BSC

Design Calculation or Analysis Cover Sheet

Complete only applicable items.

1. QA:QA

2. Page 1

3. System	4. Document Identifier
Surface Nuclear Confinement HVAC System	060-M8C-VCT0-00600-000-00B

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CRCF 1 Air Pressure Drop Calculation (ITS)

6. Group

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8. Notes/Comments

1. Added Reference 2.2.10, due to its issuance since Revision A.
2. Changed Reference 2.2.8 from the CRCF Sketch to the CRCF General Arrangement, due to its issuance since Revision A.
3. Updated Appendix B to bring the CRCF ITS exhaust system design in line with the Receipt Facility's exhaust system design.

Attachments	Total Number of Pages

RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. EGS (Print/Sign/Date)	16. Approved/Accepted (Print/Sign/Date)
00A	Initial Issue.	25	25	Clayton De Losier	Orlando Asuncion	Tracy Johnson	Hadi Jalali
00B	Updated Appendix B to bring the CRCF ITS exhaust system design in line with the Receipt Facility's exhaust system design.	25	25	Clayton De Losier [signature] 6/7/07	Orlando Asuncion [signature] 6/7/07	Tracy Johnson [signature] for Tracy Johnson 6/7/07	Hadi Jalali [signature] 6/10/07

DISCLAIMER

The calculations contained in this document were developed by Bechtel SAIC Company, LLC (BSC) and are intended solely for the use of BSC in its work for the Yucca Mountain Project.

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ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Is Reasonably Achievable
ASHRAE	American Society of Heating, Refrigerating & Air-Conditioning Engineers
atm	atmosphere
BSC	Bechtel SAIC Company, LLC
cfm	cubic feet per minute
CRCF	Canister Receipt and Closure Facility
fpm	feet per minute
HEPA	High Efficiency Particulate Air (filter)
HVAC	Heating, Ventilating, and Air Conditioning
in. w.g.	inches water gauge
ITS	Important to Safety
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
VFD	Ventilation Flow Diagram
WP	Waste Package
ΔP	pressure drop

1. PURPOSE

The purpose of this calculation is to determine the total airside pressure drop for the exhaust subsystem serving the ITS areas of the Canister Receipt and Closure Facility 1.

The total airside pressure drop will be used to select the exhaust fan and its associated motor size. It will also be used to determine the duct pressure classification for duct design, installation, and testing and balancing.

2. REFERENCES

2.1 PROCEDURES/DIRECTIVES

2.1.1 EG-PRO-3DP-G04B-00037, Rev. 8, *Calculations and Analyses*. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070420.0002.

2.2 DESIGN INPUTS

2.2.1 BSC (Bechtel SAIC Company) 2006. *Preliminary Preclosure Safety Classification of SSCs*. 000-PSA-MGR0-00200-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061220.0030.

2.2.2 BSC (Bechtel SAIC Company) 2006. *Basis of Design for the TAD Canister-Based Repository Design Concept*. 000-3DR-MGR0-00300-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061023.0002.

2.2.3 BSC (Bechtel SAIC Company) 2006. *Project Design Criteria Document*. 000-3DR-MGR0-00100-000-006. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061201.0005.

2.2.4 SMACNA (Sheet Metal and Air Conditioning Contractors National Association) 1990. *HVAC Systems Duct Design*. 3rd Edition. Chantilly, Virginia: Sheet Metal and Air Conditioning Contractors National Association. TIC 232335. (DIRS 166230).

2.2.5 ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers) 2005. *2005 ASHRAE® Handbook, Fundamentals*. Inch-Pound Edition. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 257499 (ISBN 1-931862-70-2).

2.2.6 ASHRAE (American Society of Heating, Refrigerating & Air-Conditioning Engineers) 1997. *Duct Fitting Loss Coefficient Tables*. Atlanta, Georgia: American Society of Heating, Refrigerating and Air-Conditioning Engineers. TIC: 254160 (ISBN 1-883413-42-7).

2.2.7 BSC (Bechtel SAIC Company) 2007. *CRCF 1 Ventilation Confinement Zoning Analysis*. 060-M1A-VC00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070221.0012.

2.2.8 BSC (Bechtel SAIC Company) 2007. *Canister Receipt and Closure Facility 1 General Arrangement Ground Floor Plan*. 060-P10-CR00-00102-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070517.0002.

2.2.9 DOE-HDBK-1169-2003. *Nuclear Air Cleaning Handbook*. Washington, D.C.: U.S. Department of Energy. ACC: MOL.20060105.0204. (DIRS 167097).

2.2.10 BSC (Bechtel SAIC Company) 2007. *CRCF 1 Heating and Cooling Load Calculation (Tertiary Non ITS)*. 060-M8C-VCT0-00400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070531.0018.

2.3 DESIGN CONSTRAINTS

None

2.4 DESIGN OUTPUTS

2.4.1 *CRCF 1 Equipment Sizing and Selection Calculation (ITS)*. 060-M8C-VCT0-00500-000.

3. ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

3.1.1 Duct Friction Pressure Drop

The duct friction pressure drop is assumed to be 0.2 in. w.g. per 100 feet of duct.

Rationale: This is a conservative value for the preliminary duct sizing and pressure drop estimates, considering a required duct velocity of 2500 fpm (Reference 2.2.9, Section 5.2.2, page 5-2). The friction rate based on the actual duct size and flow rates will be used in the detailed design calculation, when the duct layout is finalized.

3.1.2 Duct Run with the Largest Pressure Drop

The longest duct run is assumed to have the highest pressure drop, where the longest duct run is determined from the duct routing shown in the ductwork diagram, Figure 1.

Rationale: The ductwork diagram, Figure 1, is representative of a typical ductwork layout, and using the longest duct run as the run with the highest pressure drop is standard engineering practice during the early stages of a simple HVAC system design. The duct run with the highest pressure drop will be verified in the detailed design calculation.

3.1.3 Duct Length and Quantity of Fittings and Dampers

The preliminary duct routing shown in the ductwork diagram, Figure 1, is used to calculate the longest duct run. Also, the following HVAC fittings and dampers listed below and shown in Appendix B are assumed to be present in the longest duct run.

- One smooth elbow without vanes is assumed to exist for every 50 feet of ductwork in the longest duct run.
- A return register, with 45^{o} blades on the face, is included in the longest duct run.
- Parallel blade combination fire and smoke dampers are assumed to exist everywhere the longest duct run passes through a potentially fire rated wall or floor.
- Fully open butterfly dampers are used to account for tornado dampers.

Rationale: The preliminary ductwork diagram, Figure 1, is representative of a typical ductwork layout. Using smooth elbows without vanes every 50 feet, the specified exit fittings, and including the various damper quantities, as noted above, gives a conservative and realistic approach to account for the HVAC fittings and dampers normally included in the duct run with the largest pressure drop. The final length of ductwork and quantity of system dampers and fittings will be verified when the final ductwork layout is available.

3.1.4 Pressure Drop for Unspecified Duct Fittings

The pressure drops for transitions, tee connections (main or straight through portions), and other miscellaneous duct fittings in the longest duct run are small enough to be accounted for with a 20% safety factor, which is applied to the pressure drop calculated for the longest duct run.

Rationale: The HVAC system design is not sufficiently developed to specify the transitions, tee connections (main or straight through portions), and other miscellaneous duct fittings. The use of a 20% safety factor is standard engineering practice during the early stages of design, and should be sufficient to account for the typically small pressure drop values associated with the aforementioned fittings. The final fitting pressure drops will be calculated and verified when the final duct layout is available and all fitting types are known.

3.1.5 VFD for the ITS Confinement HVAC System

The VFD for the ITS confinement HVAC system, Appendix B, contains all of the ITS areas, airflow rates, and the HVAC equipment and components needed to support the ITS areas.

Rationale: The ITS areas are defined by Reference 2.2.7, Table 7.1.3-1, page 12, and the airflow rates come from Reference 2.2.10. Also, all of the HVAC equipment and components that are shown on the VFD are the typical items that would be found in a nuclear HVAC system similar to the ITS confinement HVAC system.

3.1.6 ITS Areas

It is assumed that the ITS areas that need to be supported by the ITS HVAC exhaust subsystem (Reference 2.2.1, Appendix A, page A-19) are defined by Reference 2.2.7, Table 7.1.3-1, page 12.

Rationale: There is currently no confirmed ITS area analysis; therefore, Reference 2.2.7 represents the most accurate information at this time. The final ITS areas will be verified and used in the final pressure drop calculation, when the confinement and zoning analysis is finalized.

3.1.7 Longest Duct Run in the ITS Confinement HVAC System

The longest duct run for the exhaust subsystem in the ITS confinement HVAC system is between Room 1025 and the exhaust for the Train A HEPA filter plenum.

Rationale: The area that is shown to contain the exhaust subsystem, Figure 1, corresponds to References 2.2.7 and 2.2.8. It should also be noted, that the duct layout for the Train B exhaust system is symmetrical to the Train A exhaust system. This then allows either Train A or B to be used to represent the longest duct run. The longest duct run will be verified when the final ductwork layout is available.

3.1.8 Component Face Velocities

The component face velocities used in the determination of the pressure drops for all HVAC equipment, excluding components located in the HEPA filter plenum, is based on Assumption 3.1.1 and the flow rates shown in Appendix B (Assumption 3.1.5), which come from Reference 2.2.10. Table 1 shows a range of component face velocities and how component face velocities within a given range were consistently chosen.

Table 1. Component Face Velocity Determination

Component Face Velocity Range (ft/min)	Component Face Velocity Used (ft/min)
1 - 500	500
501 - 1000	1000
1001 - 1500	1500
1501 - 2000	2000
2001 - 2500	2500

Rationale: The ability to determine face velocity through the relationship between duct velocity, duct friction, duct size, and flow rate is a well-known engineering principle. Estimating the component face velocities in a preliminary design is necessary to account for estimated duct sizes, and using the largest face velocity from a specified range of values gives a conservative pressure drop estimate. Final face velocities for the components will be verified when the final duct layout is available.

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

3.2.1 Air Density

Air density at sea level standard conditions, 0.075 lbm/ft^3, is used in this calculation and Appendix A.

Rationale: The altitude effect on air density at an elevation of 3,310 feet is only a small factor in the overall calculation, and using standard air density is more conservative and will result in a larger pressure drop value.

3.2.2 HEPA Filter Pressure Losses

The HEPA filters in the HEPA filter plenum, shown in Appendix B, have pressure losses as follows:

- The 1st stage HEPA filter in the HEPA filter plenum has a pressure loss of 3 in. w.g.
- The 2nd stage HEPA filter in the HEPA filter plenum has a pressure loss of 2 in. w.g.

Rationale: The *Nuclear Air Cleaning Handbook* recommends that normal in-service pressure should be between 3-5 in. w.g. (Reference 2.2.9, Section 3.3.6.1, page 3-14). Therefore, the maximum total pressure loss across the HEPA filters should be 5 in. w.g., where a pressure loss of 3 in. w.g. for the 1st stage HEPA filter is used for ALARA reasons and a pressure loss of 2 in. w.g. for the 2nd stage HEPA filter allows for the maximum recommended pressure loss across the HEPA filters. It should also be noted, that these pressure loss values still conform to the maximum pressure loss data for HEPA filters (Reference 2.2.4, Table 9-1, page 9.3).

4. METHODOLOGY

4.1 QUALITY ASSURANCE

This calculation was prepared in accordance with procedure EG-PRO-3DP-G04B-00037, *Calculations and Analyses* (Reference 2.1.1). The portion of the surface nuclear confinement HVAC system outlined in this calculation is classified as ITS in the *Preliminary Preclosure Safety Classification of SSCs* (Reference 2.2.1, Appendix A, page A-19) and *Basis of Design for the TAD Canister-Based Repository Design Concept* (Reference 2.2.2, Section 19.1.2, page 216). Therefore, the approved record version of this calculation is designated QA:QA.

4.2 USE OF SOFTWARE

This calculation was prepared using hand calculations; therefore, no software was used.

4.3 CALCULATION METHODOLOGY

Manual methods are used to calculate the standard pressure drop values for the longest duct run, which is accomplished through the simple addition of all the pressure drop values, obtained from Appendix A, for each component in the longest duct run.

A more detailed outline of the methodology used to calculate the pressure drop values for the longest duct run is as follows:

1. From the appropriate ITS area analysis (Assumption 3.1.6) determine the locations that the HVAC system must support.

2. Create a single line diagram, Figure 1, for the duct routing having the longest duct run for the exhaust subsystem (Assumption 3.1.7).

3. Determine the length of the longest duct run from the single line diagram, Figure 1, and the quantities of HVAC components from Appendix B and Assumption 3.1.3.

4. Use Appendix A to determine the pressure drop values for each duct component and fitting.

5. Calculate duct pressure drop based on a friction pressure drop of 0.2 in. w.g. per 100 ft. of duct (Assumption 3.1.1).

6. Create a table for the total pressure drop of all the components included in the longest duct run of the exhaust subsystem, Table 2.

7. Apply a safety factor of 20% (Assumption 3.1.4), and round up to the nearest 0.1 in. w.g. to obtain the final total pressure drop value.

5. LIST OF ATTACHMENTS

There are no attachments for this calculation.

6. BODY OF CALCULATION

6.1 PRESSURE DROP CALCULATION

The longest duct run for the exhaust subsystem in the CRCF 1 ITS HVAC system, shown in Figure 1 and Appendix B with darkened lines, is examined to determine the pressure drop based upon length of ductwork, quantity of fittings and dampers, and air devices. Table 2 is then generated to identify these components and their respective pressure drops. All of the individual pressure drops for each component in the longest duct run of the exhaust subsystem are then added and multiplied by a 20% safety factor, to yield the total pressure drop for the exhaust subsystem.

6.1.1 CRCF 1 HVAC Exhaust Subsystem

The pressure drop for the CRCF 1 HVAC exhaust subsystem is presented in Table 2.

Table 2. CRCF 1 HVAC Exhaust Ductwork Pressure Drop

COMP NO. Note 1	**COMPONENT DESCRIPTION** Note 2	**QTY** Note 3	**AIR VELOCITY (ft/min)** Note 4	**LOSS COEF.** Note 5	**STD ΔP (in. w.g.)** Note 6	**STD ΔP x QTY (in. w.g.)** Note 7
129	Pressure Loss, Due to Room Negative Pressure	1	NA	NA	0.300	0.300
103	Return Register, 45° Deflection	1	500	NA	0.144	0.144
54	Parallel Blade Control Damper, Large, Fully Open, L/R=1.0	2	2500	0.52	0.203	0.405
15	High Eff. Filter 90% (Reference 2.2.3, Section 4.9.2.2.6, page 120), 6" Deep, Dirty	1	NA	NA	1.000	1.000
17	HEPA Filter 99.97% (Reference 2.2.3, Section 4.9.2.2.6, page 120), 1st Stage, Dirty	1	NA	NA	3.000[10]	3.000
18	HEPA Filter 99.97% (Reference 2.2.3, Section 4.9.2.2.6, page 120), 2nd Stage, Dirty	1	NA	NA	2.000[10]	2.000
54	Parallel Blade Control Damper, Large, Fully Open, L/R=1.0	1	2500	0.52	0.203	0.203
96	Centrifugal Fan Inlet, w/ 4 Gore Elbow, SWSI, ED7-2. r/Do=3.00, L/Do=0	1	2500	0.67	0.261	0.261
95	Centrifugal Fan Outlet w/ Position C Elbow, SWSI, SR7-7, Ab/Ao=0.9, L/Le=0.25	1	3000	0.67	0.376	0.376
54	Parallel Blade Control Damper, Large, Fully Open, L/R=1.0	1	2500	0.52	0.203	0.203
49	Backdraft Damper	1	2000	NA	1.000	1.000
127	Butterfly Damper, Rectangular, Fully Open	1[9]	2500	0.50	0.195	0.195
111	Stack Head, SD2-6. De/D = 1.0	1	3000	1.00	0.561	0.561

COMP NO. Note 1	**COMPONENT DESCRIPTION** Note 2	**QTY** Note 3	**AIR VELOCITY (ft/min)** Note 4	**LOSS COEF.** Note 5	**STD ∆P (in. w.g.)** Note 6	**STD ∆P x QTY (in. w.g.)** Note 7
133	Combination Fire and Smoke Dampers, Parallel Blades, Fully Open, L/R=1.0	3	2500	0.52	0.203	0.608
126	Round Elbow, 90°, CD3-2, r/D=1, D=6 in.	8	2500	0.25	0.097	0.779
50	Ductwork (0.2 in. w.g. pressure/per 100 ft, Assumption 3.1.1)	368[8]	2500	NA	0.002	0.736
					PRESSURE DROP	**11.771**
					Factor of Safety	x 1.2
					TOTAL PRESSURE DROP	14.125
					Use	**14.2**

1. See Appendix A for the reference source of each component number. Component is selected by description and velocity.
2. Refer to Figure 1 for ductwork routing and Appendix B for selected component placement.
3. Refer to Assumption 3.1.3, Figure 1, and Appendix B.
4. Velocity is calculated based upon Assumption 3.1.8.
5. See Appendix A for pressure drop coefficient source.
6. From Equations No. 1 and 2 or the applicable reference noted in Appendix A.
7. A 20% factor of safety is applied to the pressure prop, yielding the total pressure drop. The result is rounded up to the nearest multiple of 0.1, for the value to use (Assumption 3.1.4).
8. Duct length is calculated based on Assumption 3.1.2 and Figure 1, where 18’+140’+23’+22’+18’+9’+50’+88’ = 368’
9. Used to represent tornado dampers (Assumption 3.1.3).
10. Pressure drop values are based on Assumption 3.2.2.

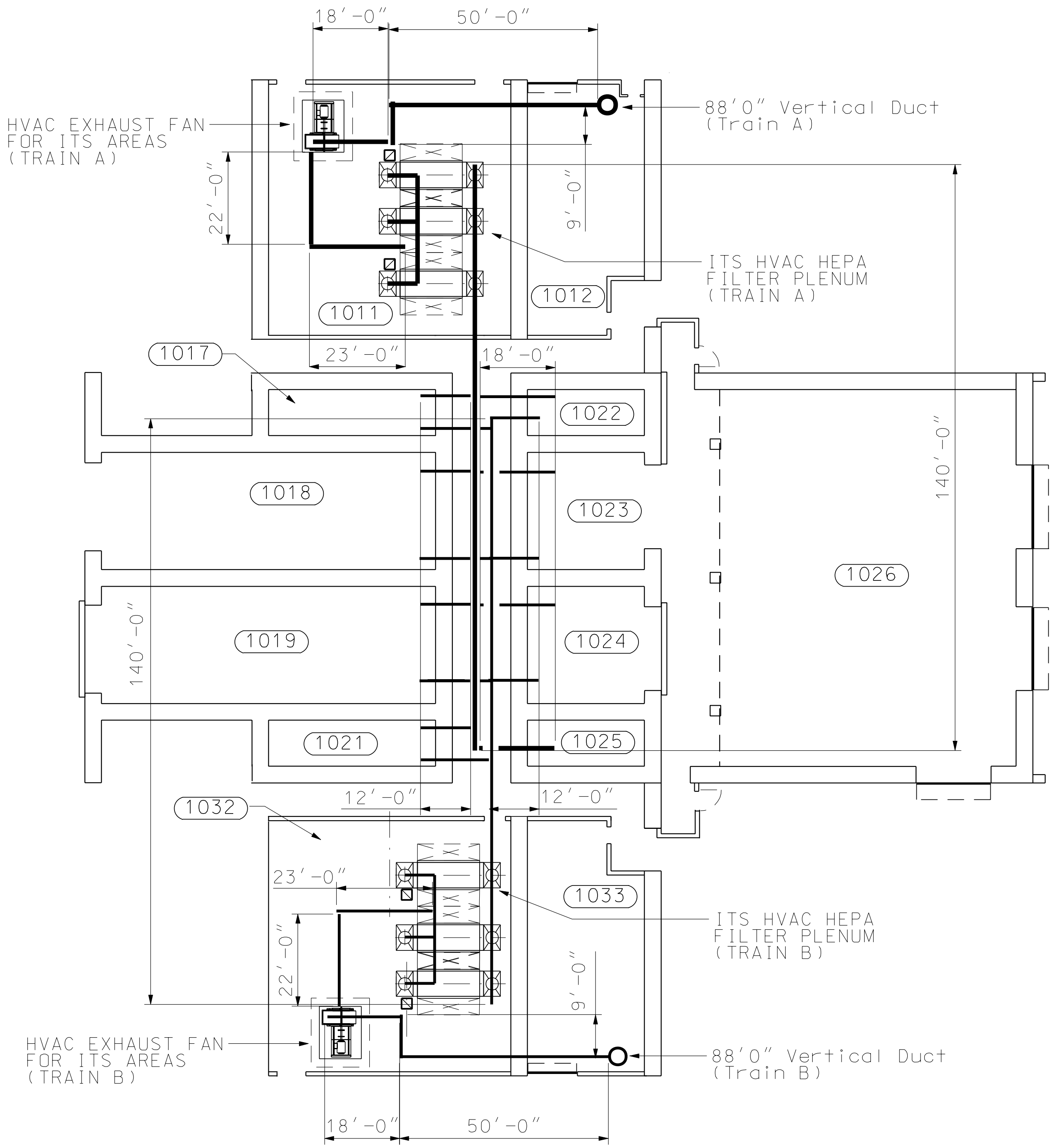

Figure 1. CRCF 1 Ground Floor HVAC Exhaust Ductwork Diagram
(Assumptions 3.1.6 and 3.1.7)

7. RESULTS AND CONCLUSIONS

Based upon the given input information, the results of the CRCF 1 ITS HVAC exhaust subsystem pressure drop calculation are reasonable, in Table 3. These results are then suitable for the sizing and selection of the CRCF 1 ITS HVAC exhaust fan. However, due to the use of sketches in this calculation, Reference 2.1.1 prevents the results of this calculation from being used for procurement, fabrication, or construction purposes.

Table 3. CRCF 1 HVAC Ductwork Pressure Drop Value

DUCT SYSTEM	TOTAL PRESSURE DROP WITH 20% S.F. (in. w.g.)	USE (in. w.g.)
CRCF 1 HVAC Exhaust Ductwork	14.125	14.2

APPENDIX A. AIRSIDE PRESSURE LOSS TABLE

The standard pressure drops for the HVAC components in Table A-1 are obtained from SMACNA (Reference 2.2.4, Chapters 9 and 14) and ASHRAE (Reference 2.2.6), where these values are retrieved based on an approximation of the components face velocity (Assumption 3.1.8). In the absence of a pressure drop value for a given component the pressure loss coefficient and approximate face velocity for that component, based on Assumption 3.1.8, is used in Equation 2 (Reference 2.2.5, Chapter 35, page 35.2, Equation 9, Assumption 3.2.1), to obtain a total pressure loss value for that component, from Equation 1 (Reference 2.2.5, Chapter 35, page 35.9, Equation 27).

$$\Delta P_j = C \times P_v \qquad \text{(Equation No. 1)}$$

Where:

ΔP_j = total pressure loss, in. w.g.
C = fitting loss coefficient
P_v = velocity pressure, in. w.g.

$$P_v = (V/4005)^2 \qquad \text{(Equation No. 2)}$$

Where:

V = face velocity, fpm

Table A-1. Airside Pressure Loss Table for HVAC Components

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
1	Entrance Loss, Bellmouth with Wall, ED1-3, r/D=0	1000	0.50	0.031	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
2	Bird Screen	500	NA	0.020	SMACNA 1990 3rd Ed, Figure 9-21
3	Louver, 2"- 45° Blade Angle	500	NA	0.125	SMACNA 1990 3rd Ed, Figure 9-13
4	Louver, 4"- 45° Blade Angle	500	NA	0.036	SMACNA 1990 3rd Ed, Figure 9-13
5	Louver, 6"- 45° Blade Angle	500	NA	0.052	SMACNA 1990 3rd Ed, Figure 9-13
6	Parallel Blade Volume Damper, Large, Fully Open, L/R=1.0	1,000	0.52	0.032	SMACNA 1990 3rd Ed, Table 14-18E
7	Parallel Blade Volume Damper, Large, Fully Open, L/R=1.0	1,500	0.52	0.073	SMACNA 1990 3rd Ed, Table 14-18E

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
8	Parallel Blade Volume Damper, Large, Fully Open, L/R=1.0	2,000	0.52	0.130	SMACNA 1990 3rd Ed, Table 14-18E
9	Parallel Blade Volume Damper, Large, Fully Open, L/R=1.0	2,500	0.52	0.203	SMACNA 1990 3rd Ed, Table 14-18E
10	Opposed Blade Volume Damper, Large, Fully Open, L/R=1.0	1,000	0.52	0.032	SMACNA 1990 3rd Ed, Table 14-18F
11	Opposed Blade Volume Damper, Large, Fully Open, L/R=1.0	1,500	0.52	0.073	SMACNA 1990 3rd Ed, Table 14-18F
12	Opposed Blade Volume Damper, Large, Fully Open, L/R=1.0	2,000	0.52	0.130	SMACNA 1990 3rd Ed, Table 14-18F
13	Opposed Blade Volume Damper, Large, Fully Open, L/R=1.0	2,500	0.52	0.203	SMACNA 1990 3rd Ed, Table 14-18F
14	Pre Filter 30-36% 4" Deep Cartridge, Dirty	NA	NA	0.700	SMACNA 1990 3rd Ed, Table 9-1
15	High Eff. Filter 90%, 6" Deep, Dirty	NA	NA	1.000	SMACNA 1990 3rd Ed, Table 9.1
16	HEPA Filter 99.97%, Remote, Dirty	NA	NA	3.000	SMACNA 1990 3rd Ed, Table 9.1
17	HEPA Filter 99.97%, 1st Stage, Dirty	NA	NA	3.000	SMACNA 1990 3rd Ed, Table 9.1
18	HEPA Filter 99.97%, 2nd Stage, Dirty	NA	NA	2.000	SMACNA 1990 3rd Ed, Table 9.1
19	Heating Coil, 1-Row, 8-Fin	500	NA	0.060	SMACNA 1990 3rd Ed, Figure 9-5
20	Heating Coil, 1-Row, 8-Fin	700	NA	0.110	SMACNA 1990 3rd Ed, Figure 9-5
21	Heating Coil, 1-Row, 14-Fin	500	NA	0.230	SMACNA 1990 3rd Ed, Figure 9-5
22	Heating Coil, 1-Row, 14-Fin	700	NA	0.410	SMACNA 1990 3rd Ed, Figure 9-5
23	Heating Coil, 2-Row, 8-Fin	500	NA	0.110	SMACNA 1990 3rd Ed, Figure 9-6
24	Heating Coil, 2-Row, 8-Fin	700	NA	0.220	SMACNA 1990 3rd Ed, Figure 9-6
25	Heating Coil, 2-Row, 14-Fin	500	NA	0.350	SMACNA 1990 3rd Ed, Figure 9-6
26	Heating Coil, 2-Row, 14-Fin	700	NA	0.720	SMACNA 1990 3rd Ed, Figure 9-6
27	Heating Coil, 3-Row, 8-Fin	500	NA	0.150	SMACNA 1990 3rd Ed, Figure 9-7
28	Heating Coil, 3-Row, 8-Fin	700	NA	0.320	SMACNA 1990 3rd Ed, Figure 9-7

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
29	Heating Coil, 3-Row, 14-Fin	500	NA	0.750	SMACNA 1990 3rd Ed, Figure 9-7
30	Heating Coil, 3-Row, 14-Fin	700	NA	1.400	SMACNA 1990 3rd Ed, Figure 9-7
31	Heating Coil, 4-Row, 8-Fin	500	NA	0.230	SMACNA 1990 3rd Ed, Figure 9-8
32	Heating Coil, 4-Row, 8-Fin	700	NA	0.490	SMACNA 1990 3rd Ed, Figure 9-8
33	Heating Coil, 4-Row, 14-Fin	500	NA	0.950	SMACNA 1990 3rd Ed, Figure 9-8
34	Heating Coil, 4-Row, 14-Fin	700	NA	1.900	SMACNA 1990 3rd Ed, Figure 9-8
35	Cooling Coil, 4-Row, 8-Fin	500	NA	0.450	SMACNA 1990 3rd Ed, Figure 9-9
36	Cooling Coil, 4-Row, 8-Fin	550	NA	0.510	SMACNA 1990 3rd Ed, Figure 9-9
37	Cooling Coil, 4-Row, 12-Fin	500	NA	1.000	SMACNA 1990 3rd Ed, Figure 9-9
38	Cooling Coil, 4-Row, 12-Fin	550	NA	1.200	SMACNA 1990 3rd Ed, Figure 9-9
39	Cooling Coil, 6-Row, 8-Fin	500	NA	0.720	SMACNA 1990 3rd Ed, Figure 9-10
40	Cooling Coil, 6-Row, 8-Fin	550	NA	0.850	SMACNA 1990 3rd Ed, Figure 9-10
41	Cooling Coil, 6-Row, 12-Fin	500	NA	1.400	SMACNA 1990 3rd Ed, Figure 9-10
42	Cooling Coil, 6-Row, 12-Fin	550	NA	1.600	SMACNA 1990 3rd Ed, Figure 9-10
43	Cooling Coil, 8-Row, 8-Fin	500	NA	0.900	SMACNA 1990 3rd Ed, Figure 9-11
44	Cooling Coil, 8-Row, 8-Fin	550	NA	1.100	SMACNA 1990 3rd Ed, Figure 9-11
45	Cooling Coil, 8-Row, 12-Fin	500	NA	1.700	SMACNA 1990 3rd Ed, Figure 9-11
46	Cooling Coil, 8-Row, 12-Fin	550	NA	2.000	SMACNA 1990 3rd Ed, Figure 9-11
47	Backdraft Damper	1,000	NA	0.300	SMACNA 1990 3rd Ed, Figure 9-3
48	Backdraft Damper	1,500	NA	0.600	SMACNA 1990 3rd Ed, Figure 9-3
49	Backdraft Damper	2,000	NA	1.000	SMACNA 1990 3rd Ed, Figure 9-3
50	Ductwork (0.2 in. w.g. pressure/per 100 ft)	2,500	NA	0.002	Total Press Drop = Quantity x Standard Press Drop
51	Parallel Blade Control Damper, Large, Fully Open, L/R=1.0	1,000	0.52	0.032	SMACNA 1990 3rd Ed, Table 14-18E

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
52	Parallel Blade Control Damper, Large, Fully Open, L/R=1.0	1,500	0.52	0.073	SMACNA 1990 3rd Ed, Table 14-18E
53	Parallel Blade Control Damper, Large, Fully Open, L/R=1.0	2,000	0.52	0.130	SMACNA 1990 3rd Ed, Table 14-18E
54	Parallel Blade Control Damper, Large, Fully Open, L/R=1.0	2,500	0.52	0.203	SMACNA 1990 3rd Ed, Table 14-18E
55	Opposed Blade Control Damper. Large, Fully Open, L/R=1.0	1,000	0.52	0.032	SMACNA 1990 3rd Ed, Table 14-18F
56	Opposed Blade Control Damper. Large, Fully Open, L/R=1.0	1,500	0.52	0.073	SMACNA 1990 3rd Ed, Table 14-18F
57	Opposed Blade Control Damper. Large, Fully Open, L/R=1.0	2,000	0.52	0.130	SMACNA 1990 3rd Ed, Table 14-18F
58	Opposed Blade Control Damper. Large, Fully Open, L/R=1.0	2,500	0.52	0.203	SMACNA 1990 3rd Ed, Table 14-18F
59	Fire Damper, 2-Hour Type A - Blade in Airstream	1,000	NA	0.036	SMACNA 1990 3rd Ed, Figure 9-4
60	Fire Damper, 2-Hour Type A - Blade in Airstream	1,500	NA	0.100	SMACNA 1990 3rd Ed, Figure 9-4
61	Fire Damper, 2-Hour Type A - Blade in Airstream	2,000	NA	0.200	SMACNA 1990 3rd Ed, Figure 9-4
62	Fire Damper, 2-Hour Type A - Blade in Airstream	2,500	NA	0.350	SMACNA 1990 3rd Ed, Figure 9-4
63	Fire Damper, 2-Hour Type B - Blade out of Airstream	1,000	NA	0.015	SMACNA 1990 3rd Ed, Figure 9-4
64	Fire Damper, 2-Hour Type B - Blade out of Airstream	1,500	NA	0.047	SMACNA 1990 3rd Ed, Figure 9-4
65	Fire Damper, 2-Hour Type B - Blade out of Airstream	2,000	NA	0.110	SMACNA 1990 3rd Ed, Figure 9-4
66	Fire Damper, 2-Hour Type B - Blade out of Airstream	2,500	NA	0.200	SMACNA 1990 3rd Ed, Figure 9-4
67	Rectangular Smooth Elbow without Vanes, CR3-1, r/W=1.00, H/W=0.50	1,500	0.25	0.035	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
68	Rectangular Smooth Elbow without Vanes, CR3-1, r/W=1.00, H/W=0.50	2,000	0.25	0.062	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
69	Rectangular Smooth Elbow without Vanes, CR3-1, r/W=1.00, H/W=0.50	2,500	0.25	0.097	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
70	Rectangular Mitered Elbow w/ Double Thickness Vanes, 90°, CR3-15	1,500	0.25	0.035	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
71	Rectangular Mitered Elbow w/ Double Thickness Vanes, 90°, CR3-15	2,000	0.25	0.062	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
72	Rectangular Mitered Elbow w/ Double Thickness Vanes, 90°, CR3-15	2,500	0.25	0.097	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
73	Rectangular Mitered Elbow without Vanes, CR3-6. 90° Elbow, Most Conservative Loss Coefficient	1,500	1.30	0.182	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
74	Rectangular Mitered Elbow without Vanes, CR3-6. 90° Elbow, Most Conservative Loss Coefficient	2,000	1.30	0.324	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
75	Rectangular Mitered Elbow without Vanes, CR3-6. 90° Elbow, Most Conservative Loss Coefficient	2,500	1.30	0.507	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
76	Round 3 Gore Elbow, CD3-12. r/D=1.0	1,500	0.42	0.059	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
77	Round 3 Gore Elbow, CD3-12. r/D=1.0	2,000	0.42	0.105	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
78	Round 3 Gore Elbow, CD3-12. r/D=1.0	2,500	0.42	0.164	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
79	Round Mitered Elbow without Vanes, CD3-15, D=6 in.	1,500	1.31	0.184	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
80	Round Mitered Elbow without Vanes, CD3-15, D=6 in.	2,000	1.31	0.327	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
81	Round Mitered Elbow without Vanes, CD3-15, D=6 in.	2,500	1.31	0.510	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
82	Mitered Elbow with Variable Inlet/Outlet Areas, ER3-1, H/W_o=1.0, $W1/W_o$=1.4	1,500	0.95	0.133	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
83	Mitered Elbow with Variable Inlet/Outlet Areas, ER3-1, H/W_o=1.0, $W1/W_o$=1.4	2,000	0.95	0.237	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
84	Mitered Elbow with Variable Inlet/Outlet Areas, ER3-1, H/W_o=1.0, $W1/W_o$=1.4	2,500	0.95	0.370	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
85	Supply Rectangular Duct Branch, Diverging, SR5-13, A_b/A_c=0.4, Q_b/Q_c=0.4	1,500	0.73	0.102	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
86	Supply Rectangular Duct Branch, Diverging, SR5-13, A_b/A_c=0.4, Q_b/Q_c=0.4	2,000	0.73	0.182	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
87	Supply Rectangular Duct Branch, Diverging, SR5-13, A_b/A_c=0.4, Q_b/Q_c=0.4	2,500	0.73	0.284	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
88	Supply Round Duct Branch, Diverging, SD5-10, A_b/A_c=0.4, Q_b/Q_c=0.4	1,500	0.65	0.091	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
89	Supply Round Duct Branch, Diverging, SD5-10, A_b/A_c=0.4, Q_b/Q_c=0.4	2,000	0.65	0.162	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
90	Supply Round Duct Branch, Diverging, SD5-10, A_b/A_c=0.4, Q_b/Q_c=0.4	2,500	0.65	0.253	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
91	Supply Rectangular Duct, Tee 90° Diverging, SR5-5. A_b/A_c=0.8, Q_b/Q_c=0.9	1,000	1.07	0.067	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
92	Exhaust Rectangular Duct, Tee 45° Converging, Dead End, ER5-3, Q_b/Q_c=1.0	1,000	0.91	0.057	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
93	Exhaust Rectangular Duct, Tee 45° Converging, ER5-3, Q_b/Q_c=0.5	1,000	0.76	0.047	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
94	Exhaust Rectangular Duct, Tee 45° Converging, Straight Through, ER5-3, Q_s/Q_c=0.5	1,000	2.23	0.139	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
95	Centrifugal Fan Outlet w/ Position C Elbow, SWSI, SR7-7, A_b/A_o=0.9, L/Le=0.25	3,000	0.67	0.376	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
96	Centrifugal Fan Inlet, w/ 4 Gore Elbow, SWSI, ED7-2. r/D_o=3.00, L/D_o=0	2,500	0.67	0.261	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
97	Round Diffuser	600	NA	0.056	SMACNA 1990 3rd Ed, Table 9-5
98	Square Diffuser, Adjustable	600	NA	0.080	SMACNA 1990 3rd Ed, Table 9-5
99	Rectangular Diffuser	600	NA	0.096	SMACNA 1990 3rd Ed, Table 9-5
100	Perforated Diffuser	600	NA	0.083	SMACNA 1990 3rd Ed, Table 9-5
101	Linear Slot Diffuser	600	NA	0.110	SMACNA 1990 3rd Ed, Table 9-5
102	Supply Register, 45° Deflection	500	NA	0.047	SMACNA 1990 3rd Ed, Table 9-6
103	Return Register, 45° Deflection	500	NA	0.144	SMACNA 1990 3rd Ed, Table 9-7
104	Perforated Return Register	600	NA	0.100	SMACNA 1990 3rd Ed, Table 9-7
105	Exhaust Louver, 4", 45° Blade Angle	500	NA	0.036	SMACNA 1990 3RD Ed, Figure 9-13
106	Exit Loss, Exhaust Stack, SR2-6, L/D_h=0.5, Angle=26°	2,500	0.49	0.191	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
107	Exit Loss to Atmosphere, SR2-1, Turbulent Flow	1,000	1.00	0.062	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
108	Exit Loss to Atmosphere, SR2-1, Turbulent Flow	2,000	1.00	0.249	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
109	Discharge into the Plenum, SR2-1, Turbulent Flow	1,000	1.00	0.062	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
110	Entry from the Plenum, Bellmouth with Wall, ED 1-3, r/D=0	1,000	0.50	0.031	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_S (in. w.g.)	REFERENCE SOURCE
111	Stack Head, SD2-6. De/D = 1.0	3,000	1.00	0.561	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
112	Wye, Rectangular, θ=45°	900	0.45	0.023	SMACNA 1990 3rd Ed, Table 9-7
113	Mitered Elbow, CR3-6, θ=45°, H/W=1	1,000	0.34	0.021	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
114	Rectangular Mitered Elbow w/ Double Thickness Vanes, CR3-15	500	0.25	0.004	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
115	Exhaust Hood without screen, θ=15°, L/D=0.3	2500	0.80	0.312	SMACNA 1990 3rd Ed. Table 14-16, A
116	Exhaust Hood without screen, θ=15°, L/D=0.3	1000	0.80	0.050	SMACNA 1990 3rd Ed. Tables 14-15 & 14-17
117	Converging Tee, 45° Entry Branch to Rectangular Main	500	-0.76	-0.012	SMACNA 1990 3rd Ed. Table14-13, F
118	Abrupt Exit, SR 2-1, Most Conservative Loss Coefficient	1,000	2.00	0.125	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
119	Modular Air-to-Air Plate Heat Exchanger, 8 fin, process air	1,500	NA	1.800	SMACNA 1990 3rd Ed, Figure 9-22
120	Modular Air-to-Air Plate Heat Exchanger, 8 fin, make-up air	2,000	NA	2.200	SMACNA 1990 3rd Ed, Figure 9-22
121	Bird Screen	2,000	NA	0.160	SMACNA 1990 3rd Ed, Figure 9-21
122	Louver, 6"- 45° Blade Angle	2,000	NA	0.900	SMACNA 1990 3rd Ed, Figure 9-13
123	Entrance Loss, Bellmouth with Wall, ED1-3, r/D=0	2500	0.50	0.195	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
124	Terminal Control Unit, Basic Assembly, 2-Row Coil w/ Attenuator, CR8-11	1500	3.80	0.533	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997
125	Centrifugal Fan Inlet, Located in Cabinet, ED7-1, L/D_o=0.3	2500	0.80	0.312	ASHRAE, Duct Fitting Loss Coefficient Tables, 1998
126	Round Elbow, 90°, CD3-2, r/D=1, D=6 in.	2500	0.25	0.097	ASHRAE, Duct Fitting Loss Coefficient Tables, 1997

COMP NO.	COMPONENT DESCRIPTION	AIR VELOCITY (ft/min)	LOSS COEF.	STANDARD ΔP_s (in. w.g.)	REFERENCE SOURCE
127	Butterfly Damper, Rectangular, Fully Open	2500	0.50	0.195	SMACNA 1990 3rd Ed. Table14-18, G
128	Production Line Welding Booth	3500	0.50	0.382	ACGIH 2004 25th Ed. Figure VS-90-03
129	Pressure Loss, Due to Room Negative Pressure	NA	NA	0.300	Appendix B
130	Combination Fire and Smoke Dampers, Parallel Blades, Fully Open, L/R=1.0	1,000	0.52	0.032	SMACNA 1990 3rd Ed, Table 14-18E
131	Combination Fire and Smoke Dampers, Parallel Blades, Fully Open, L/R=1.0	1,500	0.52	0.073	SMACNA 1990 3rd Ed, Table 14-18E
132	Combination Fire and Smoke Dampers, Parallel Blades, Fully Open, L/R=1.0	2,000	0.52	0.130	SMACNA 1990 3rd Ed, Table 14-18E
133	Combination Fire and Smoke Dampers, Parallel Blades, Fully Open, L/R=1.0	2,500	0.52	0.203	SMACNA 1990 3rd Ed, Table 14-18E
134	Combination Fire and Smoke Dampers, Opposed Blade, Fully Open, L/R=1.0	1,000	0.52	0.032	SMACNA 1990 3rd Ed, Table 14-18F
135	Combination Fire and Smoke Dampers, Opposed Blade, Fully Open, L/R=1.0	1,500	0.52	0.073	SMACNA 1990 3rd Ed, Table 14-18F
136	Combination Fire and Smoke Dampers, Opposed Blade, Fully Open, L/R=1.0	2,000	0.52	0.130	SMACNA 1990 3rd Ed, Table 14-18F
137	Combination Fire and Smoke Dampers, Opposed Blade, Fully Open, L/R=1.0	2,500	0.52	0.203	SMACNA 1990 3rd Ed, Table 14-18F

APPENDIX B. CRCF 1 PRELIMINARY VENTILATION FLOW DIAGRAM

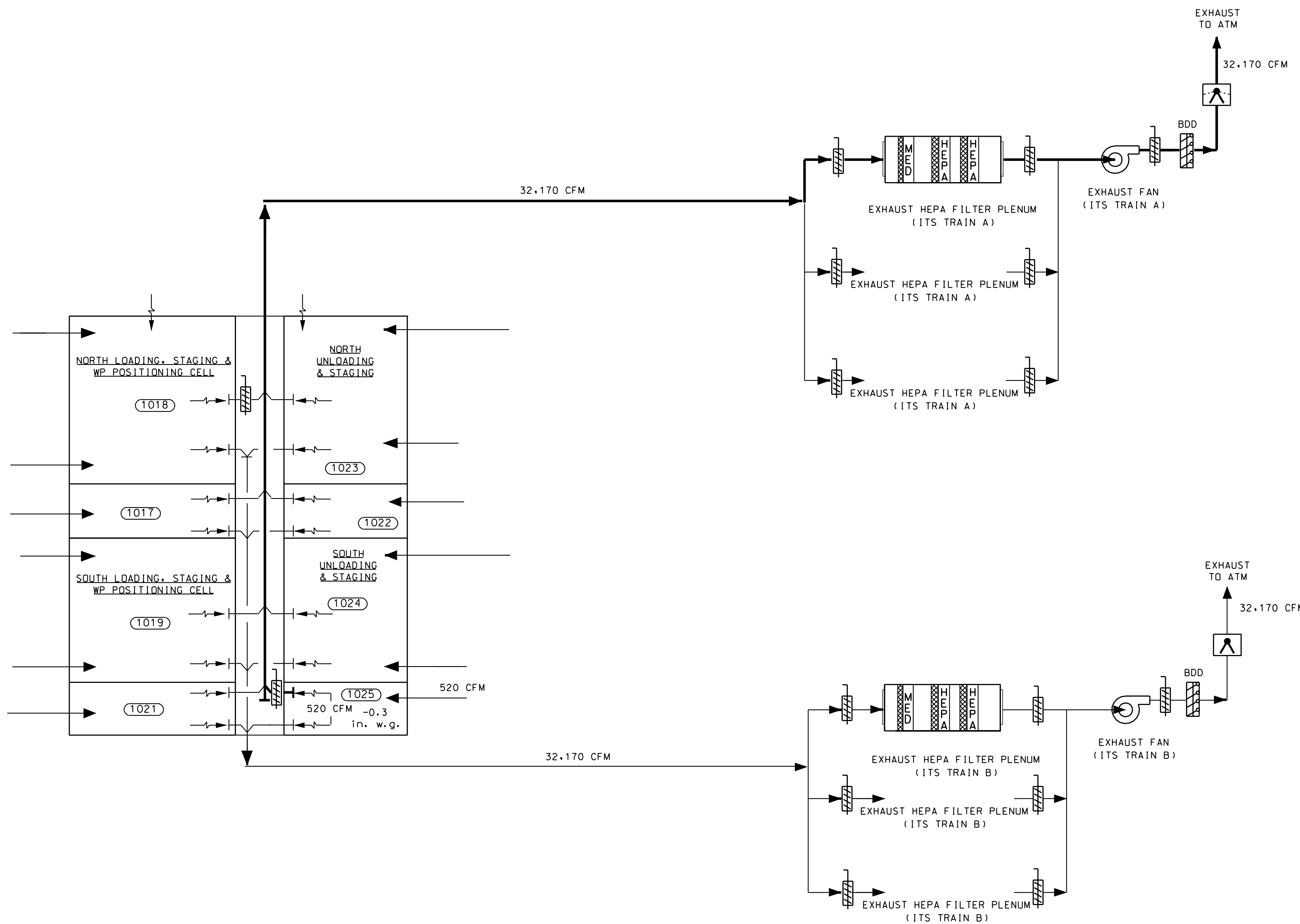

Figure B-1. CRCF 1 ITS Area Preliminary Ventilation Flow Diagram
(Assumption 3.1.5)