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Limerick Generating Station, Units 1 and 2
Facility Operating License Nos. NPF-39 and NPF-85
NRC Docket Nos. 50-352 and 50-353

Subject: Control Room Envelope Unfiltered Air Inleakage Test Results, in Response to Generic Letter 2003-01, "Control Room Habitability," Tracer Gas Test Results

References: (1) NRC Generic Letter 2003-01, "Control Room Habitability," dated June 12, 2003

(2) Letter from Michael P. Gallagher (Exelon/AmerGen) to NRC, dated August 11, 2003, "Exelon/AmerGen 60-Day Response To NRC Generic Letter 2003-01, "Control Room Habitability"

(3) Letter from Michael P. Gallagher (Exelon/AmerGen) to NRC, dated December 9, 2003, "Exelon/AmerGen 180-Day Response To NRC Generic Letter 2003-01, 'Control Room Habitability'"

(4) Letter from Michael P. Gallagher (Exelon/AmerGen) to NRC, dated March 19, 2004, "Generic Letter 2003-01, 'Control Room Habitability,' Integrated Control Room Envelope Unfiltered Inleakage Test Schedules"

This letter provides the results of integrated Control Room Envelope (CRE) inleakage testing performed at Limerick Generating Station, Units 1 and 2 during the week of September 13, 2004.

Generic Letter 2003-01, "Control Room Habitability," (Reference 1) requested that licensees provide confirmation that 1) the control room meets the applicable habitability regulatory requirements (e.g., GDC 1, 3, 4, 5, and 19), and 2) the Control Room Habitability Systems (CRHSs) are designed, constructed,

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configured, operated, and maintained in accordance with the design and licensing bases.

References 2 and 3 provided the Exelon/AmerGen 60-day and 180-day responses to reference 1, NRC Generic Letter 2003-01, "Control Room Habitability," dated June 12, 2003. These responses included the commitment for Limerick Generating Station to perform integrated CRE inleakage testing utilizing the American Society for Testing and Materials (ASTM) standard E741, "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution." Reference 4 provided the planned schedule for performance of the testing at Limerick Generating Station, and committed to provide a complete response to the Generic Letter requested information, based on the test results, within 90 days of completion of the test.

The following provides a description of the testing performed and the results.

CRE Inleakage Testing

Reference 1 requested that licensees confirm that the most limiting unfiltered inleakage into the CRE is less than the values assumed for design basis radiological and hazardous chemical analyses. Reference 1 refers to ASTM E-741, "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution," as an example of an acceptable test methodology.

NCS and Lagus Applied Technologies performed the CRE inleakage testing at Limerick Generating Station (LGS) in accordance with ASTM E-741 methodology. This test was completed on September 16, 2004.

Test Configurations

The inleakage test is considered comprehensive if it quantifies all of the unfiltered inleakage associated with the control room envelope for all system modes of operation. The Limerick Main Control Room (MCR) Heating, Ventilation and Air-Conditioning (HVAC) System and Control Room Emergency Fresh Air Supply (CREFAS) System are common to Units 1 and 2. The systems are safety related and active components are designed with redundancy to meet single active failure criteria.

The Control Room Envelope (CRE) consists of the control room, peripheral offices at the west and east ends of the control room, toilet room, and utility room; all on elevation 269'-0". The CRE includes the volume of the MCR HVAC system and the CREFAS system up to their isolation valves. The volume of the CRE, MCR HVAC and CREFAS Systems in the emergency (isolation) mode is approximately 137,000 cubic feet.

The Control Room HVAC System consists of two 100% capacity independent and redundant trains. Each train consists of a 100% capacity supply air-handling unit and a 100% capacity return air fan. The two trains share common supply and return ducts. Normal alignment of the Control Room HVAC System is with one train operating and the second train in standby.

The CREFAS System also consists of two 100% independent and redundant trains. Each train has a 100% capacity return air fan for treatment of recirculated control room air or outside supply air, a set of isolation valves and a high efficiency air filtration unit which consists of an electric heating coil, prefilter, HEPA filter, a charcoal adsorber and a second HEPA filter. The CREFAS system operates following a Design Basis Accident (DBA), chlorine, or toxic chemical accident. The CREFAS System utilizes the Main Control Room HVAC System as a flow path to and from the control room whenever CREFAS is in operation. A simplified schematic of the Control Room HVAC System and CREFAS with MCR HVAC in normal operation is shown on attached Figure 1.

Radiation monitors, toxic chemical detectors, and chlorine detectors continuously monitor air at the control room envelope outside air intake. The detection of high radiation, chlorine or toxic chemical release is alarmed in the control room.

Upon high radiation detection, control room habitability is maintained through automatic initiation of CREFAS via the train(s) that detected the radiation in the radiation isolation mode. Procedural guidance is provided to the operators to complete the isolation of both CREFAS trains if not already performed automatically. In the radiation isolation mode of CREFAS, the normal fresh air intake is isolated; the control room outside air exhaust is isolated; contaminated fresh air is rerouted so that all outside air must pass through the CREFAS emergency charcoal filter before it enters the control room and a portion of the control room air is recirculated through the CREFAS emergency charcoal filter. In the radiation isolation mode, the CREFAS System maintains the Control Room Envelope under a positive pressure (minimum of 1/8 inch W.G. relative to the turbine enclosure, auxiliary equipment room and outside atmosphere) to inhibit the infiltration of outside air, as required by Technical Specifications. A simplified schematic of the Control Room HVAC and CREFAS systems with the CREFAS system in the radiation isolation mode is shown on attached Figure 2.

Upon chlorine detection, the system automatically isolates the control room via the train(s) that detected the chlorine. Procedural guidance is provided to the operators to complete the isolation of both CREFAS trains if not already performed automatically. It also provides indication to Control Room Operators upon detection of other high toxic chemical concentration for manual isolation of the control room utilizing controls available in the control room. To maintain control room habitability during a chlorine or toxic chemical isolation, the Control Room HVAC system is totally isolated from the outside air supply and exhaust paths, with the CRE at neutral pressure (with respect to the turbine enclosure,

auxiliary equipment room and outside atmosphere) and the CREFAS charcoal filters recirculating a portion of the control room air. A simplified schematic of the Control Room HVAC System and CREFAS with CREFAS in the chlorine isolation mode is shown on attached Figure 3.

As described above, the redundant MCR HVAC trains share common ductwork with only the supply and return fans creating separate flow paths. The flowpath of the CREFAS is similar except that the filter assemblies and fans are separate while the supply and return ductwork are common. Thus testing each train separately provided independent testing of the train-specific ductwork to assure all flow paths are tested.

The following CREFAS isolation valves are installed in the common ductwork of the Control Room HVAC System in a series configuration to provide redundancy. Testing each train separately, independently demonstrated the integrity of each of the following isolation dampers:

HV-078-021A/B
HV-078-052A/B
HV-078-057A/B
HV-078-071A/B

Intake air isolation valves HV-078-020A/C and HV-078-020B/D are installed in their respective CREFAS trains, in series upstream of their associated charcoal filter. The valves are normally closed and open only in the radiation isolation mode to admit fresh makeup air into the CREFAS System. Thus, their integrity was verified during operation of the opposite train in the radiation isolation mode.

The CREFAS System has two modes of emergency operation. They are following a Design Basis Accident (DBA) or a chlorine and/or or toxic chemical accident. Following a DBA, CREFAS operates in the radiation isolation mode, isolating the normal intake (HV-078-021A/B) and exhaust paths (HV-078-052A/B, HV-078-057A/B, HV-078-071A/B) in the Control Room HVAC System while admitting fresh makeup air as required into the operating CREFAS charcoal filter to maintain positive MCR pressure. Following a chlorine and/or or toxic chemical accident, CREFAS operates in the chlorine isolation mode, isolating all sources of intake and exhaust to the MCR (this includes the normal intake, and exhaust paths, in the Control Room HVAC System as well as the CREFAS fresh makeup air, HV-078-020A/B/C/D). Because there is no fresh-air makeup, the MCR pressure slowly degrades to a neutral pressure with respect to the Turbine Enclosure, Auxiliary Equipment Room and outside atmosphere.

When an actual isolation signal is received, plant-operating procedures direct the MCR operators to complete the isolation on any channel that has not initiated an isolation signal or complete its isolation such that both trains of CREFAS isolation valves are closed. Table 6.4-1 of the UFSAR, "Control Room Emergency HVAC

System Failure Analysis", states that a redundant isolation valve in series compensates for the failure of an isolation valve.

To provide the most conservative test results, each CREFAS train ('A' & 'B') was tested in the radiation isolation mode with only its train of isolation valves providing isolation. Additionally, testing of the Chlorine Isolation Mode was performed on the 'A' Train as it exhibited the greatest unfiltered inleakage in the radiation isolation mode and with only its train of isolation valves providing system isolation. The adjacent area HVAC systems were left in their normal configurations.

Test Methods

Exelon Corporation contracted NCS and Lagus Applied Technology (LAT) to perform the Control Room Envelope inleakage testing at Limerick Generating Station. Testing was performed with the system aligned in the emergency modes as described above using NCS/LAT procedures that were written in accordance with ASTM E741-00, "Standard Test Method for Determining Air Change Rate in a Single Zone by Means of a Tracer Gas Dilution" using sulfur hexafluoride (SF6) as the tracer gas.

The two radiation (pressurization) mode tests were performed similarly using the Makeup Flowrate/Concentration Decay Test method. The tracer gas was continuously injected into the makeup air stream of the CREFAS system at a known constant rate while the makeup flowrate was measured three times. The tracer gas was then injected into the makeup air stream of the CREFAS system at a higher concentration for an additional period of time. After waiting for the tracer gas to disperse and adequately mix throughout the CRE, a series of five concentration versus time points were obtained at several locations within the CRE. Upon the completion of the decay testing, the tracer gas was continuously injected into the makeup air stream of the CREFAS system at a known constant rate while the makeup air flowrate was measured an additional three times.

Regression analysis was then performed on the logarithm of concentration versus time points to find the best straight-line fit to the data. The slope of the straight line is the volume normalized air inflow rate in Air Changes per Hour (ACH). The six makeup flowrate measurements were averaged to obtain the mean makeup flowrate that existed during the testing. By subtracting the measured CREFAS makeup air flowrate from the measured Total Air Inflow value, the amount of unfiltered inleakage to the CRE that is not provided by filtered makeup air flow was determined in actual cubic feet per minute (acfm).

The chlorine isolation mode test was performed using the 'A' Train of MCR HVAC and CREFAS. The tracer gas was injected into the supply side of the MCR HVAC for approximately 30 minutes. After waiting for the tracer gas to disperse and adequately mix throughout the CRE, a series of five concentration versus

time points were obtained at several locations within the CRE. Regression analysis was then performed on the logarithm of concentration versus time points to find the best straight-line fit to the data. The slope of the line is the air change rate that equates to the unfiltered inleakage.

No mixing fans were used in the CRE during the three tests as previous experience in other nuclear power plant Control Room Envelopes has shown that ventilation air flows into well ventilated rooms are sufficient to thoroughly mix the tracer gas over the time interval that elapsed prior to initiation of sampling. To ensure thorough mixing took place in the air space above the hallway encompassing the Control Room, eleven ceiling tiles were removed. Additional air samples were taken from the air space above the hallway encompassing the Control Room during the decay portion of the testing. The agreement between the concentrations measured at the various points including the additional air samples confirmed that thorough mixing occurred.

During each tracer gas unfiltered inleakage test, differential pressures between the MCR and various surrounding areas were measured using two highly accurate digital barometers. Initially, both barometers were placed next to each other in the MCR and the units were 'zeroed'. One unit was then moved to the various locations and the pressure values noted at time intervals. The indicated pressure values of the unit that remained in the MCR were also recorded at the same time intervals. The mobile unit was then returned to the MCR and both readings were recorded. This allowed a correction to be made for drift between the responses of the two units.

Differential pressures were then calculated between the various locations by differencing the drift corrected values of the two digital barometers. Elevation corrections were made to the readings of the mobile barometer to ensure that the appropriate differential pressure was determined. To facilitate this correction, a local pressure gradient was calculated using the barometric equation assuming a temperature of 70 degrees F.

Results

The following tabulates the results of the above testing:

Test	CREFAS Mode	Train In Service	Unfiltered Inleakage (ACFM)	Uncertainty (ACFM)	Outside Air Makeup Flow (SCFM)
1	Radiation / Pressurization	'B' Train	63	+/- 69*	73 +/- 68
2	Radiation / Pressurization	'A' Train	77	+/- 13*	50 +/- 11
3	Chlorine / Toxic Gas Isolation (Pressure neutral mode)	'A' Train	75	+/- 4*	N/A

* Uncertainty is reported at the 95% confidence level. Per Reg. Guide 1.197 Section 1.4 Inleakage rates below 100 cfm do not require the application of an uncertainty value.

Results of the two tests while in a radiation isolation (pressurization mode) indicate that the unfiltered inleakage into the CRE was slightly greater than the maximum design analysis assumption unfiltered inleakage of 50 scfm.

The results of the inleakage test while in a chlorine isolation (pressure neutral mode) indicate an unfiltered inleakage of 75 cfm. This is below the maximum design analysis assumption unfiltered inleakage value of 525 scfm.

Measurement of differential pressure verified that the Main Control Room was maintained at a positive pressure of at least 1/8-inch water gauge relative to the Turbine Enclosure, Auxiliary Equipment Room and outside atmosphere with an outdoor air flow rate less than 525 scfm while in the radiation isolation mode of operation.

<u>Operability of the CRE Envelope</u>

The control room HVAC system and CREFAS system ensure the control room is habitable for continuous occupancy of personnel and equipment during normal and design bases accident conditions. With the unfiltered inleakage greater than the 50 scfm assumed in the site's radiological dose calculation, it may result in a higher operator dose exposure than allowed by GDC 19 during an accident condition. With operators exposed to higher doses, the potential exists that the MCR will not be habitable for safe plant operation and that MCR habitability (operator doses) is potentially challenged.

Habitability of the MCR was evaluated, and it was verified that the increased inleakage values do not challenge operability of the MCR envelope and that the main control room HVAC system and CREFAS are still capable of performing all of their safety related design functions even with an unfiltered in-leakage value exceeding that assumed in the radiological dose analysis.

Based on TID-14844 source term, the current LGS design basis accident analysis control room operator dose is 4.7 rem whole body and 9.09 rem thyroid, assuming 50 scfm unfiltered inleakage in the Radiation Isolation Mode. The current LGS design basis accident analysis control room operator dose in the Chlorine Isolation Mode of operation is 4.7 rem whole body and 21.9 rem thyroid, assuming 525 scfm unfiltered inleakage in the Chlorine Isolation Mode (Reference UFSAR Table 15.6-22). The maximum measured inleakage rate of 77 cfm, described above, results in a dose to the control room operator in excess of 30 rem thyroid, which exceeds the GDC 19 limits of 30 rem thyroid.

A reanalysis of the LGS design basis accident radiological dose calculations, using Alternative Source Term methodology in accordance with 10 CFR 50.67 and R.G. 1.183, concluded that with control room envelope unfiltered inleakage as high as 525 scfm in the Radiation Isolation Mode, the bounding dose to the control room operator is 4.02 rem TEDE, which corresponds to 3.14 rem whole body and 25.48 rem thyroid. These dose results remain within the 10 CFR 50, Appendix A, GDC 19 limits (5 Rem whole body, 30 Rem thyroid). Note that the existing design basis allows up to 525 scfm unfiltered inleakage in the Chlorine Isolation Mode. LGS has submitted a License Amendment Request to revise the licensing basis to use Alternative Source Term (AST) methodology. This License Amendment Request was submitted to the NRC on February 27, 2004. Although the NRC staff has not yet approved this License Amendment Request, use of AST analytical results, in terms of whole body and thyroid dose, confirms that the LGS control room envelope remains operable. Use of AST analytical results for operability determinations involving control room envelope inleakage is consistent with the NEI Final White Paper, "Use of the Generic Letter 91-18 Process and Alternative Source Terms in the Context of Control Room Habitability," dated June 2004

The LGS design basis accident analysis control room operator dose, using Alternative Source Term and an assumed control room envelope inleakage rate of 525 scfm, which bounds the most limiting measured inleakage rate of 77 cfm, remains within the 10 CFR 50, Appendix A, GDC 19 limits of 5 rem whole body and 30 rem thyroid. Therefore, LGS has demonstrated that the most limiting unfiltered inleakage into the control room envelope is bounded by the value assumed in the design basis radiological AST analyses for control room habitability.

The above information completes the Limerick Generating Station response to Generic Letter 2003-01, "Control Room Habitability," requested information Items 1(a) and 1(b).

No new regulatory commitments are established by this submittal. If you have any questions or require additional information, please contact Mr. David J. Distel at (610) 765-5517.

Sincerely,

Ron J. DeGregorio
Vice President-LGS

Attachments: 1. Figure 1 Control Room Ventilation – Normal Flowpath (No Isolations)
2. Figure 2 Control Room Ventilation – Radiation Isolation Flowpath
3. Figure 3 Control Room Ventilation – Chlorine Isolation Flowpath

cc: Regional Administrator, NRC Region I
NRC Project Manager, NRR – Limerick Generating Station
NRC Senior Resident Inspector – Limerick Generating Station
R. R. Janati, Commonwealth of Pennsylvania

Figure 1

CONTROL ROOM VENTILATION

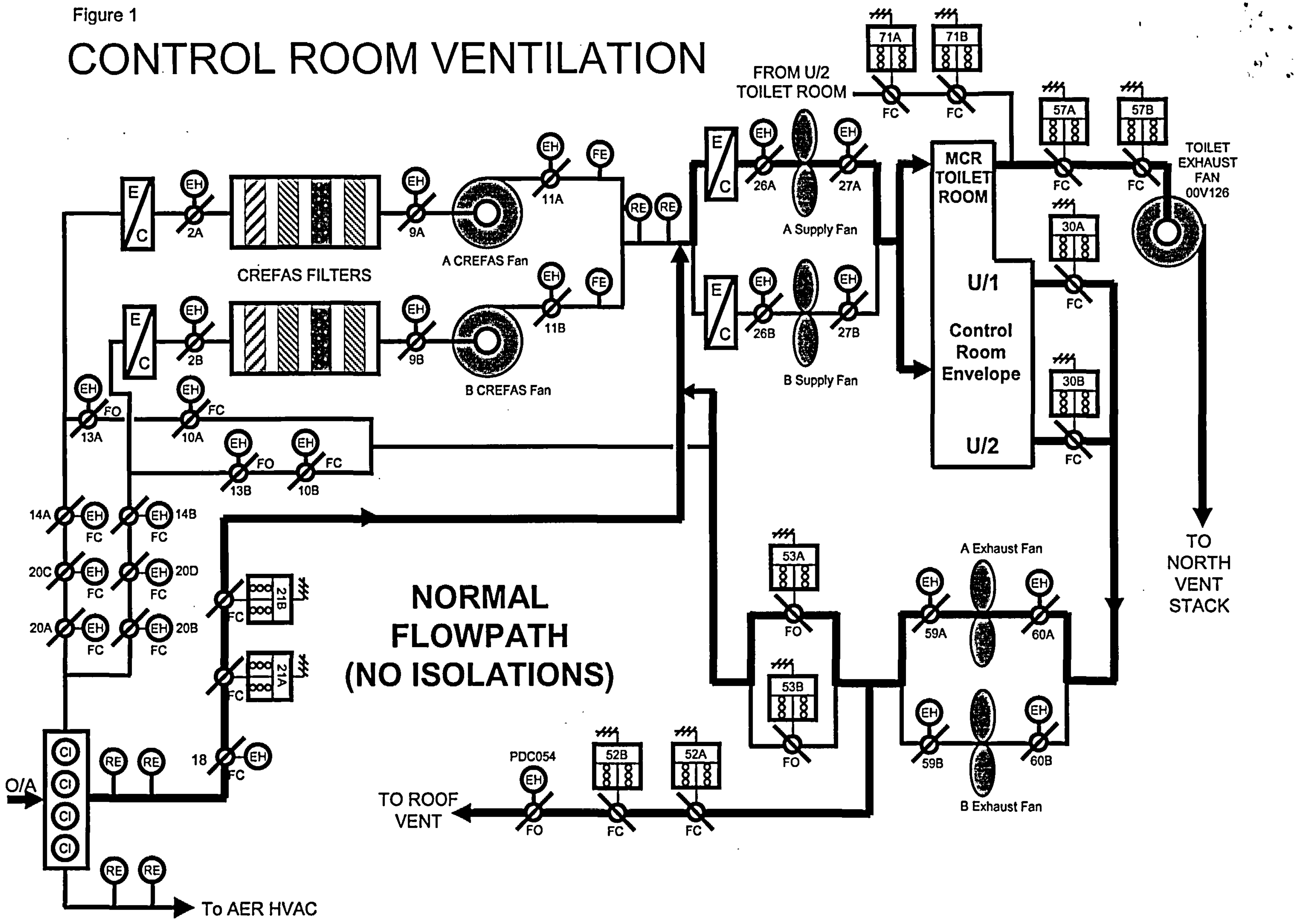

Figure 2

CONTROL ROOM VENTILATION

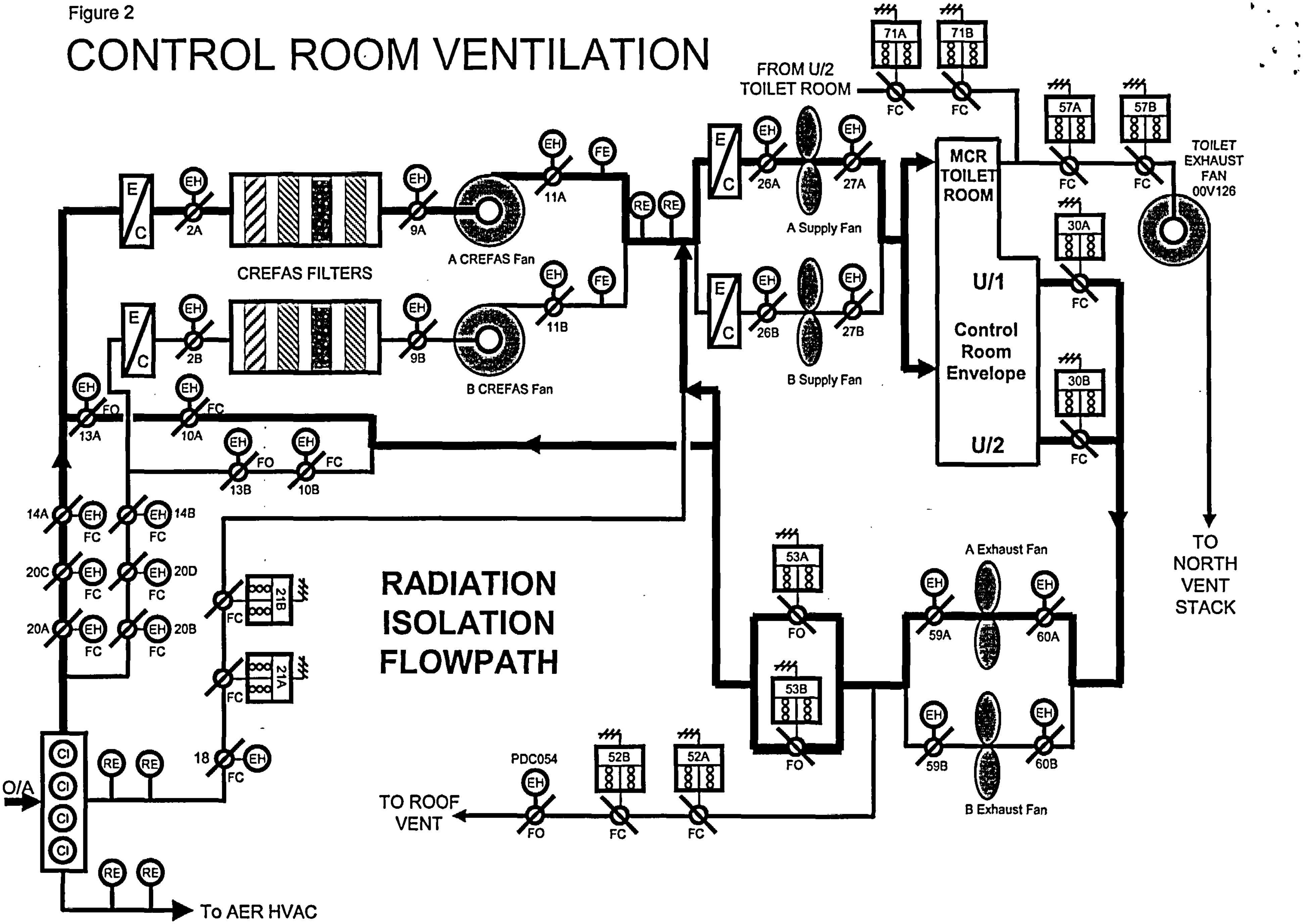

Figure 3

CONTROL ROOM VENTILATION