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Research Article

Design Change and Operational Consideration of the HVAC System during Nuclear Power Plant Decommissioning

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The heating, ventilation, and air conditioning (HVAC) system plays a crucial role in ensuring the safety of workers and preventing the release of gaseous radioactive materials into the environment during the decommissioning of a nuclear power plant (NPP). To establish an HVAC operation strategy, decommissioning phases were divided into four stages, and the HVAC systems were reclassified. In addition, assumptions have been made regarding design modifications and maintenance for the reactor containment building (RCB) HVAC, fuel handling building (FHB) HVAC, and main control room (MCR) HVAC. Based on these, for RCB HVAC operation, natural ventilation and RCB purge operation during the transition period are proposed. In the decommissioning stage, recirculation operation, entire ventilation operation consisting of continuous operation and purge operation, and finally partial ventilation operation to purify local space were proposed. Moreover, during the transition period, the FHB HVAC was proposed to operate as normal NPP, and the MCR HVAC was suggested to operate with safety-related equipment removed.

1. Introduction

In a normal nuclear power plant (NPP), the heating, ventilation, and air conditioning (HVAC) system typically serves the functions of air purification and ventilation, temperature and humidity control, and pressure regulation within specific spaces. To achieve these functions, the HVAC system continuously purifies the air using filters; adjusts temperature and humidity with heaters, coolers, and humidifiers; and regulates the air pressure in the respective space by controlling the inlet and outlet air flow rates. Furthermore, the HVAC system is interconnected with the engineering safety features (ESF) system and the radiation monitoring system (RMS) to prevent the release of gaseous radioactive materials into the environment when radioactive substances exceeding a specific limit are detected, using block valves or dampers.

During the NPP decommissioning period, the HVAC system plays a critical role in purifying and ventilating the air in the work area, creating a suitable working environment, and ensuring the safety of workers from internal exposure.

In NPP decommissioning sites where nuclear fuel is removed from the reactor core and various dismantling activities occur simultaneously, the HVAC system remains essential until the decommissioning is completed. Therefore, considering the maintenance and modification of HVAC systems used during decommissioning and establishing operational strategies before commencing NPP decommissioning are important.

This paper will propose general operation guidelines for the reactor containment building (RCB) HVAC, fuel handling building (FHB) HVAC, and main control room (MCR) HVAC based on the HVAC systems of the optimized power reactor 1000 (OPR 1000) and advanced power reactor 1400 (APR 1400).

2. HVAC Operation Plan According to the Decommissioning Phase

The decommissioning phase of an NPP is largely divided into prior phase, active phase, and end phase, and specifically proceeds in the order of preparatory phase, permanent shutdown, transition period, implementation of decommissioning, release from control, and end state [1].

Preparatory phase involves the development of a decommissioning plan, which outlines the strategies, goals, and regulatory requirements for the decommissioning process. Site characterization and assessment studies are conducted to understand the current condition of plants and potential environmental impacts. Necessary permits and licenses are obtained, and financial provisions are made for the decommissioning activities. The permanent shutdown phase involves the safe and controlled shutdown of the nuclear reactor.

During transition period, the plant is prepared for long-term maintenance and surveillance, including the removal of fuel from the reactor and its transfer to a spent fuel storage facility.

During the implementation of the decommissioning phase, decontamination, dismantling, demolition and waste management of major systems, structures, and components (SSCs) are performed. In the decontamination phase, decontamination activities are carried out to reduce radioactivity levels and remove radioactive substances from surfaces and equipment.

Decontamination activities aim to reduce occupational and environmental risks during subsequent decommissioning steps. The dismantling phase includes the physical dismantling and removal of plant SSCs. Equipment, piping, and other plant components are disassembled, decontaminated, and packaged for waste management and disposal. Waste management phase focuses on the management and disposal of various types of radioactive waste generated during the decommissioning process. Different waste streams are classified, segregated, packaged, and stored in appropriate facilities for short-term or long-term storage. Some waste may undergo treatment processes, such as compacting, solidification, or encapsulation, before final disposal.

Finally, in release from the control phase, once dismantling and waste management activities are completed, the site is remediated to meet predetermined criteria and regulatory requirements. Final radiological surveys and environmental monitoring are conducted to ensure that the site is safe for unrestricted use or for its intended future purpose. Regulatory authorities grant the final release, indicating that the decommissioned site no longer poses significant radiological risks.

It is important to note that the duration and specific activities within each phase may vary depending on factors such as the design, size, condition, regulatory requirements, and available resources of the plant.

Figure 1 shows the overall HVAC operation plan according to the decommissioning phase. Reclassification and design modification of the HVAC system for decommissioning begins in the preparatory phase and is completed during the transition period. The HVAC selected for decommissioning is operated during the transition period and implementation of decommissioning stages. HVAC systems that are no longer required for use are dismantled.

3. Reclassification of the HVAC System for Decommissioning

It should be determined whether HVAC systems used during normal operation will also be needed during the decommissioning phase, when they will be used, and whether any modifications will be needed to enable them to be used [2]. Figure 2 illustrates the reclassification process for existing HVAC systems. It does not include the HVAC system that will be newly installed for decommissioning. Initially, existing HVAC systems for decommissioning are categorized into operation required HVAC systems and immediate demolition HVAC systems. Operation required HVAC systems are further subdivided into those needed during the transition period, decommissioning phase, or both phases, with each category being classified as requiring modifications or not.

Table 1 presents the reclassification results according to the reclassification process of the HVAC system in Figure 2 based on the systems of OPR1000 and APR1400. The results of reclassification may vary depending on factors such as decommissioning method, period, and specific characteristics of the NPP systems.

4. HVAC Design Considerations for Decommissioning

4.1. General Design Considerations. In the NPP decommissioning, the HVAC design is typically subject to modification or retention, considering safety requirements, the establishment of an appropriate working environment, and cost-effectiveness. During the transition period, a lot of systems are stopped after permanent shutdown, leading to a significant reduction in the need for operational HVAC systems compared to normal operation. Therefore, within the boundaries of ensuring safety, considerations such as reducing the capacity of existing HVAC systems, shortening operational durations, reducing operable trains, and dismantling unnecessary SSCs need to be made while taking economic feasibility into account.

During the decommissioning phase, depending on the types of decontamination and decommissioning tasks, it becomes necessary to predict the generation of high radionuclides and dust in certain areas. In such cases, HVAC system design criteria, including air supply flow, air exhaust flow, temperature, and other factors, need to be redefined. Specifically, areas where high radionuclides and a lot of dust

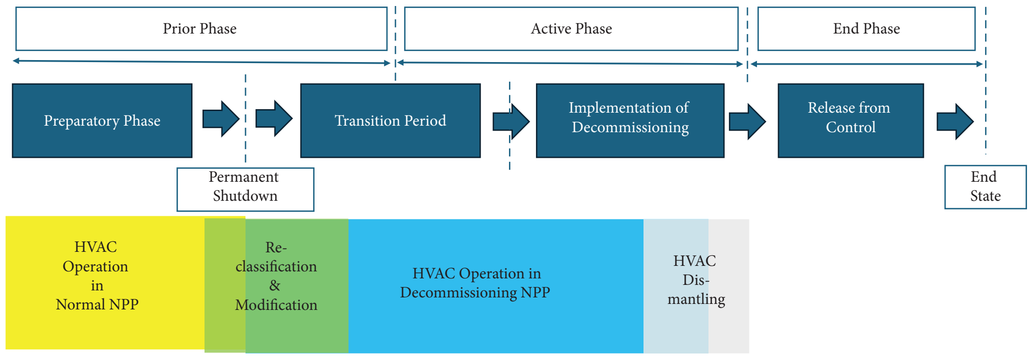

Figure 1: Decommissioning phase and overall HVAC operation plan [1].

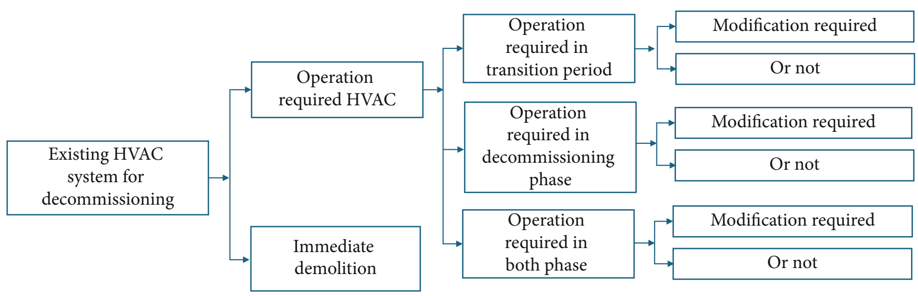

Figure 2: Reclassification process of the HVAC system.

are generated must be maintained under negative pressure to prevent the dispersion of radioactive particles. In these instances, HVAC systems in most areas of the decommissioning NPP primarily focus on air purification and ventilation to comply with the ALARA (as low as reasonably achievable) principle, rather than cooling and heating functions. Furthermore, considerations for the removal of SSCs that are no longer necessary, such as FHB HVAC and MCR HVAC should be considered.

Meanwhile, the radiological impact to decommissioning workers due to the operation of multiple adjacent NPPs is not significant [3]. Therefore, this external factor is not reflected in design considerations.

In this section, design modification and maintenance for RCB HVAC, FHB HVAC, and MCR HVAC systems are proposed to establish HVAC operation strategies in the next step.

4.2. RCB HVAC Design Considerations. During the decommissioning of NPP, the conditions in the RCB are significantly different from normal operation. The presence of thermal loads such as reactor and steam generator are removed, and the temperature conditions during normal operation were between 10°C and 49°C [4]. Consequently, in terms of temperature control, the RCB can be operated with conditions that reflect the ambient temperature of a typical workspace [5].

Figure 3 illustrates the assumptions for design modification and maintenance of the RCB HVAC and purge system [6]. SSCs that are no longer necessary, such as the control element drive mechanism (CEDM) cooling fans that cool CEDM during normal operation and the reactor cavity fans that supply cooled air to the lower reactor space, will be removed. In addition, it is assumed that two out of the four reactor containment fan coolers (RCFC), which are responsible for cooling the RCB atmosphere, will be dismantled due to the absence of thermal loads. Moreover, portable new air conditioner units will be added to specific local areas where work is performed to regulate the workspace temperature when outdoor conditions are excessively high or low.

On the other hand, for maintaining accessibility in the RCB, creating a suitable working environment, and ensuring worker safety, it is necessary to supply outdoor air to the RCB and conduct ventilation to the external environment after purification. To achieve this, the existing RCB high-volume and low-volume purge systems with air purification capabilities within the RCB, which are operated during normal operation and overhaul periods, will retain their design as shown in Figure 3. In addition, the local recirculation fans, including the steam generator enclosure recirculation fan and annulus area recirculation fan, which assist in circulating air in the RCB during ventilation operations using the RCB purge system, will also be retained in conjunction with the remaining reactor RCFC, as shown in Figure 3. However, it is important to note that local recirculation fans may disperse radioactive particles. Therefore, they will only be used during the transition period and will not be utilized during the implementation of decommissioning.

Table 1: HVAC systems reclassified for decommissioning.

HVAC system		Operation required		Immediate demolition	Modification required
		Transition period	Decommission-ing phase		
Primary	Control room	√			√
	ECCS equipment area			√	
	RCB	√	√		√
	RCB purge	√	√		√
	Aux building	√			√
	Compound building	√			
	Fuel handling building	√			
	C-1E electrical equipment area			√	
	ESW intake structure	√			
Secondary	Turbine generator building	√	√		√
	Miscellaneous building	√			
	Cold machine shop	√			
	CW intake structure	√			
	Low and medium rad waste interim building	√	√		
	Technical support centre			√	

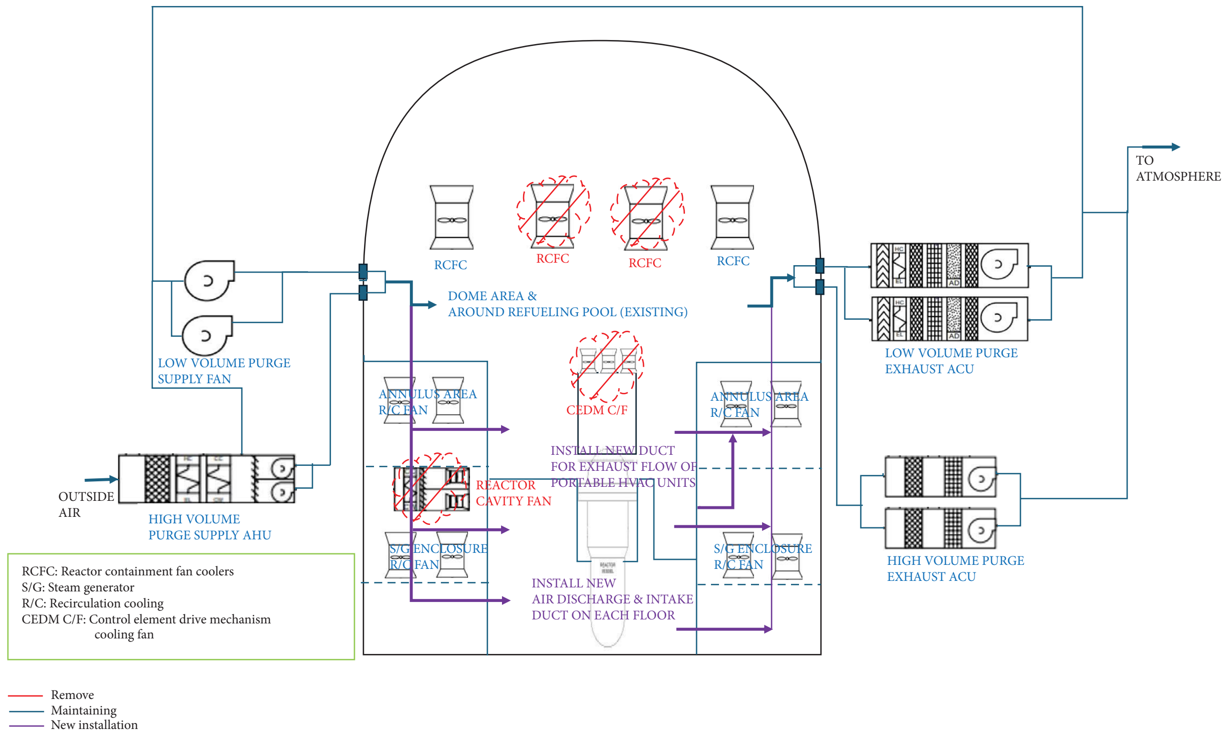

Figure 3: Design modification and maintenance of RCB HVAC and purge system [6].

The inlet ducts for air intake and the outlet ducts for air discharge of the existing RCB purge system are concentrated in the dome area and around the refuelling pool. Therefore, to ensure efficient ventilation throughout the entire RCB, some of the air intake and air discharge ducts of the RCB purge system will be extended and distributed to each floor of the RCB, allowing for the formation of air ventilation flow. These modified ducts will be used during the implementation of decommissioning.

Furthermore, in areas where high dust and high radioactive particles are generated, portable temporary HVAC units for air purification will be installed to prevent dispersion. The exhaust flow of portable temporary HVAC units is connected to the exit duct of the RCB purge system.

In the RCB ventilation process, it is desirable to maintain the engineered safety features actuation system (ESFAS), including the containment purge isolation actuation signal (CPIAS) and containment isolation actuation signal (CIAS), on a conservative basis. In other words, an interlock system is needed to shut off the exit valves of the purge system upon detecting radiation levels above a safety setpoint, preventing the release of radioactive materials into the environment. However, if the ESF system is dismantled, alternative devices need to be installed.

4.3. FHB HVAC Design Considerations. During the defueled plant operation period, all spent nuclear fuel is transferred from the reactor core to the spent fuel pool (SFP) and stored for more than 5 years. In this period, the fuel handling building (FHB) HVAC is designed to maintain the temperature of the fuel handling area at the design temperature of 10°C to 40°C, as in normal operation, and maintain the building at a slight negative pressure to prevent the spread of contaminants. Therefore, FHB HVAC must maintain the same design as during normal operation, as shown in Figure 4 [6].

In addition, the SFP cooling pump must be capable of operating both trains to cool the decay heat from spent fuel to the appropriate level conservatively in terms of diversity. Therefore, the cubicle coolers that cool the air in the SFP cooling pump room must maintain the same level of equipment design as during normal operation.

Meanwhile, the FHB emergency exhaust air control unit (ACU), which is a safety class, can maintain the existing design and be operational in preparation for spent fuel handling accidents when fuel is transferred from the reactor core to the SFP or from the SFP to the spent fuel intermediate storage facility.

Moreover, ESFAS – fuel handling area emergency ventilation activation signal (FHEVAS) automatically starts the FHB emergency exhaust ACU and stops the FHB normal supply air handling unit (AHU) and normal exhaust ACU if the dose rate in the fuel handling area exceeds the allowable range. Through this, the contaminated air is purified through various filters of the emergency exhaust ACU and discharged out of the building, and the building continues to maintain a slightly negative pressure.

4.4. MCR Design Considerations. Until the replacement of MCR with a new decommissioning surveillance room, MCR HVAC needs to remain operable to ensure the habitability of the operators. However, its functionality may be reduced

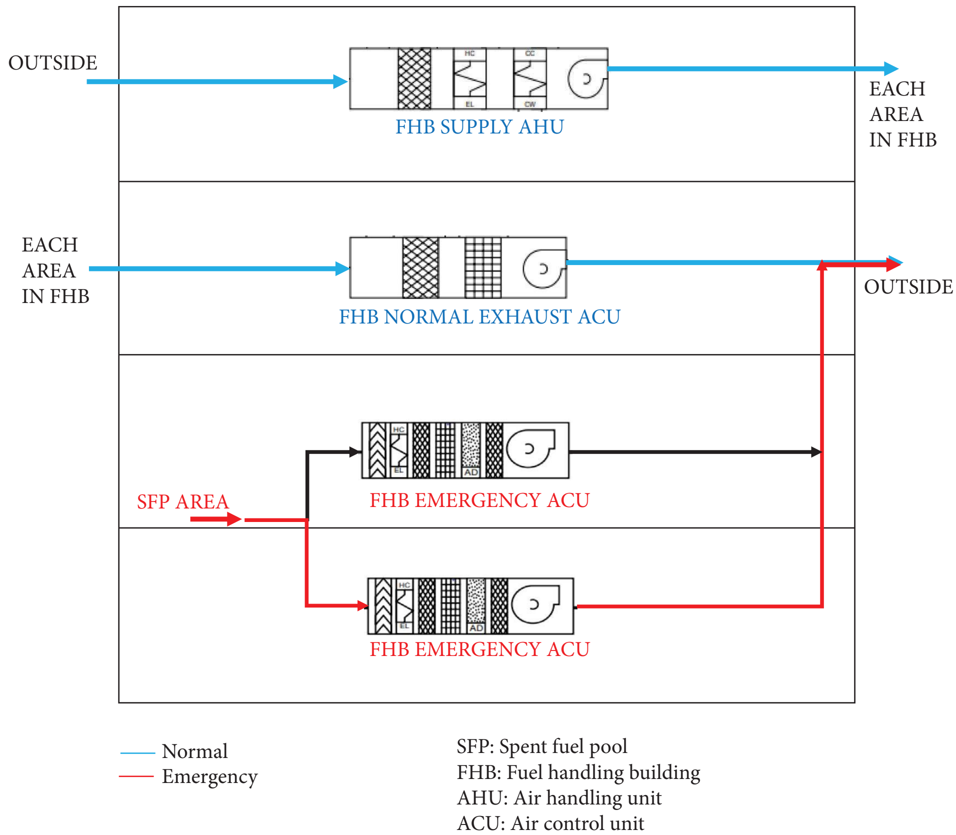

Figure 4: Design maintenance and operation of FHB HVAC in the transition period [6].

compared to normal operations. MCR provides adequate radiation protection to operators in accident conditions, as well as accessibility to MCR [7]. To achieve this, the engineered safety feature actuation system's control room emergency ventilation actuation signal (ESFAS-CREVAS) and control room emergency makeup ACU need to remain operable. In other words, if high radiation dose rate above limits is detected at the intake air, ESFAS-CREVAS is activated, and emergency makeup ACU starts to purify contaminated outside air to supply to MCR.

However, in the decommissioning NPP, accidents such as loss of coolant accident do not occur, and potential spent fuel handling accidents are limited to the interior of RCB or FHB. Therefore, the radiation control requirements of 10 CFR 50 Appendix A, criterion 19 [7], allowing access and occupancy of the control room under accident conditions, are not required. As a result, MCR environmental conditions can be relaxed to the level of a general office. ESFAS-CREVAS and MCR emergency exhaust fans can be removed as they are no longer necessary. In addition, considering the ventilation conditions at the general workplace level, recirculation of the air inside the MCR is unnecessary. Therefore, the recirculation duct can be deleted. The supply AHU, which was designed in two trains in terms of diversity, can remove a train, and the smoke removal fan, which removes smoke in the event of a fire, can be removed as the importance of MCR decreases. The supply AHU supplies clean air to toilets, kitchens, dining room, locker rooms, and shower rooms. However, unnecessary supply-related ducts would be blocked and removed. Figure 5 shows design modification and maintenance of the MCR HVAC system [8].

Table 2 comprehensively represents the assumed design changes or maintenance of HVAC systems to establish NPP decommissioning strategies. The advantage of the design change shown in Table 2 is that the cost of installing new facilities can be minimized by maintaining the function of existing facilities as much as possible instead of installing new facilities for decommissioning. In addition, operators with extensive operating experience in normally operating NPPs can be utilized, thereby reducing training costs and time. Above all, the most important advantage is that the functions and performance of RCB, MCR, and FHB HVAC, which are guaranteed to be safe when designing NPP, can be used even when decommissioning.

5. HVAC Operation Strategy for Decommissioning

5.1. RCB HVAC Operation Strategy

5.1.1. Transition Period. During the transition period, there is no direct work that causes highly radioactive materials and high dust in the RCB. However, system drainage, decontamination of some facilities, demolition of non-radioactive systems, design changes, and new installation

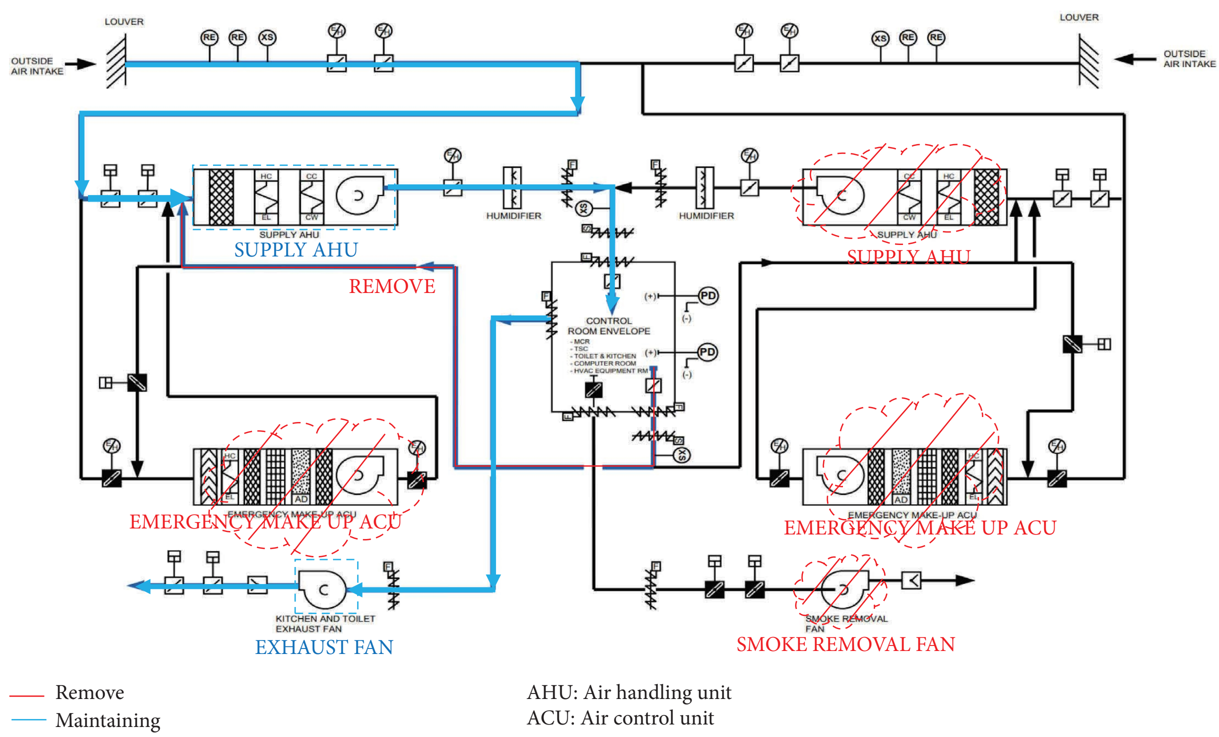

Figure 5: Design change and operation of MCR HVAC system [8].

work of various systems in preparation for the implementation of decommissioning phase are performed. Therefore, HVAC operation is required to maintain accessibility inside the RCB and create a working environment.

The RCB HVAC operation strategy is largely presented as a method of keeping external entrance such as equipment hatch open without HVAC operation and a method of intermittently operating the existing RCB purge system in the transition period. First, the method of opening the external entrance and using natural ventilation is used even in the no mode state when there is no fuel in the reactor core during the overhaul period of a normal NPP. However, this approach can only be employed when it is confirmed that all radioactive system fluids and radioactive particulate materials in the RCB have been either removed or decontaminated, and there is no possibility of new radioactive materials being released into the RCB atmosphere during the work. While this method offers cost-effectiveness, it may pose challenges in achieving adequate ventilation throughout the entire building, as it is sensitive to external factors such as temperature, humidity, and the potential entry of biological organisms.

Meanwhile, purge operation, which operates the existing RCB purge system intermittently, is used when it is necessary to improve air quality in the RCB. The RCB purge system consists of a low-volume purge system and a high-volume purge system. It takes about 40 hours for the low-volume purge fan and about 1 hour for the high-volume purge fan to ventilate the entire air of the RCB [9]. Therefore, depending on the level of air pollution, a high-volume purge system or low-volume purge system would be selectively used considering the appropriate ventilation speed. Since air pollution is generally not significant during the transition period, low-volume purge fan operation is expected to be sufficient. Currently, operating the RCFC and the local recirculation fans, including the steam generator enclosure recirculation fan and annulus area recirculation fan together, help circulate air inside the RCB and increase ventilation efficiency. Figure 6 shows the RCB ventilation operation strategy during the transition period using the low-volume purge fan of the RCB purge system and the RCFC and local recirculation fan of the RCB HAVC system simultaneously [6]. In fact, the OPR1000 and APR1400 perform RCB purge operation by simultaneously operating a low-volume purge fan and RCFC during the overhaul period, which is like the transition period.

5.1.2. Implementation of Decommissioning. When the decommissioning process for the SSCs in the RCB begins in earnest, significantly higher dose of radioactive particles and dust are generated, especially when cutting the reactor vessel, reactor vessel internals, the reactor coolant system, and the concrete surrounding the reactor.

The operation strategy largely consists of recirculation operation to purify the inside of the building, entire ventilation operation, and partial ventilation operation for areas where large amounts of air pollutants are locally generated. During recirculation operation and entire ventilation operation, instead of RCFC and local recirculation fan, a new extension duct of the RCB purge system placed on each floor is used. Through this, the spread of air pollutants is

Table 2: Design considerations for decommissioning.

System	Remove	Maintenance	New installation
RCB HVAC and purge	RCFC (2 EA), CEDM cooling fan, reactor cavity fan	RCFC (2 EA), SG enclosure R/C fan, annulus area R/C fan, all of purge system, ESFAS or alternative	Portable temporary HVAC units, air discharge and intake duct for RCB purge system on each floor, duct for portable temporary HVAC units
FHB HVAC	—	All system, ESFAS	—
MCR HVAC	Supply AHU (1 train), emergency make up ACU (2 trains), smoke removal fan, MCR recirculation duct, ESFAS	Supply AHU (1 train), exhaust fan	Temporary HVAC units

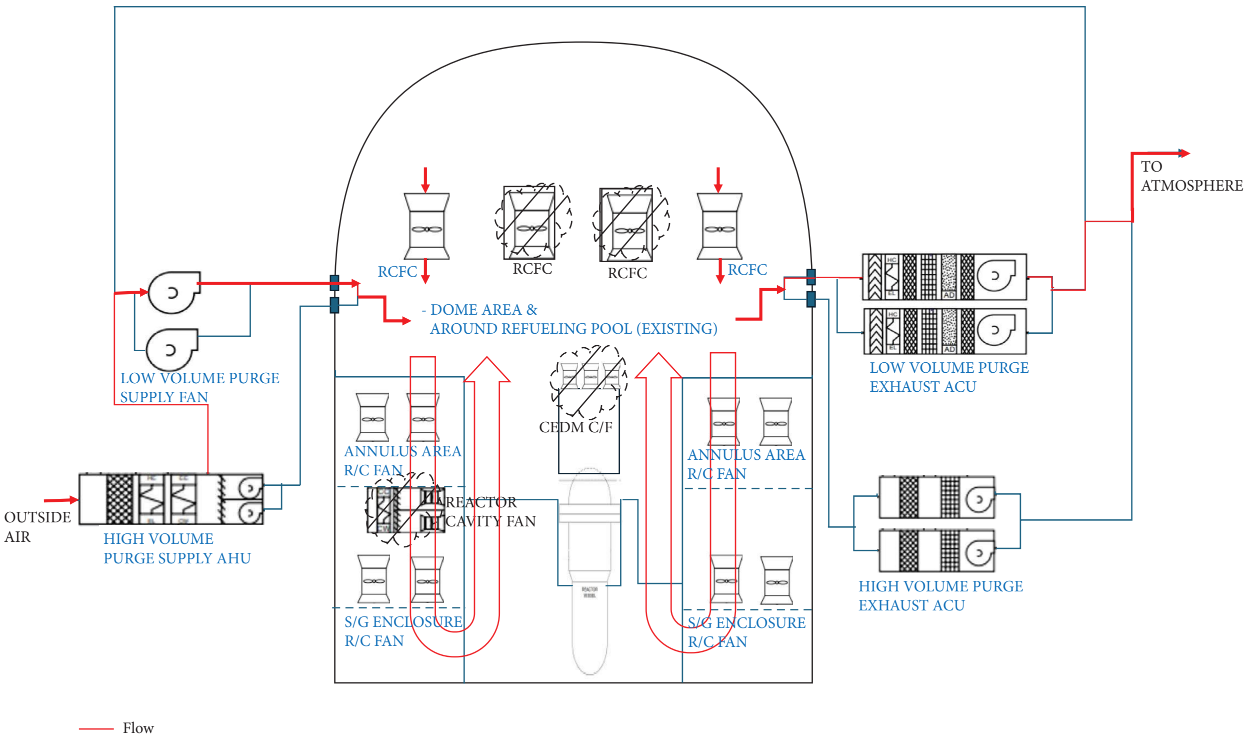

Figure 6: RCB ventilation strategy in the transition period [6].

minimized and fresh, filtered outdoor air is supplied to each floor. Air inside the RCB is sucked in directly from each floor, passed through a HEPA filter, and then discharged outside the RCB.

(1) Recirculation Operation. Recirculation operation is an operation method that recirculates the air in the RCB by starting the low-volume purge exhaust ACU and low-volume purge supply fan while the outside air intake valve and internal air discharge valve are closed. Currently, the air in RCB is purified by passing through the pre filter, HEFA filter, carbon absorber, and postfilter in the low-volume purge exhaust ACU. The recirculation operation is performed before the entire ventilation operation, such as continuous exhaust operation or purge operation, to purify the air inside the RCB to below the emission standard. Alternatively, the air inside the RCB is purified when many pollutants are released into the RCB during decommissioning and exceed the emission standards. Figure 7 shows recirculation operation using a low-volume purge system [6].

(2) Entire Ventilation Operation. RCB entire ventilation is divided into continuous operation and purge operation. The difference between the two-operation strategies is continuous or intermittent, and the operation methods and components are the same. The continuous operation method is shown in Figure 8 [6]. First, start the low-volume purge exhaust fan and purify the air by passing it through a moisture separator, an electric heating coil, a prefilter, a HEPA filter, a carbon adsorber, and a postfilter and continuously discharge it. Next, the low-volume purge supply fan is started to continuously supply outdoor air that has passed through the front filter, cooling coil, and heating coil to the RCB. Continuous operation strategy would be used when continuous air pollutants are created during work inside the RCB.

Figures 8 and 9 show the entire RCB ventilation operation using a low-volume purge fan and a high-volume purge fan, respectively [6]. Assuming that, as in normal NPP operation, one supply fan is operated at low-volume purge and two supply fans are operated at high-volume purge. The 100% capacity of the high-volume purge supply fan is 83300 cfm (41650 cfm x 2), which is about 40 times larger than the 100% capacity of the low-volume purge supply fan of 2550 cfm. Therefore, the high-volume purge system is not desirable for continuous operation because it causes excessive air flow and noise, which impairs work convenience. In addition, since the high-volume purge exhaust ACU does not have a carbon adsorber to remove gaseous radioactive iodine, it is necessary to analyze the composition of the atmosphere inside the RCB before operating.

On the other hand, purge operation is a method used during the normal operation of the NPP, overhaul period, and transition period in decommissioning. Purge operation is a strategy of intermittently operating the low-volume purge system or high-volume purge system only when it is necessary to improve air quality in the RCB. Purge operation is more economical than continuous operation and

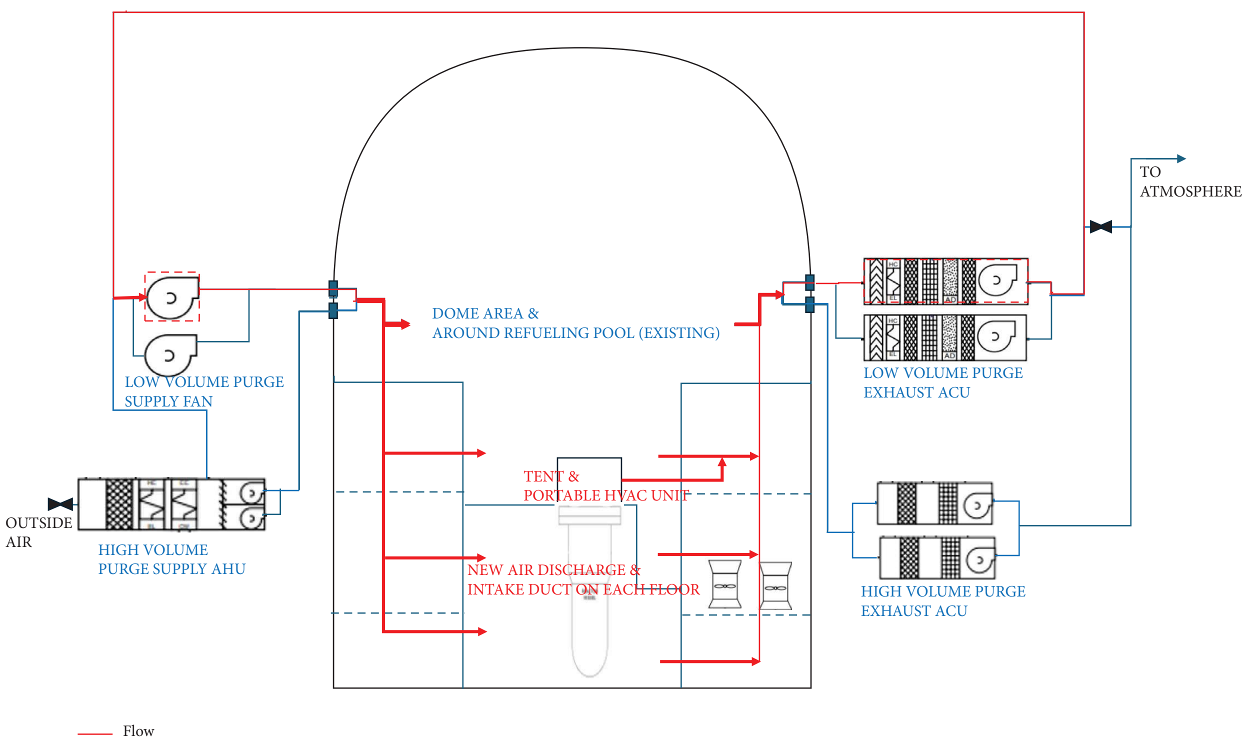

Figure 7: RCB HVAC recirculation operation in the decommissioning phase [6].

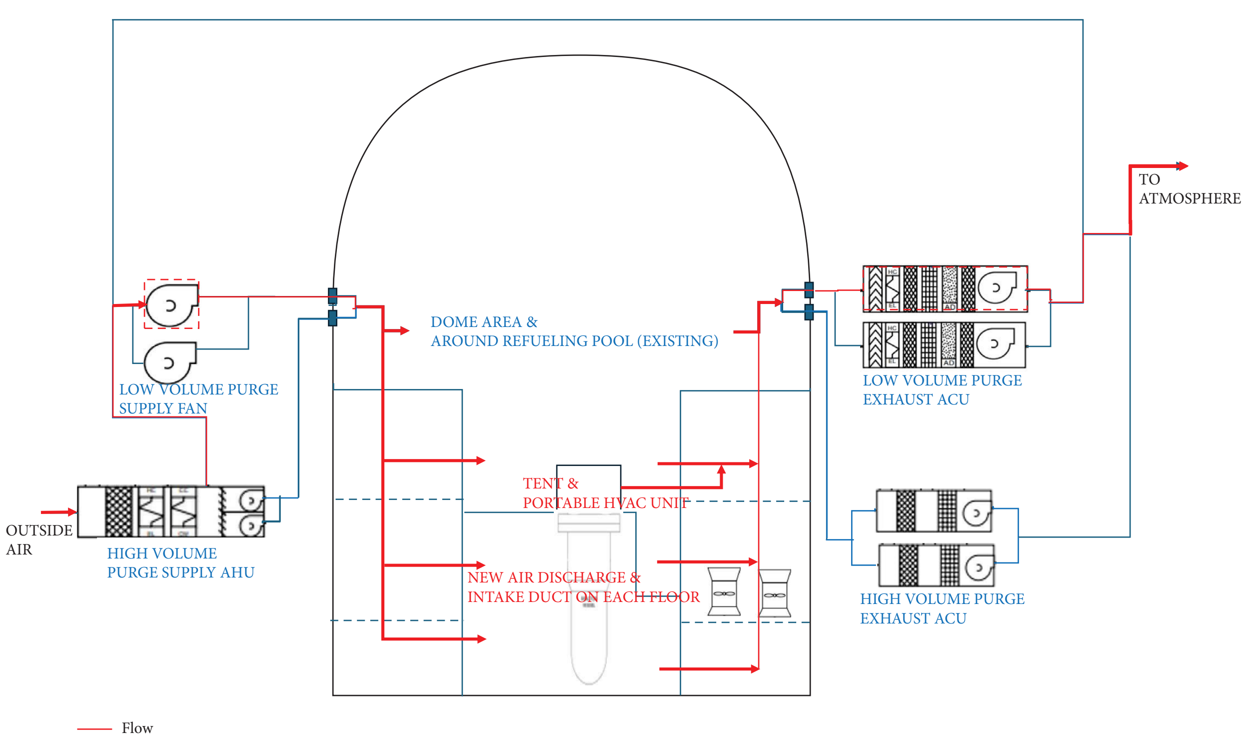

Figure 8: Entire ventilation operation using low-volume purge in the decommissioning phase [6].

is used when the amount of radioactive suspended particles or dust generated inside the RCB is relatively small and not continuous.

The XOQDOQ computer code based on the U.S. NRC's regulatory guide 1.111 was developed to assess atmospheric dispersion and ground deposition in the routine release of

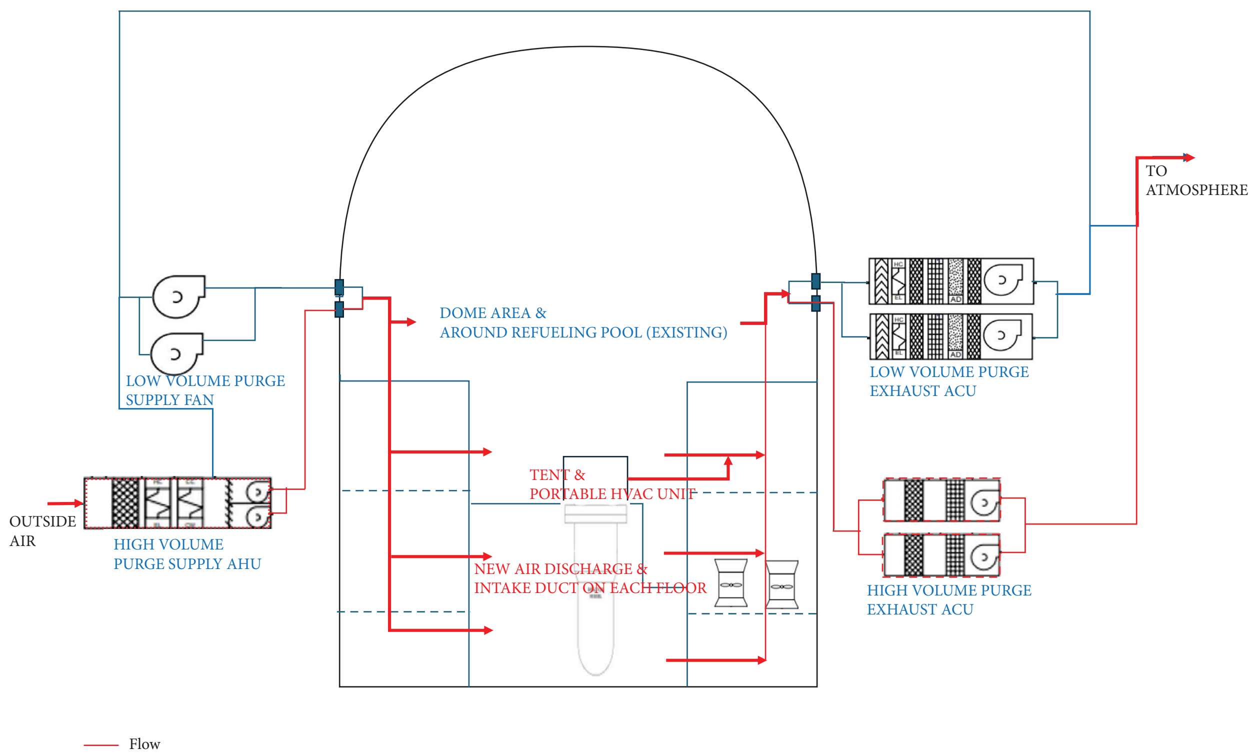

Figure 9: Purge operation using high-volume purge in the decommissioning phase [6].

radioactive effluent [10] and to evaluate independent meteorological evaluation of the continuous and anticipated intermittent release in commercial NPPs. As a result of analyzing the annual atmospheric dispersion factor proportional to the exposure dose of residents using the XOQDOQ program, the value of purge release did not exceed twice the value of continuous release even under the worst meteorological conditions [11]. These results can also be considered when selecting continuous or purge operation.

(3) Partial Ventilation Operation. Partial ventilation and purification strategies are additionally used in areas that generate high dust and high radioactive particles locally, such as cutting of reactor vessel or reactor vessel internals. As shown in Figure 10, a space sealed tent isolates the working area to prevent the spread of dust generated during work, and the portable temporary HVAC units clean the generated dust. Contaminants generated in these areas are purified as they pass through the HEPA filters of the portable temporary HVAC units, and the exhaust flow is discharged to the exterior of the RCB through connecting the exit duct of the RCB purge system [12]. This portable temporary HVAC helps alleviate the load on the HEPA filters of the RCB purge exhaust ACU and reduce the potential for radioactive contaminant release in advance.

5.2. FHB HVAC Operation Strategy. While spent fuel is stored in the SFP during the transition period, the FHB HVAC must be operated as in normal operation. In other

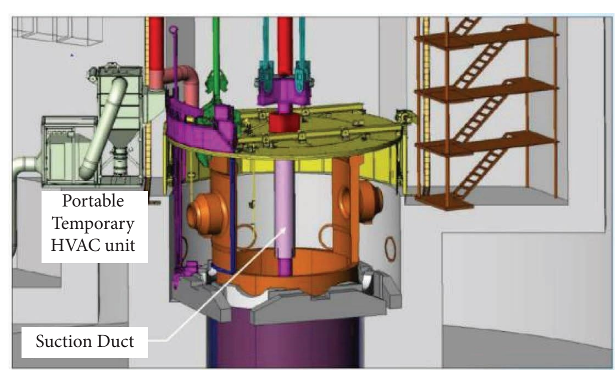

Figure 10: Portable temporary HVAC unit used during reactor vessel segmentation [12].

words, the FHB normal supply fan, normal exhaust fan, and air-cooling units continue to operate to maintain the FHB at negative pressure and provide an appropriate environment for the equipment and workers. Moreover, surveillance is needed to pressure fluctuations because the external door of the FHB would be opened when the spent fuel in the SFP is transferred to the intermediate storage facility. In addition, the fuel building emergency exhaust fan, which is a safety-related device, must be operable in both trains when transferring spent fuel in the event of a nuclear fuel handling accident. For this purpose, the ESFAS-FHBEVAS needs to be maintained in an operable state. Figure 4 shows normal and emergency operation of FHB HVAC in the transition period.

Table 3: HVAC operation strategies for decommissioning.

System	Transition period	Decommissioning phase
RCB HVAC and purge	Natural ventilation, intermittent purge (with recirculation operation using 2 RCFCs and recirculation fans)	Recirculation operation, entire ventilation operation (continuous or intermittent purge), partial ventilation operation (portable temporary HVAC units)
FHB HVAC	Normal operation (same as normal operating NPP)	—
MCR HVAC	Continuously forced ventilation (using supply and exhaust fan without recirculating flow), natural ventilation, temporary HVAC unit operation	—

5.3. MCR HVAC Operation Strategy. In the transition period, until the MCR is replaced by a new decommissioning monitoring room, ventilation equipment must be operable to ensure habitability for decommissioning personnel. However, because of accident analysis, compared to normal operation, the function may be reduced to the level of a general office. Therefore, the MCR HVAC operation strategy at this time would adopt a method of forced ventilation of the air in the MCR by continuously operating the supply fan and exhaust fan without recirculation flow. If the MCR HVAC is demolished early, natural ventilation can be used by opening the door, or a portable temporary air purifier or air conditioner would be used. Figure 5 shows normal operation of MCR HVAC in the transition period.

Table 3 represents the HVAC operation strategies according to the decommissioning phase.

6. Conclusion

In this study, an operation strategy for HVAC of the reactor containment building (RCB), fuel handling building (FHB), and main control room (MCR) during nuclear power plant decommissioning was established. For this purpose, the decommissioning phase was divided into four stages. HVAC systems were reclassified based on whether they were used during the transition period and decommissioning phase and whether the design was changed. In addition, design maintenance, changes, and new installation needs for RCB HVAC, FHB HVAC, and MCR HVAC were assumed. Based on this, in the case of the RCB HVAC operation strategy, natural ventilation and RCB purge operation were proposed during the transition period. In the decommissioning phase, entire ventilation operation consisting of recirculation operation, continuous operation, and purge operation were suggested. Finally, the partial ventilation operation to purify the local space was explained. In addition, during the transition period, the FHB HVAC can be operated with the same operating method as the NPP during normal operation, and the MCR HVAC would be operated by eliminating safety-related equipment and reducing significant portions of the system. Based on this study, it is possible to predict the reclassification, design changes, and operation strategies of the HVAC system required when decommissioning a nuclear power plant. If experiences with various reactor types are studied in the future, it will be possible to establish a standardized HVAC operation strategy.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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