US-APWR
Safety-Related Air Conditioning, Heating, Cooling, and Ventilation Systems Calculations

Non-Proprietary Version

March 2011

Revision History (Sheet 1 of 3)

Revision	Page (Section)	Description
0 (Nov-2010)	All	Original issued
1 (Mar-2011)	14	Table 3-1: - Cooling Coil Capacity in C, D-Class 1E Electrical Room Air Handling Unit is changed from “2,250,000” to “2,290,000”.
	21	Section 5.1.1, Outdoor Air Intake: - Replaced “Total required ventilation airflow is to be 1,637 cfm…” with “Total required ventilation airflow is to be 1,635 cfm…”.
	22	Section 5.1.2.1, (3) Heat Gains: - Replaced “Heat gains for CRE including 15% margin are 238,000 Btu/h…” with “Heat gains for CRE including 15% margin are 242,000 Btu/h…”. - Replaced “…one AHU is to be 119,000 Btu/h per unit.” with “…one AHU is to be 121,000 Btu/h per unit.”.
	23	Section 5.1.2.1, (5) Additional Cooling Load (Additional margin): - Replaced “Additional cooling load (additional margin) is 13,000 Btu/h” with “Additional cooling load (additional margin) is 11,000 Btu/h”.
	25	Section 5.1.2.2, (4) Heat Gains: - Replaced “...including 15% margin are 238,000 Btu/h...” with “...including 15% margin are 242,000 Btu/h...”
	25	Section 5.1.2.2, (4) Heat Gains: - Replaced “The cooling load per one AHU is to be 119,000 Btu/h.” with “The cooling load per one AHU is to be 121,000 Btu/h.”.
	25	Section 5.1.2.2, (6) Additional Cooling Load (Additional margin): - Replaced “Additional cooling load (additional margin) is 24,000 Btu/h” with “Additional cooling load (additional margin) is 22,000 Btu/h”.

Revision History (Sheet 2 of 3)

Revision	Page (Section)	Description
1 (Mar-2011)	29	Section 5.2.2.1, (1) Outdoor Air: - Replaced “...and 29.3 Btu/lb.” with “... and 29.5 Btu/lb.”. - Replaced “q = 60 × 0.075 × 2600 × (43.3 – 29.3) × 1.15 = 188,370 Btu/h, USE 189,000 Btu/h” with “q = 60 × 0.075 × 2600 × (43.3 – 29.5) × 1.15 = 185,679 Btu/h, USE 186,000 Btu/h”.
	30	Section 5.2.2.1, (2.2) Return Air Fan Motor: - Editorial changed “= 83,332 Btu/h,” with “= 83,323 Btu/h,”.
	30	Section 5.2.2.1, (3) Heat Gains: - Replaced “...15% margin are 929,000 Btu/h” with “...15% margin are 966,000 Btu/h”.
	30	Section 5.2.2.1, (4) Additional Cooling Load (Additional margin): - Replaced “...(additional margin) is 127,000 Btu/h” with “...(additional margin) is 93,000 Btu/h”.
	32	Section 5.2.2.2, (1) Outdoor Air: - Replaced “...and 30.1 Btu/lb.” with “...and 30.3 Btu/lb.”. - Replaced “q = 60 × 0.075 × 2600 × (43.3 – 30.1) × 1.15 = 177,606 Btu/h, USE 180,000 Btu/h” with “q = 60 × 0.075 × 2600 × (43.3 – 30.3) × 1.15 = 174,915 Btu/h, USE 175,000 Btu/h”.
	32	Section 5.2.2.2, (3) Heat Gains: - Replaced “Heat gains including 15% margin are 1,422,000 Btu/h (Train C: 939,000 Btu/h (Table 5.2.1-2), Train D: 483,000 Btu/h (Table 5.2.1-1))” with “Heat gains including 15% margin are 1,465,000 Btu/h (Train C: 973,000 Btu/h (Table 5.2.1-2), Train D: 492,000 Btu/h (Table 5.2.1-1))”.
	33	Section 5.2.2.2, (4) Additional Cooling Load (Additional margin): - Replaced “...(additional margin) is 119,000 Btu/h” with “...(additional margin) is 121,000 Btu/h”. - Replaced “...= 2,250,000 Btu/h” with “...= 2,290,000 Btu/h”.

Revision History (Sheet 3 of 3)

Revision	Page (Section)	Description
1 (Mar-2011)	44	Section 5.5.2.2, Heat gains including 15% margin are changed from “23,000” to “21,000”.
	45	Section 5.5.2.2, Additional cooling load is changed from “4,000” to “6,000”.
	53	Section 5.6.1, Replaced “The required airflow to establish a -1/4 inch w.g. pressure in the penetration areas and the safeguard component areas within 180 seconds with respect to adjacent areas is calculated by equation 4.1-4.” with “The required airflow to establish a -0.4 inch w.g. pressure in the penetration areas and the safeguard component areas within 180 seconds with respect to adjacent areas is calculated by equation 4.1-4.”
	55	Section 6: - Replaced “[2] “ASHRAE Handbook Fundamentals-1981,” ASHRAE” with “[2] “ASHRAE Handbook Fundamentals-2005,” ASHRAE”.

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Abstract

The purpose of this technical report is to present calculations on the heating, cooling and airflow requirement of the safety-related air conditioning, heating, cooling, and ventilation systems of US-APWR. The safety-related air conditioning, heating, cooling, and ventilation systems of US-APWR contain Main Control Room Heating, Ventilation and Air Conditioning (HVAC) System (MCRVS), Class 1E Electrical Room HVAC System (CERVS), Safeguard Component Area HVAC System (SCAVS), Emergency Feedwater Pump Area HVAC System (EFWPAVS), Safety Related Component Area HVAC System (SRCAVS) and Annulus Emergency Exhaust System (AEES). The cooling and airflow requirements for the operation mode of each air conditioning, heating, cooling, and ventilation systems are calculated.

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List of Acronyms

The following list defines the acronyms used in this document.

AAC	**Alternate AC**
ACH	**Air Change per Hour**
AEES	**Annulus Emergency Exhaust System**
AHU	**Air Handling Unit**
ASHARE	**American Society of Heating, Refrigerating and Air-Conditioning Engineers**
AUXVS	**Auxiliary Building HVAC System**
CCW	**Component Cooling Water**
CERVS	**Class 1E Electrical Room HVAC System**
CLTD	**Cooling Load Temperature Differential**
CRDM	**Control Rod Drive Mechanism**
CRE	**Control Room Envelope**
CS	**Containment Spray**
DB	**Dry Bulb**
EFU	**Emergency Filtration Unit**
EFW	**Emergency Feedwater**
EFWPAVS	**Emergency Feedwater Pump Area HVAC System**
ESF	**Engineered Safety Features**
FU	**Filtration Unit**
HVAC	**Heating, Ventilation and Air Conditioning System**
I&C	**Instrumentation and Control**
LOCA	**Loss of Coolant Accident**
LOOP	**Loss of Offsite Power**
LRT	**Leakage Rate Testing**
MCR	**Main Control Room**
MCRVS	**Main Control Room HVAC System**
M-G	**Motor-Generator**
R/B	**Reactor Building**
RH	**Relative Humidity**
RHR	**Residual Heat Removal**
RSC	**Remote Shutdown Console**
SCAVS	**Safeguard Component Area HVAC System**
SFP	**Spent Fuel Pit**
SI	**Safety Injection**
SRCAVS	**Safety Related Component Area HVAC System**
UPS	**Uninterruptible Power Supply**
WB	**Wet Bulb**
WG	**Water Gauge**

1. INTRODUCTION

This document contains calculations on the cooling and airflow requirement of the safety-related HVAC systems. The safety-related HVAC systems contain as follows:

- Main Control Room HVAC System (MCRVS)
- Class 1E Electrical Room HVAC System (CERVS)
- Safeguard Component Area HVAC System (SCAVS)
- Emergency Feedwater Pump Area HVAC System (EFWPAVS)
- Safety Related Component Area HVAC System (SRCAVS)
- Annulus Emergency Exhaust System (AEES)

2. DESIGN CONDITION

This chapter summarizes the design conditions for calculating the cooling and airflow requirements of the safety-related HVAC systems.

2.1 Outdoor Air Condition

The safety-related HVAC system is designed with the zero (0) percent exceedance values to accommodate all environmental conditions. The 0% exceedance temperatures are used in this calculation as following:

- 0% exceedance maximum : 115 ^{o}F (DB) / 80 ^{o}F (WB)

2.2 Room Air Condition

Design room air condition served by safety-related HVAC system is specified in Table 2.2-1.

2.3 Ventilation Requirement

The air ventilation requirements are specified in Table 2.3-1. The class 1E battery room exhaust system is designed to be capable of maintaining the hydrogen concentration below 1% by volume in accordance with Regulatory Guide 1.128 (Reference [1]).

2.4 Internal Heat Gains

The internal heat gains from electrical boards, lights, people, and components that can contribute the major of the cooling load in building are shown in following sections.

2.4.1 Electrical Boards

Heat gain from the electrical boards is specified in Table 2.4.1-1.

2.4.2 Lighting

Heat gain from the lighting is specified in Table 2.4.2-1.

2.4.3 People

Heat gain from people in control room envelope (CRE) is specified as 350 Btu/h per person.

2.4.4 Components

Heat gain from the components (e.g., thermal heat exchangers and pumps etc.) is shown in Table 2.4.4-1.

2.4.5 Piping and Supports

Heat gain from the piping and its supports is specified in Table 2.4.5-1.

2.5 Surface Temperature of Exterior Roofs and Walls

The values used for determining the conductive heat gain through exterior walls and roofs is specified in Table 2.5-1. The values are based on the Cooling Load Temperature Differential (CLTD) method in the ASHRAE Fundamentals Handbook-1981 (Reference [2]), Chapter 26.

2.6 Heat Gain or Loss through Roofs, Walls and Floors

Roofs and walls exposed to outside air are provided with thermal insulation to minimize heat loss from air-conditioned areas. The thermal insulation properties are specified in Table 2.6-1. The effect of the thermal insulation is ignored when the heat gains through roofs and walls are calculated.

2.7 Supply Air Temperature

Supply air temperature provided to each areas served by the HVAC systems is specified in Table 2.7-1.

2.8 Fan Total Pressure

Total design pressure of air handling unit supply fan is specified in Table 2.8-1. This value is applied to estimate the air temperature rise across the fan.

2.9 Other Design Consideration

The SCAVS and the AEES are designed in consideration of specific design feature.

The SCAVS connects to the Auxiliary Building HVAC system (AUXVS) supply and exhaust ducts. During normal operation, the AUXVS serves the safeguard component areas via the SCAVS distribution ductwork. During a design basis accident or Loss of Offsite Power (LOOP), the safeguard component areas are cooled by individual safeguard component area air handling units.

The AEES is designed to establish a 1/4 inch water gauge (WG) pressure in the penetration areas and the safeguard component areas within 240 seconds to mitigate a potential leakage to the environment of fission products from the containment following Loss of Coolant Accident (LOCA).

Following section includes the specific design values in consideration of the SCAVS and the AEES operation.

2.9.1 Safeguard Component Area HVAC System

Following specific design conditions are applied to SCAVS calculations and specific design values are summarized in Table 2.9-1.

- Water leakage from Engineered Safety Features (ESF) components during accident condition
- Infiltration from surrounding areas during accident condition
- Use the common distribution ductwork

2.9.2 Annulus Emergency Exhaust System

Specific design conditions applied to the AEES are summarized in Table 2.9-2.

Table 2.2-1 Room Air Condition

HVAC System	Rooms	Air Condition
MCRVS	Main Control Room (Including sub-room)	73 - 78 °F 25 - 60 % RH
CERVS	Class 1E I&C Room	68 - 79 °F
	Remote Shutdown Console Room	73 - 78 °F
	Class 1E Battery Room	65 - 77 °F
	MCR/Class 1E Electrical HVAC Equipment Room MCR Emergency Supply Filtration Unit & Fan Room	50 - 130 °F
	Class 1E Electrical Room Class 1E Battery Charger Room Class 1E UPS Room AAC Selector Circuit Panel Room Reactor Trip Breaker Room M-G Set Room M-G Set Control Panel Room CRDM Cabinet Room LRT Room	50 - 95 °F
SCAVS	SI Pump Room CS/RHR Pump Room CS/RHR Heat Exchanger Room Safeguard Component Area AHU Room R/B Sump Tank Room	50 - 130 °F (50 - 105 °F) (Note)
EFWPAVS	EFW Pump Area	50 - 105 °F
SRCAVS	CCW Pump Area Charging Pump Room Penetration Area Annulus Emergency Exhaust Filtration Unit Area Spent Fuel Pit Pump Area	50 - 130 °F
	Essential Chiller Unit Area	50 - 105 °F

Note : During normal plant operation, the safeguard component areas are maintained within this temperature range by the AUXVS through the distribution ductwork of the SCAVS.

Table 2.3-1 Ventilation Requirements

Table 2.4.1-1 Heat Gain from Electrical Boards

Table 2.4.2-1 Heat Gain from Lighting

Table 2.4.4-1 Heat Gain from Components

Table 2.4.5-1 Heat Gain from Piping and Supports

Table 2.5-1 Surface Temperature of Exterior Roofs and Walls

Table 2.6-1 Thermal Insulation Properties

Table 2.7-1 Supply Air Temperature

Table 2.8-1 Fan Total Pressure

Table 2.9-1 Specific Design Conditions of SCAVS

Table 2.9-2 Specific Design Conditions of AEES

3. SUMMARY OF COMPONENT CAPACITY

The safety-related HVAC system component capacity is summarized in Table 3-1.

Table 3-1 System Component Capacity (Sheet 1 of 3)

Main Control Room Air Handling Unit	
Unit Airflow Capacity, cfm	10,000 per unit
Cooling Coil Capacity, Btu/h	341,000 per unit
Main Control Room Toilet/Kitchen Exhaust Fan	
Fan Airflow Capacity, cfm	1,800 per unit
Main Control Room Smoke Purge Fan	
Fan Airflow Capacity, cfm	20,000 per unit
Class 1E Electrical Room Air Handling Unit	
Unit Airflow Capacity, cfm	40,000 per unit - train A, B 52,000 per unit - train C, D
Cooling Coil Capacity, Btu/h	1,650,000 per unit - train A, B 2,290,000 per unit - train C, D
Class 1E Battery Room Exhaust Fan	
Fan Airflow Capacity, cfm	2,600 per unit
Class 1E Electrical Room Return Air Fan	
Fan Airflow Capacity, cfm	37,400 per unit - train A, B 49,400 per unit - train C, D
Safeguard Component Area Air Handling Unit	
Unit Airflow Capacity, cfm	5,000 per unit
Cooling Coil Capacity, Btu/h	180,000 per unit

Table 3-1 System Component Capacity (Sheet 2 of 3)

EFW Pump (Motor-Driven) Area Air Handling Unit	
Unit Airflow Capacity, cfm	2,100 per unit
Cooling Coil Capacity, Btu/h	110,000 per unit
EFW Pump (Turbine-Driven) Area Air Handling Unit	
Unit Airflow Capacity, cfm	1,300 per unit
Cooling Coil Capacity, Btu/h	62,000 per unit
Essential Chiller Unit Area Air Handling Unit	
Unit Airflow Capacity, cfm	1,000 per unit
Cooling Coil Capacity, Btu/h	30,000 per unit
CCW Pump Area Air Handling Unit	
Unit Airflow Capacity, cfm	1,000 per unit
Cooling Coil Capacity, Btu/h	30,000 per unit
Charging Pump Area Air Handling Unit	
Unit Airflow Capacity, cfm	1,000 per unit
Cooling Coil Capacity, Btu/h	10,000 per unit
Penetration Area Air Handling Unit	
Unit Airflow Capacity, cfm	5,000 per unit
Cooling Coil Capacity, Btu/h	330,000 per unit
Annulus Emergency Exhaust Filtration Unit Area Air Handling Unit	
Unit Airflow Capacity, cfm	1,000 per unit
Cooling Coil Capacity, Btu/h	10,000 per unit

Table 3-1 System Component Capacity (Sheet 3 of 3)

Spent Fuel Pit Pump Area Air Handling Unit	
Unit Airflow Capacity, cfm	1,500 per unit
Cooling Coil Capacity, Btu/h	100,000 per unit
Annulus Emergency Exhaust Filtration Unit & Fan	
Design flow rate, cfm	5,600 per unit

4. EQUATION

The equations applied to calculate the following requirements are as follows.

4.1 Airflow Rate Requirements

4.1.1 Cooling Airflow Requirements

Cooling airflow requirements are calculated by following equations. These equations are generally used to estimate the airflow rate for cooling.

$Q = q / (60 \times \rho \times C_p \times (t_i - t_o)) \times \alpha$: equation 4.1-1

where,

Q	: Airflow rate requirements	, cfm
q	: Heat Loads	, Btu/h
C_p	: Specific heat	, 0.24 Btu/lb-°F
ρ	: Density	, 0.075 lb/ft^3
t_i	: Design room temperature	, °F
t_o	: Supply air temperature	, °F
α	: Margin	, 1.15

4.1.2 Ventilation Requirements for Removal of Hydrogen

Adequate Class 1E battery room ventilation is required to prevent the accumulation of hydrogen. The required airflow through the battery room is in accordance with BS EN50272-2 (Reference [3]). Required ventilation airflow rate is calculated by the following equation.

$Q = v \times g \times s \times n \times I_{gas} \times Cn \times 10^{-3}$: equation 4.1-2

where,

Q	: Airflow rate requirements	, cfm
v	: Necessary dilution of hydrogen	
g	: Hydrogen gas evolution rate	, cfm/cell-A
s	: General safety factor	
n	: Number of cells	
I_{gas}	: Current producing gas in mA per Ah	, Amp/Ah ($= I_{boost} \times f_g \times f_s$)
I_{boost}	: Typical boost charge current	, Amp/Ah
f_g	: Gas emission factor	
f_s	: Gas emission safety factor	
Cn	: Capacity for lead acid cells	, Ah

4.1.3 Airflow Requirements for AEES

The required exhaust airflow rate, to establish the negative pressure in the penetration areas and the safeguard component areas within the drawn-down time with respect to adjacent areas by operation of AEES, is calculated by following equation.

$$Q = \frac{60 \cdot (P + \Delta P) \cdot V}{P_0 \cdot (T - T_f)} + Q_{in}$$

: equation 4.1-4

where,

Q	: Required airflow	, cfm
P	: Establishing negative pressure	, in.w.g.
P_0	: Surrounding area ambient pressure (Standard air)	, in.w.g.
ΔP	: CV expansion effect	, in.w.g.
V	: Free volume of penetration and safeguard component areas	, ft^3
T	: Time of establishing the design negative pressure	, sec.
T_f	: Time of reaching fan design airflow rate	, sec.
Q_{in}	: Infiltration to the penetration area and safeguard component area	, cfm

CV expansion effect (ΔP) is calculated by following equation.

$\Delta P = P \times \{V / (V - \Delta V) - 1\}$: equation 4.1-5

where,

ΔP	: Effect of the expansion of CV	, in.w.g.
P	: Initial pressure	, in.w.g.
V	: Volume in the penetration area	, ft^3
ΔV	: Volume decrease in the penetration area	, ft^3

Volume decrease (ΔV) in the penetration areas is calculated by following equation.

$\Delta V = 3.14 \times \{(R_{cvo} + \Delta R)^2 - R_{cvo}^2\} \times h$: equation 4.1-6

where,

ΔV	: Volume decrease in the penetration area	, ft^3
R_{cvo}	: Outside radius of CV	, ft
ΔR	: Radial expansion of CV	, ft
h	: Height of the penetration area	, ft

Radial expansion of CV (ΔR) is calculated by following equation

$\Delta R = P \times R^2 / (E \times t)\ (1 - \nu/2)$: equation 4.1-7

where,

ΔR	: Radial expansion of CV	, ft
P	: Internal pressure of CV	, psig
R	: Average radius of CV	, ft
t	: Thickness of CV	, ft
E	: Modulus of elasticity for concrete	, ksi
ν	: Poisson's ratio	

4.2 Heat Gains

This section includes the heat load calculation regarding the outdoor intake, infiltration air, fan operation, and humidification.

4.2.1 Outdoor Air or Infiltration Air

Heat gain from outdoor and infiltration is calculated by following equation.

$q = 60 \times \rho \times Q \times (h_i - h_o) \times \alpha$: equation 4.2-1

where,

q	: Heat gain from outdoor	, Btu/h
ρ	: Density	, 0.075 lb/ft^3
Q	: Outdoor air intake or infiltration air	, cfm
h_i	: Enthalpy of outdoor air or infiltration air	, Btu/lb
h_o	: Enthalpy of return air or room air	, Btu/lb
α	: Margin	, 1.15

4.2.2 Fan in case of Motor in Airstream

Heat gain from fan of which motor and drive are inside the airstream is calculated by following equation.

$q = 2545 \times 0.000157 \times H \times Q / (\eta_f \times \eta_m) \times \alpha$: equation 4.2-2

where,

q	: Fan motor load	, Btu/h
H	: Fan total pressure	, in.w.g.
Q	: Airflow rate requirement	, cfm
η_f	: Fan efficiency(Note1)	
η_m	: Motor efficiency(Note2)	
α	: Margin	, 1.15

Note:
1. Typical centrifugal fan and axial fan efficiency use 0.7 and 0.55.
2. A typical motor efficiency use 0.9.

4.2.3 Humidification

Heat gain due to humidification is calculated by the following equation.

$q = 60 \times \rho \times Q\ (h_o - h_i) \times \alpha$: equation 4.2-3

where,

q	: Cooling load	, Btu/h
ρ	: Density	, 0.075 lb/ft^3
Q	: Airflow rate	, cfm
h_i	: Enthalpy before humidification	, Btu/h
h_o	: Enthalpy after humidification	, Btu/h
α	: Margin	, 1.15

4.3 Air Temperature Rise across Fans and Electrical Heaters

Leaving air temperature from fans electrical heaters in creases when the entering air passes through the fan on Electrical heaters. The equations for the temperature rise regarding the entering air temperature is discussed in following sections.

(a) Temperature Rise across fan

The air temperature rise across fan is calculated by the following equation.

$\Delta t = 2545 \times 0.000157 \times H / (1.08 \times \eta_f \times \eta_m)$: equation 4.3-1

where,

Δt	: Temperature rise across fan	, ^oF
H	: Fan total pressure	, in.w.g.
η_f	: Fan efficiency (Note1)	
η_m	: Motor efficiency (Note2)	

Note:
1. Typical centrifugal fan and axial fan efficiency use 0.7 and 0.55.
2. A typical motor efficiency use 0.9.

(b) Temperature Rise across electrical heaters

The air temperature rise across electric heater is calculated by the following equation.

$t_o = q / (60 \times Q \times \rho \times C_p) + t_i$: equation 4.3-2

where,

t_o	: Leaving air temperature	, ^oF
q	: Heat gain from electric heating coil	, Btu/h
Q	: Airflow rate	, cfm
C_p	: Specific heat	, 0.24 Btu/lb-^oF
ρ	: Density	, 0.075 lb/ft^3
t_i	: Inlet air temperature	, ^oF

4.4 Cooling Capacity

The cooling capacity is calculated by following equation.

$q = 60 \times \rho \times Q \times (h_i - h_o) \times \alpha$: equation 4.4-1

where,

q	: Cooling requirement	, Btu/h
ρ	: Density	, 0.075 lb/ft^3
Q	: AHU airflow	, cfm
h_i	: Enthalpy of cooling coil inlet	, Btu/lb
h_o	: Enthalpy of cooling coil outlet	, Btu/lb
α	: Margin	, 1.15

5. CALCULATIONS

This chapter contains the calculations for each safety-related HVAC System including the AEES.

5.1 Main Control Room HVAC System (MCRVS)

Table 5.1.1-1 summarizes the MCRVS airflow requirements based on cooling requirements.

5.1.1 Airflow Requirement

Outdoor Air Intake

Outdoor air intake flow is determined in accordance with the requirements shown in Table 2.3-1. Total required ventilation airflow is to be 1,635 cfm shown in Table 5.1.1-1, **USE 1,800 cfm**.

Exhaust Fan Flow

The toilet/kitchen exhaust fans discharge air from the CRE through the toilet/kitchen area. The exhaust fan is designed to be capable of extracting fresh air equivalent to makeup airflow requirements from the outdoor environment. Therefore, the capacity of exhaust fan is to be **1,800 cfm**.

Cooling Airflow Requirements

Cooling airflow requirements are calculated by equation 4.1-1. Required cooling airflow for each area is shown in Table 5.1.1-1.

AHU Airflow Requirements

According to MCRVS calculation sheet (Table 5.1.1-1), total cooling airflow is approximately 20,000 cfm. The MCR supply system consists of 4 units (50% x 4). Thus, one AHU airflow capacity is to be **10,000 cfm**.

Smoke Purge Fan Airflow Requirement

The MCR HVAC system is designed so that the outside air quantity will be increased to 100 percent of system supply air flow rate during smoke purge operation in accordance with URD (Reference [5]). Thus the smoke purge fan is designed to be capable of exhausting maximum 20,000 cfm purging air from MCR. Capacity of main control room smoke purge fan is to be **20,000 cfm**.

5.1.2 Cooling Coil Requirement

The air condition of the cooling coil requirement is determined for the normal operation mode and the emergency pressurization mode. During emergency pressurization mode operation, the emergency filtration unit electrical heating coils are energized to reduce the relative humidity below 70%RH to ensure the charcoal adsorber efficiency. Psychrometric charts containing the air condition are shown in Figure 5.1-1 and 5.1-2. The air condition at the cooling coil for normal operation mode is discussed in Subsection 5.1.2.1. The air condition at the cooling coil for Emergency Pressurization Mode is discussed in Subsection 5.1.2.2. The specification of cooling coil capacity is determined by incorporating sufficient margins.

5.1.2.1 Normal Operation Mode

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Outdoor Air

Heat gain from outdoor is calculated by equation 4.2-1. Outdoor air intake is 1,800 cfm and enthalpy of outdoor air and return air are 43.3 Btu/lb and 30.0 Btu/lb.

$$q = 60 \times 0.075 \times 1800 \times (43.3 - 30.0) \times 1.15$$
$$= 123,890 \text{ Btu/h}$$

During normal operation, two AHUs are in operation. Thus, the cooling load per one AHU is to be 61,945 Btu/h, USE **62,000 Btu/h** per unit.

(2) AHU Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 10,000 cfm (Section 5.1.1). Fan total pressure is 8.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 8.0 \times 10000 / (0.7 \times 0.9) \times 1.15$$
$$= 58,350 \text{ Btu/h}$$

Thus, cooling load of fan motor is **59,000 Btu/h** per unit

(3) Heat Gains

Heat gains for CRE including 15% margin are 242,000 Btu/h obtained from Table 5.1.1-1

During normal plant operation, two AHUs are in operation. Thus, The cooling load per one AHU is to be 121,000 Btu/h per unit.

(4) Humidification

When inside of Main Control Room is humidified from 51.9 %RH as initial condition to 60 %RH, Heat gain due to humidification is calculated by equation 4.2-3. Airflow rate is 20,000 cfm and enthalpy before humidification and after humidification are 28.3 Btu/h and 30.0 Btu/h.

$$q = 60 \times 0.075 \times 20000 \times (30.0 - 28.3) \times 1.15$$
$$= 175,950 \text{ Btu/h}$$

During normal operation, two AHUs are in operation. Thus, the cooling load per one AHU is to be 88,000 Btu/h per unit.

(5) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 11,000 Btu/h

Total cooling load = (1)+(2)+(3)+(4)+ (5)
= 341,000 Btu/h

5.1.2.2 Emergency Pressurization Mode

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Outdoor Air

Heat gain from outdoor is calculated by equation 4.2-1. Outdoor air intake is 1,200 cfm, enthalpy of outdoor air and return air are 43.3 Btu/lb and 28.2 Btu/lb.

$q = 60 \times 0.075 \times 1200 \times (43.3 - 28.2) \times 1.15$
$\quad = 93{,}771$ Btu/h

During emergency pressurization mode operation, two AHUs are in operation. Thus, the cooling load per one AHU is to be 46,886 Btu/h, USE **47,000 Btu/h** per unit.

(2) Fan Motors

(2.1) AHU Fan

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 10,600 cfm. Fan total pressure is 8.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 8 \times 10600 / (0.7 \times 0.9) \times 1.15$$
$$= 61{,}851 \text{ Btu/h}$$

Thus, cooling load of fan motor is **62,000 Btu/h** per unit.

(2.2) EFU Fan

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 3,600 cfm. Fan total pressure is 7.3 in.w.g. given in Table 2.8-1. Fan efficiency use 0.7.

$$q = 2545 \times 0.000157 \times 7.3 \times 3600 / 0.7 \times 1.15$$
$$= 17{,}251 \text{ Btu/h}$$

Thus, cooling load of fan motor is **18,000 Btu/h** per unit.

(3) Electric Heating Coil

Heat gain from MCR EFU electric heating coil is 18kw (61,500 Btu/h). Thus, cooling load of heating coil is 71,000 Btu/h in consideration of 15% margins.

(4) Heat Gains

Heat gains for CRE including 15% margin are 242,000 Btu/h obtained from Table 5.1.1-1.

During emergency pressurization mode operation, two AHUs are in operation. Thus, The cooling load per one AHU is to be **121,000 Btu/h**.

(5) Humidification

Not considered (Humidifier is not operated during emergency pressurization mode operation)

(6) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 22,000 Btu/h

Total cooling load = (1)+(2)+ (3)+(4)+(5)+(6)
= 341,000 Btu/h

5.2 Class 1E Electrical Room HVAC System (CERVS)

Table 5.2-1 summarizes the CERVS airflow requirements based on cooling requirements.

5.2.1 Airflow Requirement

Class 1E Battery Room Exhaust Fan Airflow Requirement

1) Ventilation Requirements for Removal of Hydrogen

Required ventilation airflow rate is calculated by equation 4.1-2. Calculation condition is as follows.

- Necessary dilution of hydrogen v = 99
- Hydrogen gas evolution rate g = 0.000269 cfm/cell-A(Note)
- General safety factor s = 5
- Number of cells n = 120(60 × 2)
- Current producing gas in mA per Ah I_{gas} = 20 Amp/Ah (= I_{boost} f_g × f_s)
- Typical boost charge current I_{boost} = 4 Amp/Ah
- Gas emission factor f_g = 1
- Gas emission safety factor f_s = 5
- Capacity for lead acid cells Cn = 2,552 Ah

Note : Hydrogen gas evolution rate is found in IEEE Std.484™-2002 (Reference [4]).

accordingly,

$$Q = 99 \times 0.000269 \times 5 \times 120 \times 20 \times 2552 \times 10^{-3}$$
$$= 815.5 \text{ cfm}$$

Thus, ventilation requirement for removal hydrogen is to be minimum 900 cfm.

Outdoor Air Intake Requirement

Outdoor air intake requirement is to be approximately **2,600 cfm** obtained from CERVS calculation sheet. Therefore, the Class 1E battery room exhaust fan capacity is to be determined as 2,600 cfm.

Cooling Airflow Requirements

Cooling airflow requirements are calculated by equation 4.1-1. Required cooling airflow for each area is shown in Table 5.2.1-1.

Class 1E Electrical Room AHU Airflow Requirements

The CERVS consists of four trains, each is sized to satisfy 100% of the cooling and heating demand of two trains, i.e., train A or B can provide cooling and heating for both trains A & B, and train C or D can provide cooling and heating for both train C & D. Therefore, airflow capacity for train A&B AHUs is 40,000 cfm, and for train C&D AHUs is 52,000 cfm. See Table 5.2.1-1.

Class 1E Electrical Room Return Air Fan Capacity

Class 1E Electrical Room return air fan capacity is based on AHUs airflow capacity and exhaust fan capacity. Therefore, A,B-Class 1E Electrical Room return air fan capacity is to be 37,400 cfm, and C,D-Class 1E Electrical Room return air fan capacity is to be 49,400 cfm.

5.2.2 Cooling Coil Requirement

5.2.2.1 A,B-Class 1E Electrical Room Air Handling Unit

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Outdoor Air

Heat gain from outdoor is calculated by equation 4.2-1. Outdoor air intake is 2,600 cfm and enthalpy of outdoor air and return air are 43.3 Btu/lb and 29.5 Btu/lb.

$q = 60 \times 0.075 \times 2600 \times (43.3 - 29.5) \times 1.15$
$= 185{,}679$ Btu/h, **USE 186,000 Btu/h**

(2) Fan Motors

(2.1) AHU Fan Motor

Heat gain from AHU fan motors is calculated by equation 4.2-2. Airflow rate requirement is 40,000 cfm. Fan total pressure is 11.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$q = 2545 \times 0.000157 \times 11 \times 40000 / (0.7 \times 0.9) \times 1.15$
$= 320{,}920$ Btu/h, USE 321,000 Btu/h

(2.2) Return Air Fan Motor

Heat gain from the return air fan motors is calculated by equation 4.2-2. Airflow rate requirement is 37,400 cfm. Fan total pressure is 2.4 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.55 and 0.9.

q = 2545 × 0.000157 × 2.4 × 37400 / (0.55 × 0.9) × 1.15
= 83,323 Btu/h, USE 84,000 Btu/h

Therefore, total cooling load of fan motors is **405,000 Btu/h**

(3) Heat Gains

Heat gains including 15% margin are **966,000 Btu/h** obtained from Table 5.2.1-1

(4) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 93,000 Btu/h

Total cooling load = (1)+(2)+(3)+(4)
= 1,650,000 Btu/h

5.2.2.2 C,D-Class 1E Electrical Room Air Handling Unit

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Outdoor Air

Heat gain from outdoor is calculated by equation 4.2-1. Outdoor air intake is 2,600 cfm. Enthalpy of outdoor air and return air are 43.3 Btu/lb and 30.3 Btu/lb.

q = 60 × 0.075 × 2600 × (43.3 – 30.3) × 1.15
= 174,915 Btu/h, **USE 175,000 Btu/h**

(2) Fan Motors

(2.1) AHU Fan Motor

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 52,000 cfm. Fan total pressure is 11.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

q = 2545 × 0.000157 × 11 × 52000 / (0.7 × 0.9) × 1.15
= 417,197 Btu/h, USE 418,000 Btu/h

(2.2) Return Air Fan

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 49,400 cfm. Fan total pressure is 2.4 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.55 and 0.9.

q = 2545 × 0.000157 × 2.4 × 49400 / (0.55 × 0.9) × 1.15
=110,057 Btu/h, USE 111,000 BTU/h

Therefore, total cooling load of fan motors is **529,000 Btu/h.**

(3) Heat Gains

Heat gains including 15% margin are **1,465,000 Btu/h**
(Train C: 973,000 Btu/h (Table 5.2.1-2), Train D: 492,000 Btu/h (Table 5.2.1-1))

Note: Heat load and loss through structure (concrete wall, floor, and ceiling etc.) regarding to Non-Class 1E electrical rooms are calculated by using 1% exceedance values in order to determined the required airflow rate that provided tempered air to there during normal plant operation. However, if the non-safety portion is provide tempered air without system's isolation, and the exhaust air returns back to Class 1E electrical room AHUs during accident condition, heat load and loss through structure should be calculated by 0% exceedance values. In the calculation for cooling coil demands, the outside air temperature condition regarding to non-safety portion is used as 0% exccedance values. Table 5.2.1-1 summarized the cooling load and heat loss of non-safety related rooms served by CERVS during abnormal conditions.

(4) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is **121,000 Btu/h**

Total cooling load = (1)+(2)+(3)+(4)
= 2,290,000 Btu/h

5.3 Safeguard Component Area HVAC System (SCAVS)

Table 5.3.1-2 summarizes the SCAVS airflow requirements based on cooling requirement during normal operation. Table 5.3.1-3 summarizes the SCAVS airflow requirements based on cooling requirement during abnormal operation.

5.3.1 Airflow Requirement

Cooling Airflow Requirements

Cooling airflow requirements are calculated by equation 4.1-1. Required cooling airflow for each area during normal plant operation and abnormal plant operation is shown in Table 5.3.1-2 and Table 5.3.1-3. During normal operation, the safeguard component areas are ventilated by the AUXVS, and during abnormal operation condition there are served by the SCAVS.

Airflow Ratio of Normal to Abnormal Operation Condition

Required airflow is the difference between during normal operation condition and abnormal operation condition. Each required airflow should be determined in order that airflow ratio of normal to abnormal operation condition should be around “1.4” because the any active balancing dampers (Variable Air Volume System) are not provided in safety related portion. Table 5.3.1-4 shows the airflow ratio.

Airflow Requirements for Normal Plant Operation

During normal plant operation, the AUXVS provides ventilation air of 27,700 cfm to safeguard component areas. (See Table 5.3.1-2)

AHU Airflow Requirements

Total cooling airflow is 5,000 cfm per one unit (See Table 5.3.1-3). .

5.3.2 Cooling Coil Requirement

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 5,000 cfm, fan total pressure is 5.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 5 \times 5000 / (0.7 \times 0.9) \times 1.15$$
$$= 18{,}234 \text{ Btu/h}, \quad \text{USE } 19{,}000 \text{ Btu/h}$$

Thus, cooling load of fan motor is **19,000 Btu/h.**

(2) Internal Heat Gain (Except for Fan Motors)

Heat gain from equipment, piping, lighting, and structure is 109,498 Btu/h obtained from Table 5.3.1-1. USE **126,000 Btu/h** added the 15% margin (16,502 Btu/h).

(3) Infiltration

Heat load of infiltration is calculated by equation 4.2-1. Infiltration flow is 375 cfm, enthalpy of infiltration air and room air are 47.0 Btu/lb$^{(Note)}$ and 36.4 Btu/lb.

$$q = 60 \times 0.075 \times 375 \times (47.0 - 36.4) \times 1.15$$
$$= 20{,}571 \text{ Btu/h}$$

Thus, the cooling load per one AHU is to be **21,000 Btu/h**

Note: In case that the infiltration air condition is 130^{o}F and 0.0141lb/lb' during LOCA events, the enthalpy is to be 47.0 Btu/lb.

(4) Leakage from ESF Components

When leakage is occurred inside safeguard component areas, the area is humidified by leakage water. Heat gain due to humidification is calculated by equation 4.2-3. Circulation airflow rate is 5,000 cfm. Enthalpy before and after the leakage are 37.5 Btu/lb and 37.2 Btu/lb.

q = 60 × 0.075 × 5000 × (37.5 – 37.2) × 1.15
= 7,763 Btu/h

Thus, the cooling load per one AHU is to be **8,000 Btu/h**

(5) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 6,000 Btu/h

Total cooling load = (1)+(2)+(3)+(4)+ (5)
= 180,000 Btu/h

5.4 Emergency Feedwater Pump Area HVAC System (EFWPAVS)

Table 5.4-1 summarizes the airflow requirement based on cooling requirements and ventilation requirements.

5.4.1 Airflow Requirement

Outdoor Air Intake

EFW pump (turbine-driven) area is ventilated by dedicated ventilation system that provides fresh air. Outdoor air intake flow is determined in accordance with the ventilation requirements in Table 2.3-1. Total required ventilation airflow is to be 85 cfm per EFW pump (turbine-driven) area Table 5.4-1. Thus, EFW pump (turbine-driven) pump area HVAC system provides 100 cfm of fresh air to EFW pump areas.

Cooling Airflow Requirements

Cooling airflow requirements are calculated by equation 4.1-1. Required cooling airflow for each area is shown in Table 5.4-1.

AHU Airflow Requirements

Total cooling airflow for motor-driven and turbine-driven area is **2,100 cfm** and **1,300 cfm** (See Table 5.4-1).

5.4.2 Cooling Coil Requirement

5.4.2.1 Motor-Driven Pump Area Air Handling Unit

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 2,100 cfm. Fan total pressure is 2.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 2 \times 2100 / (0.7 \times 0.9) \times 1.15$$
$$= 3{,}063 \text{ Btu/h}$$

Thus, cooling load of fan motor is **3,100 Btu/h**.

(2) Internal Heat Gains

Heat gain from pumps, piping and supports, lighting and concrete walls, including 15% margin, is 105,000 Btu/h obtained from Table 5.4-1.

(3) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 1,900 Btu/h.

Total cooling load = (1)+(2)+(3)
= 110,000 Btu/h

5.4.2.2 Turbine-Driven Pump Area Air Handling Unit

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Outdoor Air

Heat gain from outdoor is calculated by equation 4.2-1. Outdoor air intake is 100 cfm, enthalpy of outdoor air and return air are 43.3 Btu/lb and 35.6 Btu/lb.

$$q = 60 \times 0.075 \times 100 \times (43.3 - 35.6) \times 1.15$$
$$= 3{,}985 \text{ Btu/h}$$

Thus, the cooling load per one AHU is to be **4,000 Btu/h**.

(2) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 1,300 cfm. Fan total pressure is 2.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 2 \times 1300 / (0.7 \times 0.9) \times 1.15$$
$$= 1{,}896 \text{ Btu/h}$$

Thus, cooling load of fan motor is **2,000 Btu/h**.

(3) Internal Heat Gains

Heat gain from pumps, piping and supports, lighting and concrete walls, including 15% margin, is **54,000 Btu/h** obtained from Table 5.4-1.

(4) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is **2,000 Btu/h**.

Total cooling load = (1)+(2)+(3)+(4)
= 62,000 Btu/h

5.5 Safety Related Component Area HVAC System (SRCAVS)

Table 5.5-1 through 5.5-6 summarizes the SRCAVS airflow requirements based on cooling requirements.

5.5.1 Airflow Requirement

Cooling Airflow Requirements

Cooling airflow requirements are calculated by equation 4.1-1. Required cooling airflow for each area is shown in Table 5.5-1 through 5.5-6.

AHU Airflow Requirements

Cooling airflow requirements of each safety related component area AHU is obtained from Table 5.5-1 through 5.5-6. Each AHU airflow rate is shown below.

Essential Chiller Unit AHU	: 1,000 cfm
CCW Pump Area AHU	: 1,000 cfm
Charging Pump Area AHU	: 1,000 cfm
Penetration Area AHU	: 5,000 cfm
Annulus Emergency Exhaust Filtration Unit Area AHU	: 1,000 cfm
Spent Fuel Pit Pump Area AHU	: 1,500 cfm

5.5.2 Cooling Coil Requirement

5.5.2.1 Essential Chiller Unit Area AHU Cooling Coil

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 1,000 cfm. Fan total pressure is 3.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 3 \times 1000 / (0.7 \times 0.9) \times 1.15$$
$$= 2{,}188 \text{ BTU/h}$$

Thus, cooling load of fan motor is **3,000 Btu/h**.

(2) Heat Gains

Heat gain including 15% margin are 22,000 Btu/h obtained from Table 5.5-1

(3) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 5,000 BTU/h.

Total cooling load = (1)+(2)+(3)
= 30,000 Btu/h

5.5.2.2 CCW Pump Area AHU Cooling Coil

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 1,000 cfm. Fan total pressure is 3.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$q = 2545 \times 0.000157 \times 3 \times 1000 / (0.7 \times 0.9) \times 1.15$
$= 2{,}188$ BTU/h

Thus, cooling load of fan motor is **3,000 Btu/h**.

(2) Heat Gains

Heat gains including 15% margin are 21,000 Btu/h obtained from Table 5.5-2

(3) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 6,000 BTU/h

Total cooling load = (1)+(2)+(3)
= 30,000 Btu/h

5.5.2.3 Charging Pump Area AHU Cooling Coil

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 1,000 cfm. Fan total pressure is 3.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 3 \times 1000 / (0.7 \times 0.9) \times 1.15$$
$$= 2{,}188 \text{ BTU/h}$$

Thus, cooling load of fan motor is **3,000 Btu/h**.

(2) Heat Gains

Heat gain including 15% margin are 3,000 Btu/h obtained from Table 5.5-3

(3) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 4,000 BTU/h.

Total cooling load = (1)+(2)+(3)
= 10,000 Btu/h

5.5.2.4 Penetration Area AHU Cooling Coil

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 5,000 cfm, fan total pressure is 5.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

$$q = 2545 \times 0.000157 \times 5 \times 5000 / (0.7 \times 0.9) \times 1.15$$
$$= 18{,}234 \text{ BTU/h}$$

Thus, cooling load of fan motor is **19,000 Btu/h**.

(2) Heat Gains

Heat gains including 15% margin are 285,000 Btu/h obtained from Table 5.5-4.

(3) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 26,000 BTU/h.

Total cooling load = (1)+(2)+(3)
= 330,000 Btu/h

5.5.2.5 Annulus Emergency Exhaust Filtration Unit Area AHU Cooling Coil

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 1,000 cfm, fan total pressure is 3.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

q = 2545 × 0.000157 × 3 × 1000 / (0.7 × 0.9) × 1.15
= 2,188 BTU/h

Thus, cooling load of fan motor is **3,000 Btu/h**.

(2) Heat Gains

Heat gain through the structure including 15% margin are 2,000 Btu/h obtained from Table 5.5-5

(3) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 5,000 BTU/h.

Total cooling load = (1)+(2)+(3)
= 10,000 Btu/h

5.5.2.6 Spent Pump Pit Area AHU Cooling Coil

The cooling coil capacity is calculated by summing up the following cooling loads.

(1) Fan Motors

Heat gain from fan motors is calculated by equation 4.2-2. Airflow rate requirement is 1,500 cfm, fan total pressure is 3.0 in.w.g. given in Table 2.8-1. Fan efficiency and motor efficiency use 0.7 and 0.9.

q = 2545 × 0.000157 × 3 × 1500 / (0.7 × 0.9) × 1.15
  = 3,282 BTU/h

Thus, cooling load of fan motor is **4,000 Btu/h**.

(2) Heat Gains

Heat gains including 15% margin are 88,000 Btu/h obtained from Table 5.5-6.

(3) Additional Cooling Load (Additional margin)

Additional cooling load (additional margin) is 8,000 BTU/h.

Total cooling load = (1)+(2)+(3)
 = 100,000 Btu/h

5.6 Annulus Emergency Filtration System (AEES)

5.6.1 Airflow Requirement for Penetration Areas

The required airflow to establish a -0.4 inch w.g. pressure in the penetration areas and the safeguard component areas within 180 seconds with respect to adjacent areas is calculated by equation 4.1-4. The input values are as follows:

P	: Establishing negative pressure	, 0.4 in.w.g.
P_o	: Surrounding area ambient pressure (Standard air)	, 407 in.w.g.
ΔP	: CV expansion effect	, 0.8 in.w.g.
T	: Time of establishing a 1/4 inch w.g.	, 180 sec.
T_f	: Time of reaching fan design airflow rate	, 130 sec.
V	: Volume in the penetration area	, 411,022 ft^3
Q_{in}	: Infiltration to the penetration areas	, 1,500 cfm

where,
CV expansion effect (ΔP) stated above is calculated by equation 4.1-5 input following conditions.

P	: Initial pressure	, 407 in.w.g.
V	: Volume in the penetration area	, 411,022 ft^3
ΔV	: Volume decrease in the penetration area	, 675.9 ft^3

where,Therefore,

ΔP = 407 x {411,022 / (411,022-675.9) - 1 } = 0.67, USE 0.8 in. w.g.

where,
Volume decrease in the penetration areas (ΔV) stated above is calculated by equation 4.1-6 input following conditions.

R_{cvo}	: Outside Radius of CV	, 78.92 ft
ΔR	: Radial expansion of CV	, 0.018 ft
H	: Height of the Penetration Area	, 75.75 ft

Threrefore,

ΔV = =3.14 x {$(78.92 + 0.018)^2 - 78.92^2$} x 75.75 = 675.85, USE 675.9 ft^3

where,
Radial expansion of CV (ΔR) stated above is calculated by equation 4.1-7 input following conditions.

P	: Internal Pressure of CV	, 68 psig
R	: Average Radius of CV	, 76.75 ft
t	: Thickness of CV	, 4.33 ft
E	: Modulus of Elasticity for Concrete	, 4,769 ksi
ν	: Poisson's Ratio	, 0.17

Thus,
Radial expansion of CV (ΔR) is:

$\Delta R = 68 \times 76.75^2 / (4{,}769 \times 10^3 \times 4.33) \times (1 - 0.17/2) = 0.0177$, USE 0.018 ft

Therefore,
the required airflow (Q) is:

$$Q = \frac{60 \cdot (0.4 + 0.8) \cdot 411{,}022}{407 \cdot (180 - 130)} + 1{,}500 \quad = 2954.23$$

Add approximately 15% margin in this value. Thus, required airflow for penetration areas, including a margin is **3,500 cfm**.

5.6.2 Airflow Requirement for Safeguard Component Areas

The required airflow to establish a -1/4 inch w.g. pressure in the safeguard component areas within 180 seconds with respect to adjacent areas is calculated by equation 4.1-4. The input values are as follows:

P	: Establishing negative pressure	, 0.4 in.w.g.
P_o	: Surrounding area ambient pressure (Standard air)	, 407 in.w.g.
ΔP	: CV expansion effect	, 0 (Not applicable)
T	: Time of establishing a 1/4 inch w.g.	, 180 sec.
T_f	: Time of reaching fan design airflow rate	, 130 sec.
V	: Volume of safeguard component areas	, 312,426 ft^3
Q_{in}	: Infiltration to the penetration areas	, 1,500 cfm

Therefore,

$$Q = \frac{60 \cdot (0.4 + 0) \cdot 312{,}426}{407 \cdot (180 - 130)} + 1{,}500 \quad = 1868.46$$

Note: CV expansion effect (ΔP) is zero (0)

Additionally,

Add approximately 10% margin in this value. Thus, required airflow for safeguard component areas, including a margin is **2,100 cfm**.

5.6.3 Annulus Emergency Exhaust Fan EFU Airflow Requirements

According to the airflow requirement discussed in Section 5.6.2 and 5.6.3, the annulus emergency exhaust filtration unit and fan is determined by summing up the airflow requirement for penetration and safeguard component areas. Thus, the annulus emergency exhaust fan capacity is to be **5,600 cfm**.

REFERENCE

[1] “Installsation Design and Installation of Vented Lead-Aicd Storage Batteries for Nuclear Power Plants,” Regulatory Guide 1.128, Revision 2

[2] “ASHRAE Handbook Fundamentals-2005,” ASHRAE

[3] “Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries,” BS EN50272-2:2001

[4] “IEEE Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications,” IEEE Std 484TM-2002

[5] EPRI Advanced Light Water Reactor Utility Requirements Document Volume II

Table 5.1.1-1 MCRVS Calculation Sheet

Table 5.1.2-1 MCRVS Return Air Temperature Condition (Normal Operation Mode)

Table 5.1.2-2 MCRVS Return Air Temperature Condition (Emergency Pressurization Mode)

Table 5.2.1-1 CERVS Calculation Sheet

Table 5.2.1-2 Cooling and Heating Loads in Non-Safety Related Portion of CERVS Train-C following Accident Condition

Table 5.2.2-1 CERVS Return Air Temperature

Table 5.3.1-1 SCAVS Cooling and Heating Loads

Table 5.3.1-2 SCAVS Calculation Sheet (During Normal Operation Severed by AUXVS)

Table 5.3.1-3 SCAVS Calculation Sheet (During Abnormal Plant Operation)

Table 5.3.1-4 SCAVS Airflow Ratio of Normal to Abnormal Operation

Table 5.3.2-1 SCAVS Return Air Temperature Condition

Table 5.4.1-1 EFWPAVS Calculation Sheet

Table 5.4.2-1 EFWPAVS Return Air Temperature Condition

Table 5.5.1-1 SRCAVS (Essential Chiller Unit Area) Calculation Sheet

Table 5.5.1-2 SRCAVS (CCW Pump Area) Calculation Sheet

Table 5.5.1-3 SRCAVS (Charging Pump Area) Calculation Sheet

Table 5.5.1-4 SRCAVS (Annulus Area) Calculation Sheet

Table 5.5.1-5 SRCAVS (Annulus Filtration Unit Area) Calculation Sheet

Table 5.5.1-6 SRCAVS (Spent Fuel Pit Pump Area) Calculation Sheet

Table 5.5.2-1 SRCAVS Return Air Temperature Condition

Figure 5.1-1 MCRVS Psychrometric Chart (Normal Operation Mode)

Figure 5.1-2 MCRVS Psychrometric Chart (Emergency Pressurization Mode)

Figure 5.1-3 MCRVS Airflow Distribution Sketch (Emergency Pressurization Mode)

Figure 5.2-1 CERVS Train A&B Psychrometric Chart

Figure 5.2-2 CERVS Train C&D Psychrometric Chart

Figure 5.3-1 SCAVS Psychrometric Chart

Figure 5.4-1 EFWPAVS (Motor-Driven Pump Area) Psychrometric Chart

Figure 5.4-2 EFWPAVS (Turbine-Driven Pump Area) Psychrometric Chart

Figure 5.5-1 SRCAVS (Essential Chiller Unit Area) Psychrometric Chart

Figure 5.5-2 SRCAVS (CCW Pump Area) Psychrometric Chart

Figure 5.5-3 SRCAVS (Charging Pump Area) Psychrometric Chart

Figure 5.5-4 SRCAVS (Penetration Area) Psychrometric Chart

Figure 5.5-5 SRCAVS (Annulus Emergency Exhaust Filtration Unit Area) Psychrometric Chart

Figure 5.5-6 SRCAVS (Spent Fuel Pit Pump Area) Psychrometric Chart