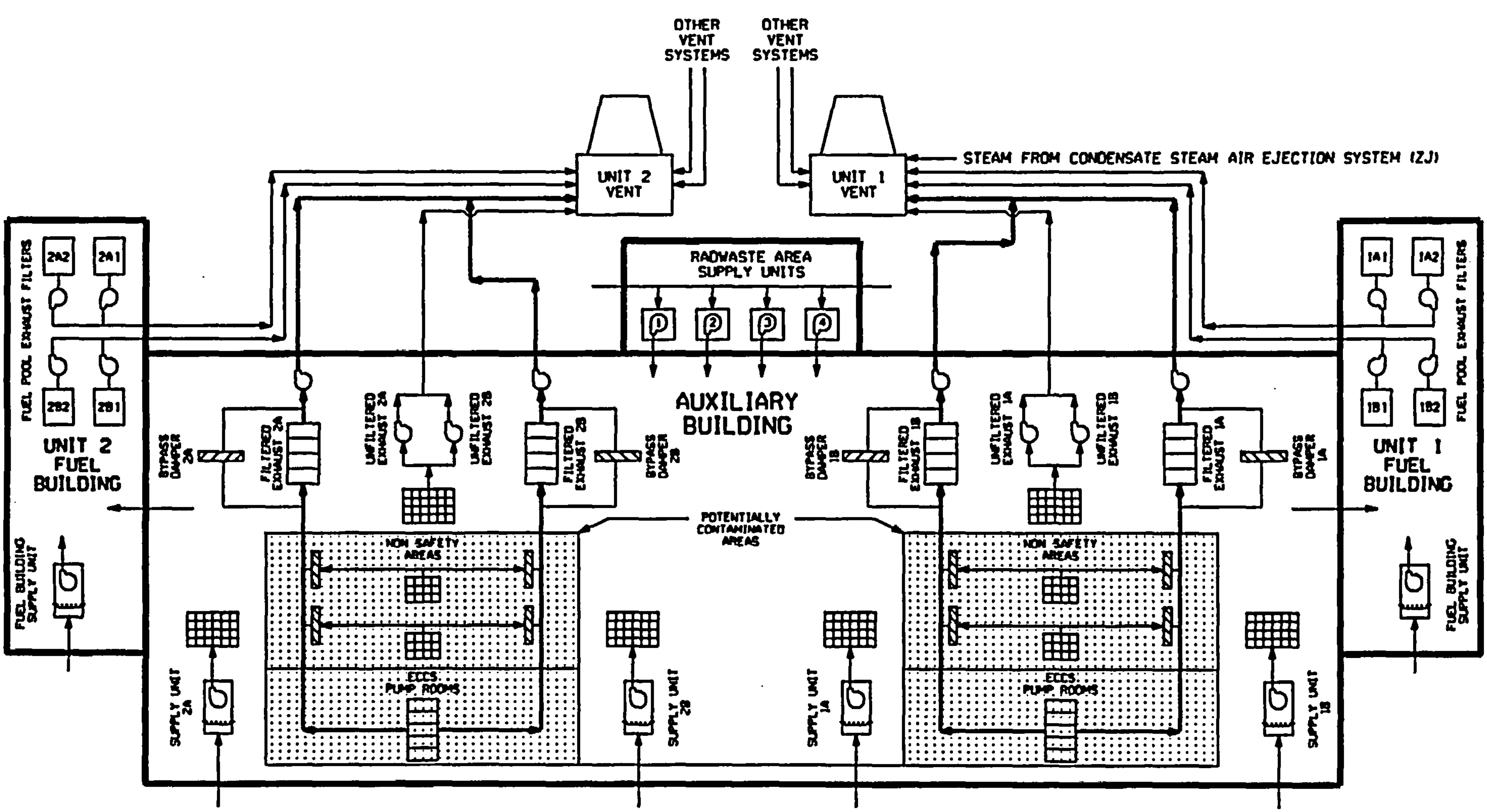
ATTACHMENT 2

NORMAL ALIGNMENT



c:/sarosdm/userdir/JEFFREED.dgn Aug. 25, 1999 15:56:12

ACCIDENT ALIGNMENT



NRCINFOVACARBON.XLS

	CARBON			CARBON			Carbon			Carbon	
	ABFU-1A			**ABFU-2A**			**ABFU-1B**			**ABFU-2B**	
DATE	% Methyl	%Elemental	DATE	% Methyl	%Elemental	DATE	% Methyl	%Elemental	DATE	% Methyl	%Elemenal
Jan-05	0.63		Jan-05	1.01		Jan-05	0.89		Jan-05	0.63	
Feb-05	1.06		Feb-05	0.33		Feb-05	1.36		Feb-05	0.42	
Mar-05	1.59		Mar-05	0.35		Mar-05	0.48		Mar-05	0.42	
Apr-05	1.29		Apr-05	0.92		Apr-05	0.81		Apr-05	0.83	
May-05	1.3		May-05	0.79		May-05	1.02		May-05	0.89	
Jun-05	1.21	0.01	Jun-05			Jun-05	0.8	0.01	Jun-05	1.55	0.01

NCS CORPORATION
1385 West Goodale Boulevard Columbus, Ohio 43212
Tel. 614-340-3700
FAX 614-340-3707

RADIOIODINE RETENTION / PENETRATION / EFFICIENCY TEST REPORT

CLIENT: Duke Power Company
Catawba Nuclear Station
Newport, South Carolina 29710

PURCHASE ORDER NO. CN54123
TEST REPORT NO. 18938
SAMPLE NO. 05-13372

SAMPLE IDENTITY: ABFU-1A

Date Sampled 6/28/2005 | Date Tested 7/10/05 | Bed Depth: 2 Inches

TEST CONDITIONS:

- Temperature: 30 °C
- Pressure: 101 kPa
- Relative Humidity: 95%
- Face Velocity: 14.63 m/min.
- Adsorbate Concentration: 17.5 mg/m3
- Duration of Loading: 120 minutes

TEST METHOD: Run per ASTM D3803-1979

- Duration of Post Sweep: 240 minutes
- Pre-Equilibration Time: 16 hours
- I^{131} Content: 0.8 uci
- Chemical Form I^{131}: Elemental Iodine
- Equilibration Time: N/A
- S.D. Total Counting Error: 0.001 %

RADIOIODINE TEST RESULTS AT:	% RETENTION	%PENETRATION	%EFFICIENCY
1"	%	%	%
2"	%	0.01 %	99.99 %
4"	%	%	%
	%	%	%

Standard Deviation

- 1st 2" Canister: 134.017
- 2nd 2" Canister: 1.421
- 3rd 2" Canister: 0.173
- 4th 2" Canister: N/A

NCS Distribution

(1) Lab File
(1) QA File

CERTIFICATE OF CONFORMANCE

The above test was performed in accordance with current revision of NCS-178 and with the above referenced purchase order.

[signature] - [illegible] 7-11-05 [signature]

07/12/2005 10:52 6143403707 NCS CORPORATION

NCS CORPORATION
1385 West Goodale Boulevard Columbus Ohio 43212
Tel. 614-340-3700
FAX 614-340-3707

RADIOIODINE RETENTION / PENETRATION / EFFICIENCY TEST REPORT

CLIENT: Duke Power Company
Catawba Nuclear Station
Newport, South Carolina 29710

PURCHASE ORDER NO. CN54123
TEST REPORT NO. 18916
SAMPLE NO. 05-13355

SAMPLE IDENTITY: ABFU-1B

Date Sampled 6/14/2005 Date Tested 6/23/05 Bed Depth: 2 Inches

TEST CONDITIONS:

Temperature	30 °C
Pressure	101 kPa
Relative Humidity	95%
Face Velocity	14.63 m/min
Adsorbate Concentration	17.5 mg/m3
Duration of Loading	120 minutes

TEST METHOD: Run per ASTM D3803-1979

Duration of Post Sweep	240 minutes
Pre-Equilibration Time	16 hours
I^{131} Content	0.7 uci
Chemical Form I^{131}	Elemental Iodine
Equilibration Time	N/A
S.D. Total Counting Error	0.001 %

RADIOIODINE TEST RESULTS AT:	% RETENTION	%PENETRATION	%EFFICIENCY
1"	%	%	%
2"	%	0.01 %	99.99 %
4"	%	%	%
	%	%	%

Standard Deviation

1st 2" Canister	132.590
2nd 2" Canister	1.425
3rd 2" Canister	0.100
4th 2" Canister	N/A

NCS Distribution

(1) Lab File

(1) QA File

CERTIFICATE OF CONFORMANCE

The above test was performed in accordance with current revision of NCS-178 and with the above referenced purchase order.

[signature] - [signature] 7-24-05

07/12/2005 10:52 6143403707

NCS CORPORATION
1385 West Goodale Boulevard Columbus, Ohio 43212
Tel. 614-340-3700
FAX 614-340-3707

RADIOIODINE RETENTION / PENETRATION / EFFICIENCY TEST REPORT

CLIENT: Duke Power Company
Catawba Nuclear Station
Newport, South Carolina 29710

PURCHASE ORDER NO. CM54123
TEST REPORT NO. 18937
SAMPLE NO. 05-13367

SAMPLE IDENTITY: ABFU-2B

Date Sampled 6/21/2005 Date Tested 7/10/05 Bed Depth: 2 Inches

TEST CONDITIONS:

Temperature	30 °C
Pressure	101 kPa
Relative Humidity	95%
Face Velocity	14.63 m/min.
Adsorbate Concentration	17.5 mg/m3
Duration of Loading	120 minutes

TEST METHOD: Run per ASTM D3803-1979

Duration of Post Sweep	240 minutes
Pre-Equilibration Time	16 hours
I^{131} Content	0.8 uci
Chemical Form I^{131}	Elemental Iodine
Equilibration Time	N/A
S.D. Total Counting Error	0.001 %

RADIOIODINE TEST RESULTS AT:	% RETENTION	%PENETRATION	%EFFICIENCY
1"	%	%	%
2"	%	0.01 %	99.99 %
4"	%	%	%
	%	%	%

Standard Deviation

1st 2" Canister	135.927
2nd 2" Canister	1.400
3rd 2" Canister	0.100
4th 2" Canister	N/A

NCS Distribution

(1) Lab File

(1) QA File

CERTIFICATE OF CONFORMANCE

The above test was performed in accordance with current revision of NCS-178 and with the above referenced purchase order.

[signature] Date 7-11-05 [signature]

NCS CORPORATION
1385 West Goodale Boulevard Columbus, Ohio 43212
Tel. 614-340-3700
FAX 614-340-3707

RADIOIODINE RETENTION / PENETRATION / EFFICIENCY TEST REPORT

CLIENT Duke Power Company
Catawba Nuclear Station
Newport, South Carolina 29710

PURCHASE ORDER NO. CN54123
TEST REPORT NO. 18939
SAMPLE NO. 05-13378

SAMPLE IDENTITY FPFU-1A2

Date Sampled 6/27/2005 Date Tested 7/10/05 Bed Depth: 2 Inches

TEST CONDITIONS:

Temperature	30 °C
Pressure	101 kPa
Relative Humidity	95%
Face Velocity	12.2 m/min.
Adsorbate Concentration	17.5 mg/m3
Duration of Loading	120 minutes

TEST METHOD: Run per ASTM D3803-1979

Duration of Post Sweep	240 minutes
Pre-Equilibration Time	16 hours
I^{131} Content	0.8 uci
Chemical Form I^{131}	Elemental Iodine
Equilibration Time	N/A
S.D. Total Counting Error	0.001 %

RADIOIODINE TEST RESULTS AT:	% RETENTION	%PENETRATION	%EFFICIENCY
1"	%	%	%
2"	%	0.01 %	99.99 %
4"	%	%	%
	%	%	%

Standard Deviation

1st 2" Canister	134.430
2nd 2" Canister	0.922
3rd 2" Canister	0.100
4th 2" Canister	N/A

NCS Distribution
(1) Lab File
(1) QA File

CERTIFICATE OF CONFORMANCE
The above test was performed in accordance with current revision of NCS-178 and with the above referenced purchase order.

[signature] Pres 7-11-05
APPROVED BY/TITLE DATE

[signature]
TEST PERFORMED

NCS CORPORATION
1385 West Goodale Boulevard Columbus, Ohio 43212
Tel. 614-340-3700
FAX 614-340-3707

RADIOIODINE RETENTION / PENETRATION / EFFICIENCY TEST REPORT

CLIENT: Duke Power Company
Catawba Nuclear Station
Newport, South Carolina 29710

PURCHASE ORDER NO. CN54123
TEST REPORT NO. 18940
SAMPLE NO. 05-13377

SAMPLE IDENTITY: FPFU-1A1

Date Sampled 6/27/2005 | Date Tested 7/10/05 | Bed Depth: 2 Inches

TEST CONDITIONS:

Temperature: 30 °C
Pressure: 101 kPa
Relative Humidity: 95%
Face Velocity: 12.2 m/min.
Adsorbate Concentration: 17.5 mg/m3
Duration of Loading: 120 minutes

TEST METHOD: Run per ASTM D3803-1979

Duration of Post Sweep: 240 minutes
Pre-Equilibration Time: 16 hours
I^{131} Content: 0.8 uci
Chemical Form I^{131}: Elemental Iodine
Equilibration Time: N/A
S.D. Total Counting Error: 0.001 %

RADIOIODINE TEST RESULTS AT:	% RETENTION	%PENETRATION	%EFFICIENCY
1"	%	%	%
2"	%	0.01 %	99.99 %
4"	%	%	%
	%	%	%

Standard Deviation

1st 2" Canister: 135.524
2nd 2" Canister: 1.253
3rd 2" Canister: 0.539
4th 2" Canister: N/A

NCS Distribution

(1) Lab File
(1) QA File

CERTIFICATE OF CONFORMANCE

The above test was performed in accordance with current revision of NCS-178 and with the above referenced purchase order.

[signature] 7-11-05
APPROVED BY/TITLE — DATE

[signature]
TEST PERFORMED

F-005, Rev. 10

Form 101.1 (R6-98)

CERTIFICATION OF ENGINEERING CALCULATION

Station And Unit Number: Catawba

Title Of Calculation: Bases for VA Filter Technical Specification Changes (Resolution to OBD PIP C98-4254)

Calculation Number: CNC-1211.00-00-0123

Total Original Pages: 1 Through: 14

Total Supporting Documentation Attachments: 5 Total Microfiche Attachments: ______

Total Volumes: 1 Type I Calculation/Analysis Yes ☐ No ☒

Type I Review Frequency: ______

Microfiche Attachment List ☐ Yes ☒ No See Form 101.4

These engineering Calculations cover QA Condition 1 Items. In accordance with established procedures, the quality has been assured and I certify that the above Calculation has been Originated, Checked, or Approved as noted below:

Originated By: Jim Kam Date: 2/3/00

Checked By: JF Reed Date: 2/8/00

Verification Method: Method 1 ☒ Method 2 ☐ Method 3 ☐ Other ☐

Approved By: KL Evans Date: 2/9/00

Issued To Document Management: RE Barker Date: 2/9/00

Received By Document Management: SJ Thomasson Date: 2-28-00

Complete The Spaces Below For Documentation Of Multiple Originators Or Checkers

Pages ______ Through ______

Originated By ______ Date ______

Checked By ______ Date ______

Verification Method: Method 1 ☐ Method 2 ☐ Method 3 ☐ Other ☐

Pages ______ Through ______

Originated By ______ Date ______

Checked By ______ Date ______

Verification Method: Method 1 ☐ Method 2 ☐ Method 3 ☐ Other ☐

Pages ______ Through ______

Originated By ______ Date ______

Checked By ______ Date ______

Verification Method: Method 1 ☐ Method 2 ☐ Method 3 ☐ Other ☐

FOR INFORMATION ONLY

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Table of Contents

1.0 Problem Statement

1.a Problem/Functional Requirement

Tech Spec surveillance requirement 3.7.12.2 states, "Perform required ABFVES filter testing in accordance with the Ventilation Filter Testing Program (VFTP)". The VFTP is described in Technical Specification Section 5.5.11. Previously, in order to meet these requirements the VA system has been tested in dual train operation. Dual train operation refers to having both the 1A and 1B or 2A and 2B system components operating at the same time.

PIP C98-4254 identified concerns associated with the Technical Specification Limits and the present dual train testing methodology. Specifically, if only one filter exhaust train is operating on either or both units the flow rate could violate the minimum residence time requirement for the carbon bed. This would result in violating the dose analysis assumptions for Auxiliary Building Ventilation Filter performance. Operation in such an alignment could occur as a result of a single failure of an Auxiliary Building Exhaust Train to align to the ECCS Flow path. The Operability Evaluation for the PIP C98-4254 instituted restrictions on the Technical Specification maximum flow rate and carbon bed penetration values. This resulted in the Auxiliary Building Ventilation System being declared Operable But Degraded.

This calculation will identify and evaluate various testing flow alignments, select the preferred testing for Catawba, and determine Technical Specification changes required to allow returning the Auxiliary Building Ventilation System to a fully Operable condition.

1.b Purpose

The purpose of this calculation is to determine what alignment the Auxiliary Building Ventilation System filtered exhaust filter units (ABFU-1A, ABFU-1B, ABFU-2A and ABFU-2B) should be tested in, as well as determine appropriate Technical Specification limits to ensure the system will continue to meet its design basis functions. This calculation will document acceptable system alignments and system airflow ranges that provide conservative, trendable monitoring of the system. The results of this calculation will also provide the basis for the applicable Technical Specification surveillance (SR 3.7.12.2) associated with system airflow rates.

This calculation is being completed to address concerns identified by PIP C98-4254.

This calculates supercedes calculation CNC-1211.00-14-0010 (PIP C94-1539 Past Operability Evaluation). Analysis completed by this calculation envelopes and expands on the analysis done by calculation CNC-1211.00-14-0010.

Calc not superceded as of 4/5/0[illegible]
Obtained calc for revisi[illegible]
Categorize as historical and superceded

1.c Applicable QA Condition

This calculation determines the preferred Technical Specification Surveillance alignment and associated Technical Specification limits to ensure that the Auxiliary Building Ventilation System will perform its accident mitigation function of filtering ECCS Pump Room leakage with a filter efficiency of 95%. Therefore, this calculation is considered QA Condition 1.

2.0 Design Method/Analytical Method

2.a State the design method used or analytical model employed

This calculation will identify various potential test alignments for the Auxiliary Building Ventilation System and determine the preferred test alignment. The selection will be based on quantitative and qualitative factors documented in the calculation. If the test alignment chosen is different from the limiting alignment then an analysis will be done to extrapolate test conditions to accident conditions to ensure that test results are bounding for the accident condition. If such an analysis is performed then test data will be obtained to validate that the analysis is conservative.

3.0 Design Basis and Reference Information

3.a Applicable Codes and Standards

ANSI N510, 1980
NRC Reg Guide 1.52, 1978
ASTM D3803-1989

3.b Criteria Cited in Technical Specifications Bearing on Calculation

Tech Spec Surveillance Requirement 3.7.12.2
Ventilation Filter Testing Program (VFTP) 5.5.11.a, 5.5.11.b, 5.5.11.c and 5.5.11.d

3.c Criteria Cited in the UFSAR Bearing on Calculation

9.4.3

3.d Criteria Cited in other SAR Documents Bearing on Calculation

Generic Letter 99-02

3.e Design Inputs

The Technical Specification Limits developed by this calculation shall support the currently assumed Auxiliary Building Ventilation Filter Efficiency of approximately 95% and shall be in accordance with the requirements outlined in Generic Letter 99-02.

3.f Design Criteria or Input From Other Calculations

CNC-1211.00-00-0099 Carbon Filter Maximum Air Flow Rate

3.g Sources of Information

ASHRAE Fundamentals 1989
CNM 1211.00-0530
PIP C94-1539
PIP C98-4254

3.h Computer Programs Used in Calculation

Microsoft Excel spreadsheet used to adjust fan curve, develop limiting system flows, and determine maximum carbon bed face velocity. Floppy disc included with calculation.

3.i Computer Program Input

None

3.j Documents Referenced in the Calculation not easily retrievable by Independent Auditor

None

4.0 Summary Information

4.a Calculation Type

The calculation is not a Type I calculation. This calculation meets the characteristics described in EDM 101, Appendix E.2, Classification of Calculations for a Type II Calculation.

4.b **Calculation Conclusion**

The calculation concludes that the preferred alignment for Technical Specification Surveillance Testing of the Auxiliary Building Ventilation System is the dual train alignment. This decision was based on various criteria including ease of obtaining the test alignment, minimal station impacts while in the test alignment, and no modifications required.

The calculation determined that the flow limits for Technical Specifications 5.5.11.a, b, and d should be established at 60,000 cfm ± 10% with both trains of fans operating in a normal alignment. The normal alignment is defined to be all 4 filtered exhaust fans in operation, all 4 unfiltered exhaust fans in operation and all 4 supply units in operation. Spent Fuel Building Ventilation on both units should also be in operation as well. The flow through each filter should be balanced so that each filter operates with a flow of 30,000 cfm ± 10%.

The calculation determined that the laboratory test of methyl iodide penetration should remain at 4% in accordance with Technical Specification 5.5.11.c, however the test shall be done at a face velocity of 48 fpm instead of the normal 40 fpm face velocity specified in ASTM D3803-89. This deviation is to ensure that the laboratory test results appropriately bound the limiting flow alignment that results in a flow rate higher than the test alignment. This deviation is specified in accordance with Generic Letter 99-02. The test results shall be adjusted for the actual VA system bed depth of 2.27 inch using the methodology of ASTM D3803-1989 prior to comparison to the Technical Specification limit.

4.c **Qualification Testing or Inspection requirements needed to verify calculation results or specific SSC Functional requirement.**

Testing was performed to validate analytical calculation results. Reference PT/0/A/4450/01C and TT/0/A/9100/071 (test dates identified in Technical Presentation portion of this calculation).

4.d **Periodic Testing or Inspection Requirements needed for continued verification/validation of calculation results or assumptions**

None

5.0 Assumptions

5.a **Assumptions to be validated as design proceeds**
None

5.b **Assumptions which can significantly impact final results and conclusions**
None

5.c **Other assumptions used to originate or revise calculation**
None

6.0 Technical Presentation

The analysis is presented below and can be summarized by the following outline:

1. Auxiliary Building Ventilation System Background

This section provides a brief discussion of the system design requirements and basic operation.

2. Preferred Surveillance Test Alignment
   This section provides a brief overview of the criteria considered in selecting the preferred alignment for routine surveillance testing as well as some of the many factors that influenced the decision.

3. Limiting Flow Rate Determination
   This section presents a discussion of how the nominal limiting flow rate was determined through conservative extrapolation of normal operating flow rates to worst case maximum flow conditions.
4. Technical Specification Changes.
   This section provides a discussion of the proposed Technical Specification changes and a justification for all changes made as well as justification for those Auxiliary Building Ventilation Technical Specifications that were not changed.
5. Attachments.
   Presents a tabular summary of the attachments to this calculation.

6.a Auxiliary Building Ventilation System Background.

System Description
The Auxiliary Building Ventilation System was primarily designed as a non-safety, non-redundant ventilation system with a subset of the system being designed as an Engineered Safeguards Feature. The system consists (on a per reactor unit basis) of 2-50% capacity "trains". Each "train" consists primarily of two 50% filtered exhaust fans (≈30,000 cfm), two 50% unfiltered exhaust fans (≈20,350 cfm), two 50% supply units (≈33,240cfm) and automatic dampers. There are additional smaller supply units that supply air to the Radwaste Area of the Auxiliary Building and other minor fans that ensure proper flow to various rooms and equipment located in the Auxiliary Building. None of these other fans are specifically "train" related.

The Engineered Safety Feature subset of the system consists of two 100% capacity fans and associated dampers and ductwork to direct flow through the filters and separate the two trains.

Note that the same filtered exhaust fans are used in the normal alignment and the ESF alignment. The difference is that the normal alignment operates the fans at full flow and exhausts from all of areas that contain equipment handling radioactive fluids. In this alignment each fan is a 50% capacity fan. In the ESF alignment, the fans operate at a reduced flow (throttled back by safety related vortex dampers) and exhaust primarily from the ECCS rooms. In this alignment, the fans have a capacity of 100% each.

The Engineered Safety Feature functions of the system are:

- Isolate the filter unit bypass and direct airflow through the filter. (Currently secured in this position due to an original design deficiency.)
- Isolate the safety, non-safety portions of the system on receipt of ESF signal. This results in each fan being aligned to draw air from only the ECCS Pump Rooms.
- Condition the fan inlet flow profile so that the fan will operate in a stable manner at the reduced flow rates (nominally 6500 cfm) in the ESF Alignment. The fan inlet vortex damper going to the minimum flow position performs this function.
- Ensure the ECCS Pump Rooms (Centrifugal Charging, Safety Injection, Residual Heat Removal, and Containment Spray) are kept at a negative pressure with respect to adjacent non-ECCS areas. This ensures that the airborne radioactive products of leakage within these rooms is filtered and discharged through the unit vent.

- Ensure the air from the ECCS Pump Rooms is filtered in a manner that supports the Dose Analysis assumption of 95% filter efficiency.
- Perform the above functions with, onsite or offsite power only, assuming a single failure.

The Engineered Safety Feature alignment of the Auxiliary Building Ventilation System is shown on Attachment 1.

During normal operation the system provides the following functions:

- Maintains the Auxiliary Building at a slight negative pressure by drawing more air out of the building than is supplied to it.
- Maintains air flow direction within the Auxiliary Building from radiologically "clean" areas to areas which may contain radiological effluents that require filtration to maintain station release limits within those allowed for normal operation or abnormal station operation.
- Maintain an Auxiliary Building environment suitable for reliable long-term operation of the components in the building, and for personnel access for equipment maintenance.

The normal operating alignment of the Auxiliary Building Ventilation System is shown on Attachment 2.

6.b Preferred Surveillance Test Alignment

< 30 000 cfm Aligment

Engineering determined that an alignment which resulted in a normal operating flow of less than the current 30,000 cfm nominal flow rate was unacceptable for several reasons. The most significant were unstable fan operation, potential normal operation Radiation Protection (RP) impacts, and the need for an extensive flow balancing effort as well as an associated modification. These are explained in more detail below.

Stable Fan Operation

Fans which can tolerate relatively large changes in differential pressure yet have a small change in flow are described as stable. Such a characteristic, in general, also leads to efficient fan operation, increased bearing life, etc. Attachment 3 presents the typical fan curve for the Auxiliary Building Filtered Exhaust Fan. Inspection of this fan curve shows that the knee is at approximately 28,000 cfm. Therefore, if the fan operates at nominal flow rate of 30,000 cfm then the fan will be stable at this flow rate. The fan will also remain stable as the filter differential pressure increases due to normal fouling causing a slight reduction in flow. Note, although it is not desirable to operate this fan below 28,000 cfm it is acceptable to do so. It should be recognized that a relatively small change in the system pressures could result in failure to meet the Technical Specification minimum flow band if the system were operated with a flow rate this low.

Radiation Protection

As stated previously, under normal operating conditions the Auxiliary Building is maintained at a slight negative pressure with air flowing from potentially radiologically "dirty" areas to "clean" areas. A relatively minor reduction in Auxiliary Building Filtered Exhaust flow could adversely impact the ability to keep the Auxiliary Building at a negative pressure and disrupt air flow of "clean" to "dirty" areas with obvious adverse consequences.

Auxiliary Building Ventilation System Rebalance

If a system alignment were chosen which resulted in increasing or decreasing flows from the current nominal flow balance, a flow rebalance would be required. It is expected that this rebalance would consume a significant amount of man-hours due to

the numerous individual registers and manual volume dampers in the Auxiliary Building Ventilation System. Some of the areas ventilated by the Auxiliary Building Filtered Exhaust System are high radiation areas or worse and, as a result, such a flow balance would be expected to incur a significant dose as well.

Factors that are included in the discussion below concerning potential Surveillance Test alignments include impact to Operations personnel in performing the test, potential for generation of RP concerns, Carbon Bed Residence time limit, and system interaction concerns. Some of these factors are not intuitively obvious and are discussed here prior to the discussion of the potential test alignments.

- Operations Impact – If testing can be performed in the normal operating alignment then this will minimize the impact of the test on the Operations Control Room Personnel. Changing the alignment of the Auxiliary Building Ventilation System is done by procedure and requires a Control Room Operator to walk around to the back side of the main control boards to shutdown and re-start Auxiliary Building Ventilation System equipment. Additionally, current operating practices require control room pressure surveillance's if the alignment of the Control Room or Auxiliary Building Ventilation Systems are changed. Therefore, surveillance test alignments that do not require the system to be taken out of its normal alignment will have the least impact on Operations.
- RP Concerns – when the Auxiliary Building Ventilation System is operated in an alignment other than the normal alignment, RP concerns are created. The concern that is generally noticed is the increased incidence of individuals being unable to exit the Single Point Access due to generating an alarm on the PCM-1B Full Body Monitors. Radioactive gasses such as xenon and their daughter products are attracted to the individuals clothing by static charge differences causing these alarms. Current RP policy requires that the individual remain in the Single Point Access area until the gasses decay to an undetectable level or some other corrective action is taken so that the person does not generate an alarm on the exit full body monitor. The incidence of "gassing" first starts to show up in the lower levels of the Auxiliary Building and progress to upper levels of the building as the length of time the Auxiliary Building Ventilation System is out of its normal alignment increases.
- Carbon Bed Residence Time Limit – the factor that most affects the iodine removal efficiency of the Auxiliary Building Ventilation Exhaust Filters is the amount of time the air stream is in contact with the carbon bed. This time is referred to as the residence time. The Auxiliary Building Ventilation System filters were originally designed to have a minimum nominal residence time of 0.25 seconds. This residence time also forms the basis for the laboratory testing of the carbon to determine its iodine removal efficiency in accordance with ASTM D3803-1989. A typical surveillance test is normally performed in the most conservative alignment that under normal circumstances would directly validate the residence time. The discussion of testing alignments below will demonstrate why this is not practical for the Auxiliary Building Ventilation System.
- System Interaction – this is a concern that was identified in the mid 1990's when the Auxiliary Building Ventilation System was operated for an extended period of time at flow rates very close to the Technical Specification lower limit. Individual fan flow rates of ≈ 27,000 were measured during this time frame. As discussed previously, flow rates this low will result in unstable fan operation. Unstable fans will have large changes in flow for relatively small changes in differential pressure. As a result, it was very difficult to determine why a fan may have violated its Technical Specification lower limit. It may have occurred because of a problem with the fan or the other train's fan on that unit or even some alignment that resulted in a change in unit vent backpressure or Auxiliary Building negative pressure may have caused the problem. As stated previously, the Auxiliary Building Filtered Exhaust System is consists of two 50% capacity fans and filters when operated in the normal

alignment. Most of the duct is shared between the two fans. As a result, if the flow on one fan goes up the flow on the other fan goes down. This is what is referred to as system interaction. when

As a result of the above impacts Engineering reduced potential options for the surveillance test to three choices. Each of these choices would be implemented in such a manner that the normal operating flow rates would be maintained at the current nominal value of 30,000 cfm. These have been described as a dual train alignment, a single train alignment, or the limiting alignment. Each of these alignments is reviewed below with the pro's and con's for each identified.

Dual Train Alignment

Testing in the dual train alignment (also referred to as the "normal" alignment) is defined as testing with both VA system trains (1A & 1B and 2A & 2B) operating along with both VF systems (Unit 1 and Unit 2) operating. The required flow rate currently would be 30,000 cfm ± 10%.

The positive aspects of testing in this alignment are:

- No impact to station operations – no equipment/systems need be shutdown or realigned from their normal configuration.
- No RP concerns created.
- This is the most effective alignment in which to monitor total system degradation. In this alignment the duct ΔP is a larger fraction of the total system ΔP, as a result problems with the duct are more readily detected.
- Testing can be performed using the installed Air Flow Monitor Devices.

The negative aspects of testing in this alignment are:

- Does not directly validate the carbon filter residence time limit is not exceeded.
- The potential flow rate change between this alignment and the limiting alignment has not been accurately quantified.
- Carbon testing is more difficult since R-11 or DOP must be injected into both filters (1A & 1B or 2A & 2B) at the same time. (Although this is how the test has been done in the past.)

Single Train Alignment

Testing in the single train alignment is defined as testing with only one VA system train operating. For example, when testing 1A, 1B is OFF while 2A and 2B are operating. Also, both VF systems (Unit 1 and Unit 2) are operating.

The positive aspects of testing in this alignment are:

- Eliminates interaction with the other train.
- Simplifies carbon filter testing by only requiring the injection of enough R-11 or DOP to test one filter.

The negative aspects of testing in this alignment are:

- RP concerns associated with off normal operation of the Auxiliary Building Ventilation System are created.
- Does not directly validate residence time limit is not exceeded. In this alignment the Fuel Building Ventilation System remains in service during the test although it is designed to trip under accident conditions. This results in an increased backpressure in the unit vent and reduced pressure in the Auxiliary Building. Both of these interactions will result in an increase in Auxiliary Building Filtered Exhaust Flow rates under accident conditions.
- There is some impact to station operations – some equipment/systems will need to be shutdown.

- The potential flow rate change between this alignment and the limiting alignment has not been accurately quantified at this time.
- Unable to perform the test using the installed Air Flow Monitor Device. The installed Air Flow Monitor Device has been determined to be inaccurate when only a single exhaust fan is in operation (PIP C94-1539) This results in the test group having to perform a pitot traverse of the duct going to the unit vent. A pitot traverse will add a minimum of two hours for two people to each test.

Limiting Alignment 37000 CFM

Testing in the limiting alignment is the limiting form of single train testing. It is defined as testing with only one VA system train on one Unit (1A or 1B or 2A or 2B) operating and having both VF systems (Unit 1 and Unit 2) shutdown. From the standpoint of correlating surveillance tests to accident conditions this would be the preferred alignment. However, as discussed below, this is not a viable alignment for a routine surveillance test.

Talking abt field testing alignments Carbon lab penetration test?

Air flow < 37000 CFM

The positive aspects of testing in this alignment are:

- Directly validates residence time limit is not exceeded. All interactions are eliminated.
- Simplifies carbon filter testing by only requiring the injection of enough R-11 or DOP to test one filter.

The negative aspects of testing in this alignment are:

- Creates the potential to draw steam from the Unit 1 Vent Stack into other ventilation systems that are shut down to support this alignment. Carbon filters within these other ventilation systems could be damaged or degraded.
- There is a significant impact to station operations – numerous ventilation systems will need to be shutdown and not operated in its normal configuration during testing. This will seriously impact any activities within either the Unit 1 or Unit 2 Fuel Buildings since all ventilation to these areas will be shutdown. This creates considerable operational hardships including personnel and equipment safety hazards, and the prevention of fuel movement or other maintenance activities within the fuel pool area. Other plant activities that could be affected are chemistry sampling, hot machine shop work, laundry facility work and other work within the Auxiliary Building.
- RP concerns are created with off normal operation of the Auxiliary Building Ventilation System.
- Unable to perform the test using the installed Air Flow Monitor Device. The installed Air Flow Monitor Device has been determined to be inaccurate when only a single exhaust fan is in operation (PIP C94-1539) This results in the test group having to perform a pitot traverse of the duct going to the unit vent. A pitot traverse will add a minimum of two hours for two people to each test.

System Interactions

Based on the discussion presented above it is clear that the limiting alignment is not viable for a routine surveillance test. Engineering has reviewed the pro's and con's associated with the dual train and the single train alignment and concluded the preferred alignment would be the dual train alignment. This alignment had two significant negative aspects, (a) the carbon bed residence time was not directly validated and (b) the maximum flow through a filter train had not been accurately quantified. The third negative has been determined to be of minimal significance since the test is currently performed in this alignment. The remainder of this calculation will determine the nominal limiting flow rate and justify the adequacy of performing a test in the dual train alignment and extrapolating the results to the limiting condition.

Form 101.2 Revision 1
26164 (R9-89)

File/Calculation No. CNC-1211.00-00-0123

REVISION DOCUMENTATION SHEET

Revision Number	Review Frequency Changed Yes/No	Revision Description
0	No	Original Issue

0000 5953 0729

6.c Limiting Flow Rate Determination

To determine the nominal limiting flow rate the following steps will be performed:

1. Using the original manufacturers curve for the Auxiliary Building Filtered Exhaust Fan develop a fan curve for the fans as installed. The manufacturer originally tested the fans at 1586 rpm. Due to conservatism in the original sizing calculation the fans were set up to run at approximately 1480 rpm during initial flow balancing of the system.
2. Develop a curve fit of the adjusted fan curve to facilitate extrapolation of system flows from the dual train alignment to the nominal limiting flow rate.
3. Conservatively extrapolate the flows from the nominal dual train flow to the nominal limiting flow.
4. Validate the conservatism of the extrapolation.

Adjusted Fan Curve Development

The original fan curve data is documented in CNM 1211.00-0508 and is reproduced in the Table below. The fan curve data is then adjusted using the fan laws (1996 ASHRAE Handbook HVAC Systems and Equipment Chapter 18 Table 2). The fan laws dictate:

$$Q_1 = Q_2 \bullet N_1 / N_2$$

$$P_1 = P_2 \bullet (N_1 / N_2)^2$$

Where:

- Q is flow rate – cfm.
- P is fan pressure – inwc.
- Subscript 1 is for the application under consideration.
- Subscript 2 is for the tested fan.
- N_2 is 1586 rpm.
- N_1 is 1480 rpm. This value was chosen because it is slightly above the speed at which the fans operate. According to Attachment 4 all of the fans operate between 1471 and 1476 rpm. A higher speed results in a more conservative extrapolation of flow rates because the fan appears to be stronger.

The results of the analysis are tabulated below:

Test-Flow - Q_2	Test Pressure - P_2	Adjusted Flow - Q_1	Adjusted Pressure - P_1
22973.1	16.3864	21437.7	14.26923258
26815.1	15.8669	25022.92	13.81685339
30563.6	15.7779	28520.89	13.73935244
34438.9	14.1482	32137.18	12.32021411
38358.9	11.8373	35795.19	10.30788867
42258.9	9.2568	39434.53	8.06079628
45782.5	6.7238	42722.64	5.855066765

Curve Fit Evaluation

The adjusted data from above was curve fitted to a third order polynomial. The first set of data points was not used because they are outside the range of interest. The results of this curve fit resulted in the following equation for the adjusted fan curve:

$$P = 6.648720 \bullet 10^{-13}(Q)^3 - 8.359623 \bullet 10^{-8}(Q)^2 + 2.836066 \bullet 10^{-3}(Q) - 14.56836$$

The original fan curve, adjusted fan curve, and curve fit data are plotted on Attachment 3. The validity of the curve fit data may be validated either by examination of the curve on Attachment 3 or by examination of the data tabulated below:

Adjusted Flow	Adjusted Pressure	Curve Fit Pressure
28520.89	13.74	13.74
32137.18	12.32	12.30
35795.19	10.31	10.33
39434.53	8.06	8.04
42722.64	5.86	5.86

Examination of the data in the table above demonstrates that the 3rd order polynomial curve fit provides an excellent fit of the data, significantly better than what could be obtained reading off of a hand drawn curve.

Flow extrapolation

The dual train flow rate is extrapolated to limiting system conditions using the following process. First some simplifying assumptions are made. According to Bernoulli's equation, pressure losses are of three types: elevation differences, static pressure differences and friction losses. In an air system elevation differences are assumed to be negligible due to the low density of the fluid involved. For purposes of this evaluation all static pressure difference are assumed to be zero. Therefore, all pressure loss is assumed to be friction loss. The final assumption is that at the nominal flow rate all flow is fully turbulent. With this assumption the flow coefficient of the entire system is a constant and pressure losses are only a function of the ratio of the square of the flow rates.

Given the assumptions from above, the following process is used to extrapolate the flow rates. At the nominal flow rate of 30,000 cfm the fan pressure is calculated using the curve fit equation developed previously. A clean filter Δp of 4 inwc is conservatively assumed based on manufacturer data (CNM 1211.00-0530). The manufacturer indicates that individual filter components should have the following differential pressure under clean conditions:

Component	Loss
Pre-filter	0.80 inwc
HEPA	1.00 inwc
Carbon Bed	1.20 inwc
HEPA	1.00 inwc
Total	4.00 inwc

These filter drops do not include the pressure losses associated with the entrance and exit losses for the filter unit. Not including these additional losses will result in a conservatively high extrapolation of the limiting flow rate. The friction loss attributed to the duct is calculated by subtracting the filter Δp from the fan pressure. The results of this evaluation are tabulated below:

Fan Flow - cfm	Fan Head	Filter ΔP - inwc	Duct ΔP
30000	13.229	4	9.229

The duct ΔP is based on 60,000 cfm since two fans are running and the duct is shared between them. In the limiting alignment, only one fan is running. Therefore, an iterative process is set up where a fan flow is guessed. The curve fit equation is then used to calculate the fan pressure. The filter ΔP and duct ΔP are extrapolated using the equations below:

Filter $\Delta P = 4 \text{ inwc} \bullet (CFM_{lim})^2/(30000)^2$
Duct $\Delta P = 9.229 \bullet (CFM_{lim})^2/(2 \bullet 30000)^2$

Where:
CFM_{lim} is the estimated limiting flow rate.
Filter ΔP_{lim} is the filter ΔP at the estimated limiting flow rate.
Duct ΔP_{lim} is the duct ΔP at the estimated limiting flow rate.

The total pressure is then calculated by:
Total Pressure = Filter ΔP + Duct ΔP

This process is repeated until the Curve Fit Fan Pressure equals the Total Pressure.

This iterative process results in a nominal limiting flow rate of approximately 37,000 cfm. The details are tabulated below.

Flow – cfm	Curve Fit Fan Pressure – inwc	Filter ΔP - cfm	Duct ΔP - inwc	Total ΔP - inwc
37,006	9.597	6.086	3.511	9.597

The fan horsepower at this flow rate can also be calculated using the fan laws. Fan horsepower is proportional to the ratio of the fan speeds cubed. The adjusted fan horsepower curve is plotted on Attachment 3. This curve shows that fan power requirements at 37,000 cfm is approximately 90 hp. The installed fan motors are 100 hp therefore the fan motors are adequately sized to support fan operation at these flow rates. This conclusion is also supported by periodic operation in a single train alignment during maintenance on the system with no problems observed with fan motor operation. Flow rates in this alignment are similar to the flow rates analyzed here.

Extrapolation Validation
As stated previously the extrapolation made several assumptions. These assumptions were stated to be conservative without a detailed justification of each assumption. Therefore, field test data was obtained to validate the overall conservatism of the validation. The system was tested in dual train alignment, single train alignment and limiting train alignment. The limiting train alignment could only be performed on Unit 1 because of the need to keep airflow into the Unit 1 Vent to ensure that the steam was swept out of the unit vent and not drawn into the filters. The testing was performed using PT/0/A/4450/001C for the dual train alignment and TT/0/A/9100/070 for the single and limiting alignment. The results of these field tests are tabulated below and clearly demonstrate that the analysis was conservative.

All Flow < 35,34 CFM req'd to maintain resid. time

Fan	Test Date	Dual Train Flow	Single Train Flow	Limiting Flow
ABFU-1A	8/30/99	29957	33306	34111
ABFU-1B	9/1/99	27852	32774	32646[1]
ABFU-2A	8/31/99	30354	33256	NA
ABFU-2B	9/2/99	29277	32512	NA

6.d Technical Specification Changes

[1] It is not clear at this time why "A" and "B" Train flow did not increase roughly the same amount from the single train to the limiting alignment. It is sufficient for the purposes to demonstrate that the analysis conservatively bounds the actual data.

This review will be accomplished by tabulating each of the Technical Specification Surveillance's and indicating whether a change is required.

Technical Specification Surveillance		Comments
3.7.12.1	Operate each ABFVES train for ≥ 10 continuous hours with the heaters operating.	No change required. Surveillance is not flow rate dependent.
3.7.12.2	Perform required ABFVES filter testing in accordance with the Ventilation Filter Testing Program (VFTP).	No change required. Technical Specification 5.5.11 (VFTP) is reviewed below.
3.7.12.3	Verify each ABFVES train actuates on an actual or simulated actuation signal.	No change required. Surveillance is not flow rate dependent.
3.7.12.4	Verify one ABFVES train can maintain the ECCS pump rooms at negative pressure relative to adjacent areas.	No change required. Surveillance is not flow rate dependent.

Technical Specification 5.5.11 was also reviewed. This Technical Specification defines the basic parameters to be addressed by the Ventilation Filter Test Program (VFTP). This section of the Technical Specifications will require revisions to clarify that two fans are in operation with a total flow of 60,000 cfm for each section of this Technical Specification.

Section A. of this Technical Specification discusses the inplace testing of the HEPA Filter. The purpose of the inplace HEPA test is to determine if a leakage path exists around the HEPA filters. The test results at a nominal filter flow rate of 30,000 cfm will conservatively bound the inplace leakage at the limiting flow rate of 37,000 cfm as described below. These flow rates are well within the capabilities of the filters and the filter housing. The manufacturer recommends a maximum filter ΔP of 4 inwc for the HEPA (Reference CNM 1211.00-0530). Under current operating practices the HEPA is changed out at 2 inwc per (PT/1,2/A/4450/002). If a HEPA was at 2 inwc and the filter unit went into the single train alignment the ΔP would increase to ≈ 3 inwc as determined below:

$$\Delta P_{\lim} = 2 \bullet inwc \bullet (37{,}000 cfm / 30{,}000 cfm)^2$$

Counter

This is well within the manufacturer's limit therefore the structural limits of the filter housing will not be challenged. The HEPA's are mounted on the upstream face of the HEPA filter frame. An increase in flow, with its resultant increase in ΔP, will result in increasing the force that is holding the HEPA to the frame. This should result in even less leakage around the HEPA filter, which should result in improved inplace leakage results if the test were performed at the nominal limiting flow rate. Some confirmation of this analysis is provided by the fact that periodic maintenance activities have been done on line since startup. The flow rates achieved in this alignment are the same as the single train flow rate described in this analysis. No problems have ever been observed resulting from this additional flow rate on any of the filter components. Therefore, this section will require no changes other than the change described above.

Section B. of this Technical Specification discusses inplace testing of the carbon adsorber. The purpose of the inplace carbon adsorber test is to determine if a leakage path around the carbon exists. The framing for the carbon bed consists of 3/16 inch plate steel welded to the filter housing. Based on engineering judgement the increase in flow will not result in any change to the inplace leakage of the carbon bed due to deflection of the bulkhead. The increased flow rate

will not displace the carbon in the bed because it has no where to go. Additionally, as stated previously, flow rates equivalent to the single train flow rate has been experienced in the past during maintenance with no damage to carbon bed. Therefore, this section will require no changes other than the change described above.

Section C. of this Technical Specification discusses the laboratory test of the carbon adsorber. This Technical Specification will need to be revised to require the test to be performed in accordance with ASTM D3803-1989 except that it must be done at the limiting flow rate face velocity. In order to minimize the number of carbon bed replacements it is proposed that Catawba take credit for the actual filter bed depth. The actual filter bed depth is 2.2751 inches per CNC-1211.00-00-0099. Therefore, the test results are to be adjusted for a 2.27 inch bed in accordance with the guidance provided in ASTM D3803-1989 prior to comparing the test results to the Technical Specification limit. These recommended changes are in accordance with the guidance provided in Generic Letter 99-02 and ASTM D3803-1989.

Section D. of this Technical Specification discusses limiting filter differential pressures for the specified flow rate. The filter limit of 8 inwc at 30,000 cfm ± 10% was reviewed for acceptability. It is highly unlikely that the current system could achieve a filter differential pressure of 8 inwc and still be within the Technical Specification allowed flow of 30,000 cfm ± 10%. We can use the same methodology as before but assume the filter Δp is 8 inwc instead of 4 inwc then calculate a duct loss for the dual train alignment then use this data to extrapolate to the single train alignment. This analysis indicates that if the system was in this condition (again highly unlikely), then the flow rate would increase to approximately 33,560 cfm with a filter Δp of approximately 10 inches. This flow rate bounded by the nominal single train flow rate calculated previously of approximately 37,000 cfm. Therefore there is no concern from a flow standpoint. The total filter Δp of 10 inwc is within the manufacturers limits as documented in the table below.

Component	Clean Δp	Max Δp
Pre-filter	0.80 inwc	2.00 inwc
HEPA	1.00 inwc	4.00 inwc
Carbon Bed	1.20 inwc	1.20 inwc[2]
HEPA	1.00 inwc	4.00 inwc
Total	4.00 inwc	11.20 inwc

Therefore, this section will require no changes other than the change described above.

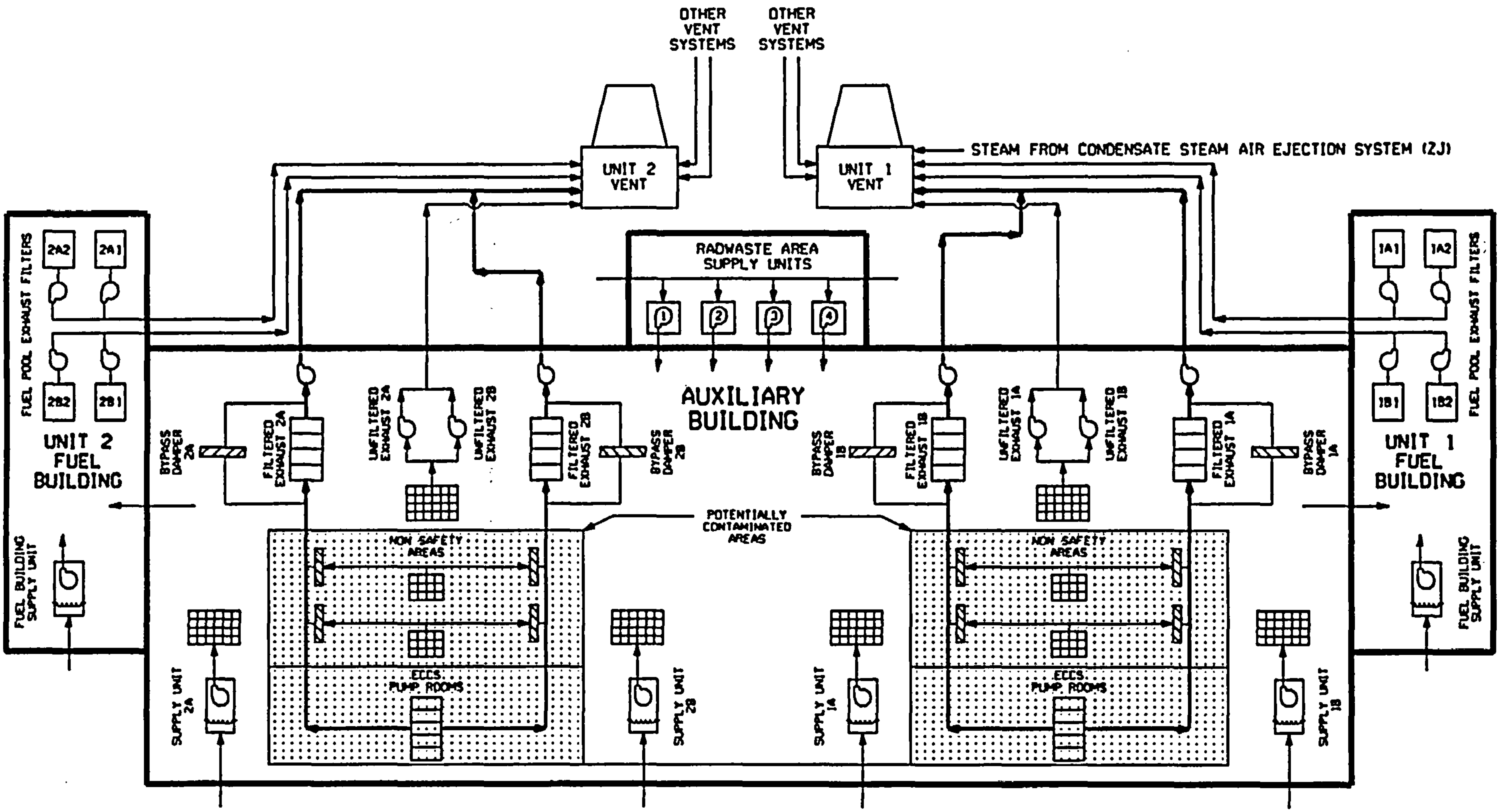
Section E. of this Technical Specification discusses required heater capacities. Heater capacity is independent of flow rate through the heater. Therefore, this section will require no changes other than the change described above.

Attachments
(1) VA Accident Alignment
(2) VA Normal Alignment
(3) Typical VA System Fan Curve
(4) Auxiliary Building Ventilation Fan Operating Speeds
(5) Floppy Disc – VA Flow Analysis

[2] The manufacturer did not specify a maximum Δp for the carbon bed. Previously in this calculation an upper limit of ≈ 3 inwc was justified. For conservatism the manufacturers clean value of 1.2 inwc was used in this analysis.

ATTACHMENT 1

ACCIDENT ALIGNMENT



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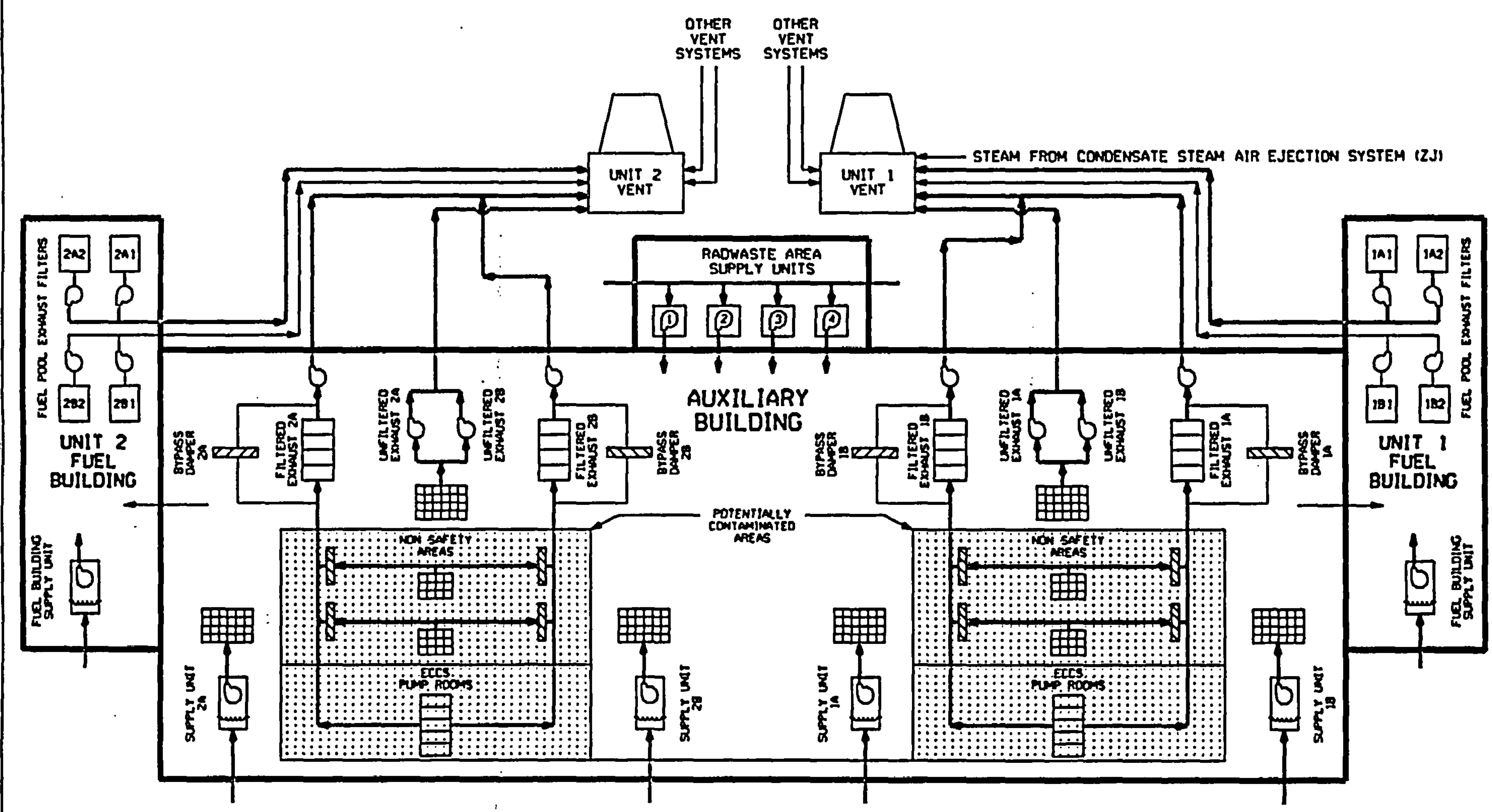
ATTACHMENT 2

NORMAL ALIGNMENT



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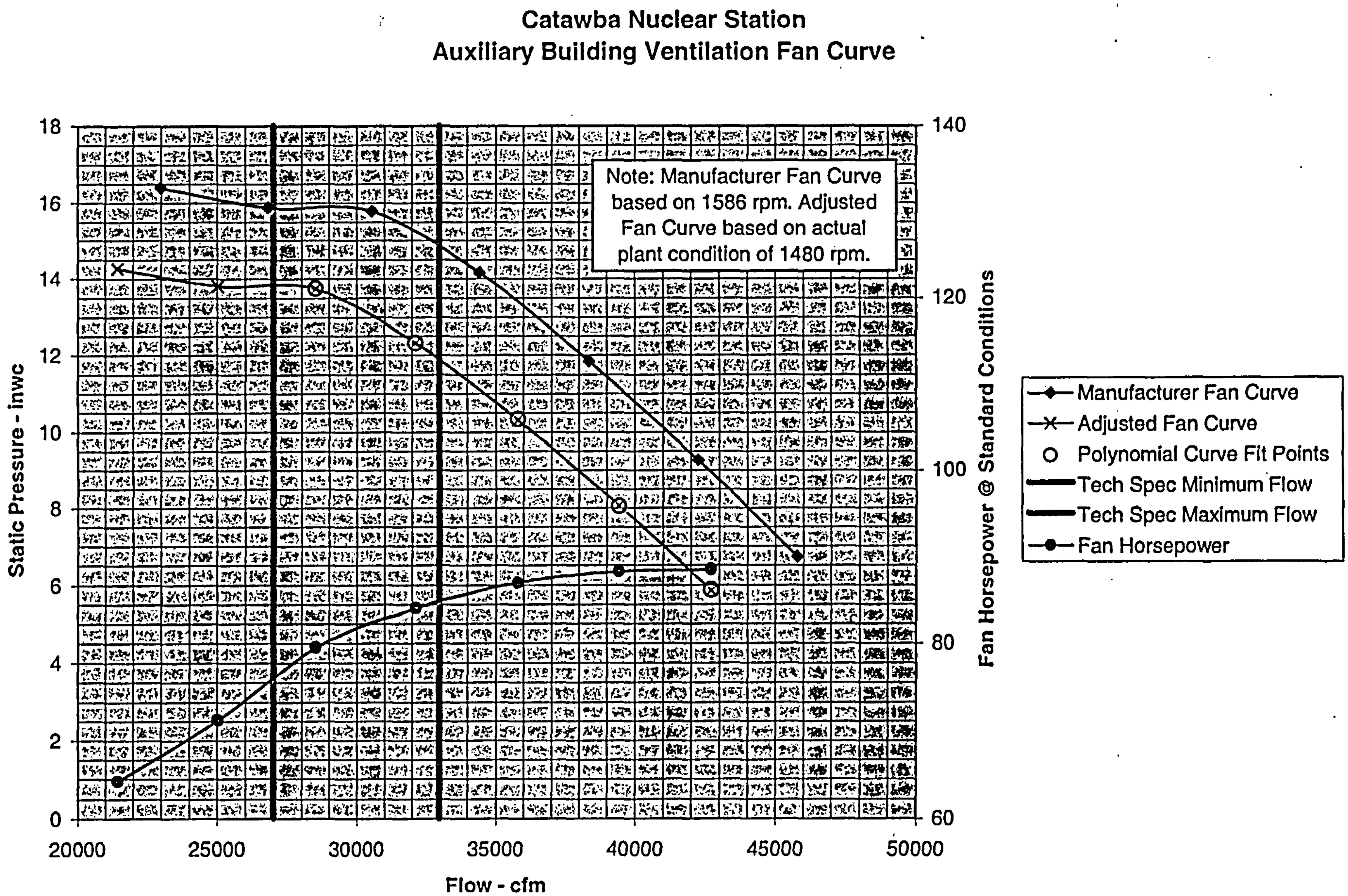

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Memo to File

December 2, 1999

Subject: Catawba Nuclear Station
Auxiliary Building Ventilation System (VA)
Filtered exhaust fans rpm
File: 217.02

Testing was completed on December 2, 1999 to measure Auxiliary Building filtered exhaust fan rotation speed. The following are the results from this testing:

ABFXF-1A has a fan rotation speed of 1471 rpm

ABFXF-1B has a fan rotation speed of 1476 rpm

ABFXF-2A has a fan rotation speed of 1475 rpm

ABFXF-2B has a fan rotation speed of 1476 rpm

Testing was completed by R E Conley. Stobe light (ID No. CNIAC 8118) was utilized during this test. The stobe light has a calibration due date of September 3, 2000.

RE Conley

Ronald E Conley
HVAC Systems Engineer

hvac/va/abfxf rpms

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MISCELLANEOUS ROOMS

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