VERMONT MECHANICAL INCORPORATED

P. O. Box 728
Williston, VT 05495
Ph : (802) 862-5900

Submittal

Job: DLR75-000
Delehanty Hall @ UVM
180 Colchester Ave
Burlington, VT 05405

Spec Section No: 23 05 93
Submittal No: 2
Revision No: 0
Sent Date: 10/7/2015
Due Date: 10/14/2015

Spec Section Title:

Submittal Title: Final Balance Report

VMI PO #: Subcontract

Contractor:
Vermont Mechanical, Inc.
Chantal Bitzer

Lead time after approval: N/A

Date items required at project:

Contractor

This submittal has been checked for general conformance with the information given in the contract documents. Final quantities, measurements, and coordination with other trades shall take place in the field.

This submittal will now go to the General Contractor, Architect, and Engineer for final approval.

Architect

Other:
Slade;David

General Contractor

Engineer

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Cosmogenic Nuclide Laboratory Fume Hood Balance

Delehanty Hall

University Of Vermont

Burlington, Vermont

Vermont Mechanical # DLR750006201

Precision Balancing # 2774

October 2, 2015

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HVAC & Building Comfort Troubleshooting

NEBB Cert. No. 3172

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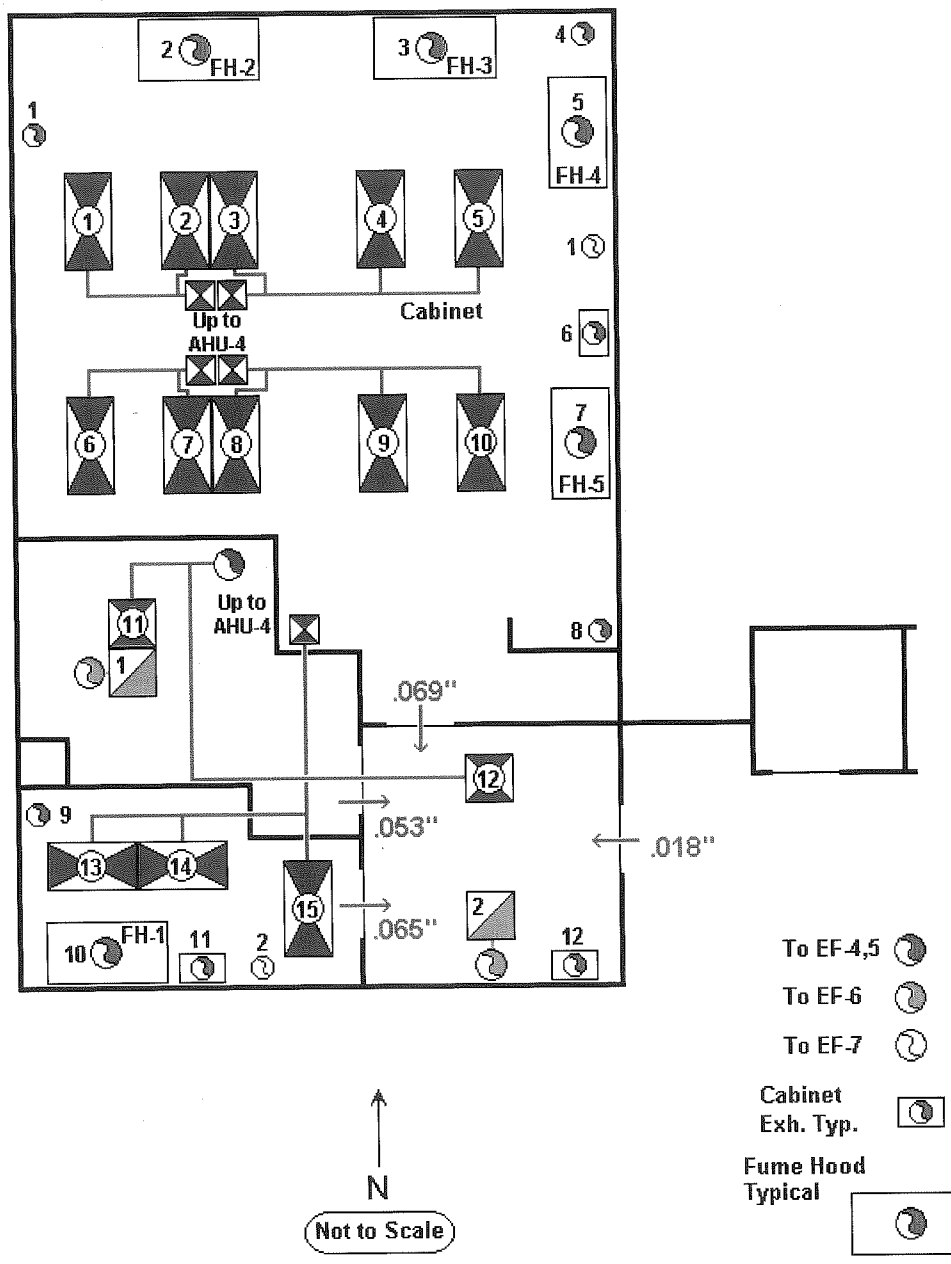
Cosmogenic Nuclide Laboratory
Delehanty Hall
University Of Vermont
Burlington, Vermont
Vt. Mech # DLR750006201
Precision Balancing # 2774

October 2, 2015



File Name: 2774Sept

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Precision Balancing No. 2774		Contractor No. Vt. Mech. # DLR750006201	
Contract No.	Job Name: Delehanty Hall, UVM		Technician: TC & TW
Project: 2774AHU4	Location: Burlington, Vermont		Date: 10-2-15

Air Apparatus Test Report

System/Unit: AHU-4

UNIT DATA

Make	Clean PAK	Class/Discharge	/
Model No.	Size 22 Fanwall	Tag No.	AHU-4
Serial No.	A09 AH-01	Location	Rooftop

MOTOR DATA

Make	Toshiba (Two Motors)	Model / Part No.	B0154FLF2USH02	RPM	1775
Frame	254T	Volts / Phase /Hz	230-460, 3, 60	S.F.	1.15
H.P.	15	Full Load Amps	37 - 18.5	Flac	N/A
Measured Volts	3.4 KW (Freq)	Measured Amps	15.8 (Freq)	BHP	N/A

DRIVE DATA

Fan Data			Motor Data		
Sheave Size / Make	Direct Drive		Sheave Size / Make	Direct Drive	
Bushing / Bore Size	Direct Drive		Bushing / Bore Size	Direct Drive	
No. Belts / Make / Size	Direct Drive		Sheave C to C	Direct Drive	
Fan Design RPM	2222 (74 Hz)	Fan Actual RPM	1,694	Motor Actual RPM	1,694

AIR DATA

	Design	Actual		Design	Actual
Total CFM	7,500 Rated	6,689	Total S.P.	6.0"	N/A
O.A. CFM	6,850	6,689	Disch. S. P.	/	N/A
Ret. Air CFM	/	/	Suc. S. P.	/	N/A

Pre-Heat S.P. Drop	N/A	Cooling Coil S.P. Drop	N/A	Re-Heat S.P. Drop	N/A
Pre-Filter S.P. Drop	N/A	Hi Eff. Filter S.P. Drop	N/A		
Vortex Damp. Pos.	57 Hz	O.A. Damper Pos.	90% OP	Ret. Air Damp Pos.	/

NOTES

1.) Unable to drill unit for pressure readings.

2.) System read with 'A' fan running.

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Precision Balancing No. 2774		Contractor No. Vt. Mech. # DLR750006201	
Contract No.	Job Name: Delehanty Hall, UVM		Technician: TC & TW
Project: 2774AH4DF	Location: Burlington, Vermont		Date: 10-2-15

Diffuser, Register, & Grille Test Report

System/Unit: AHU-4

Area Served	Outlet Number	Type	Size	"K" Factor	Design		Pre CFM	Final		%Diff	Refer to Note
					FPM	CFM		FPM	CFM	CFM	
	1	HEPA	12"	1	500	500	500	505	505	1.0%	
	2	HEPA	12"	1	500	500	470	498	498	-0.4%	
	3	HEPA	12"	1	500	500	501	535	535	7.0%	
	4	HEPA	12"	1	500	500	507	502	502	0.4%	
	5	HEPA	12"	1	500	500	490	479	479	-4.2%	
	6	HEPA	12"	1	500	500	498	514	514	2.8%	
	7	HEPA	12"	1	500	500	460	475	475	-5.0%	
	8	HEPA	12"	1	500	500	383	400	400	-20.0%	3
	9	HEPA	12"	1	500	500	503	520	520	4.0%	
	10	HEPA	12"	1	500	500	477	505	505	1.0%	
	11	CD	10"	1	300	300	250	255	255	-15.0%	3
	12	CD	6"	1	50	50	32	30	30	-40.0%	3
	13	HEPA	12"	1	500	500	459	454	454	-9.2%	
	14	HEPA	12"	1	500	500	500	504	504	0.8%	
	15	HEPA	12"	1	500	500	498	513	513	2.6%	
					Total from Previous Page(s)			Previous Total			
					Total	6850		Total	6689		

NOTES

1.) Refer to drawing for diffuser location.

2.) Flowhood used 'K' factor equals (1) one.

3.) Ceiling not accessable to make damper adjustments.

4.) Pre-Readings from 7-27-15 Report (Total = 6,528 CFM)

5.) AHU-4 static setpoint = .70"

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Precision Balancing No. 2774		Contractor No. Vt. Mech. # DLR750006201	
Contract No.	Job Name: Delehanty Hall, UVM		Technician: TC & TW
Project: 2774EF45F	Location: Burlington, Vermont		Date: 10-2-15

Diffuser, Register, & Grille Test Report

System/Unit: E.F. 4 & 5

Area Served	Outlet Number	Type	Size	"K" Factor	Design		Pre CFM	Final		%Diff	Refer to Note
					FPM	CFM		FPM	CFM	CFM	
	1	SS	4"	.087	575	50	54	595	52	4.0%	
	2	SS	12"	.786	1368	1075	889	1182	929	-13.6%	3
	3	SS	14"	1.07	1005	1075	1041	967	1035	-3.7%	3
	4	SS	4"	.087	575	50	42	528	46	-8.0%	
	5	SS	12"	.786	1368	1075	768	1130	888	-17.4%	3
	6	SS	3"	.049	612	30	29	570	28	-6.7%	
	7	SS	14"	1.07	1005	1075	1072	1060	1134	5.5%	3
	8	SS	4"	.087	575	50	49	542	47	-6.0%	
	9	SS	4"	.087	575	50	53	639	56	12.0%	
	10	SS	14"	1.07	1005	1075	1036	1013	1084	0.8%	3
	11	SS	3"	.049	612	30	30	620	30	0.0%	
	12	SS	3"	.049	612	30	26	526	26	-13.3%	

Total from Previous Page(s) | **Previous Total**

Total 5665 | **Total** 5355

NOTES

1.) Refer to drawing for exhaust location.

2.) Drops balanced with EF-4 running.

3.) 1,075 CFM listed in design column is minimum CFM required (per manufacturer).

4.) Pre-Readings from 7-27-15 Report (Total = 5,089 CFM)

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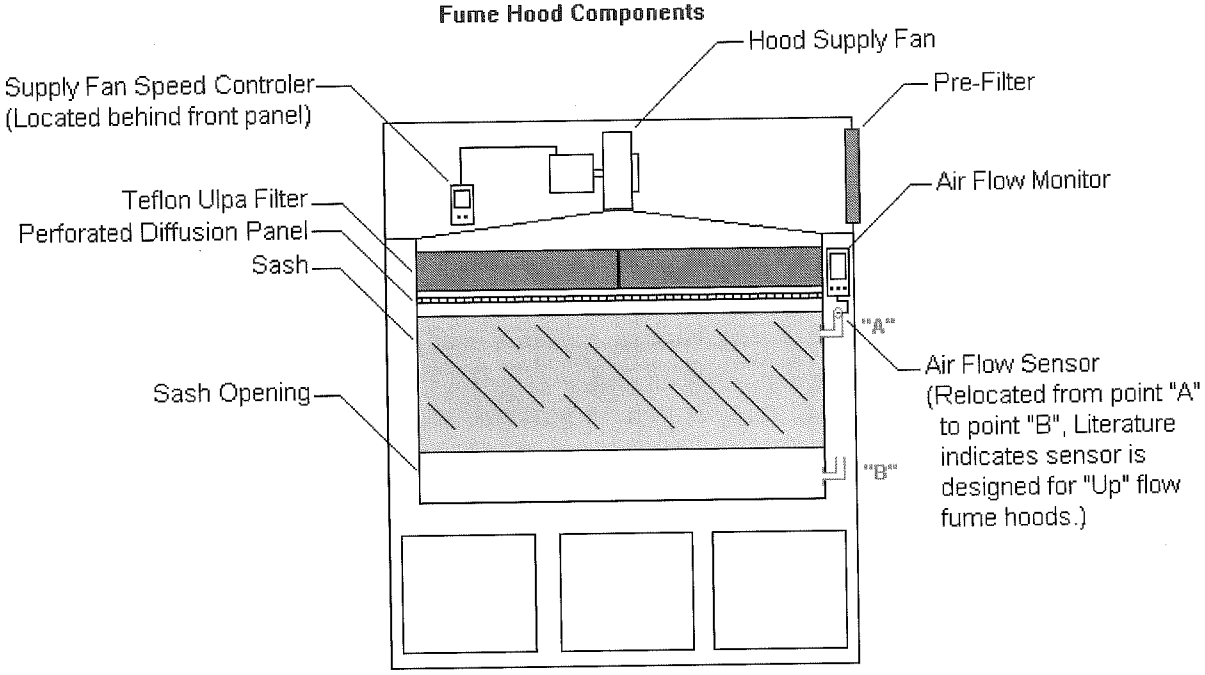
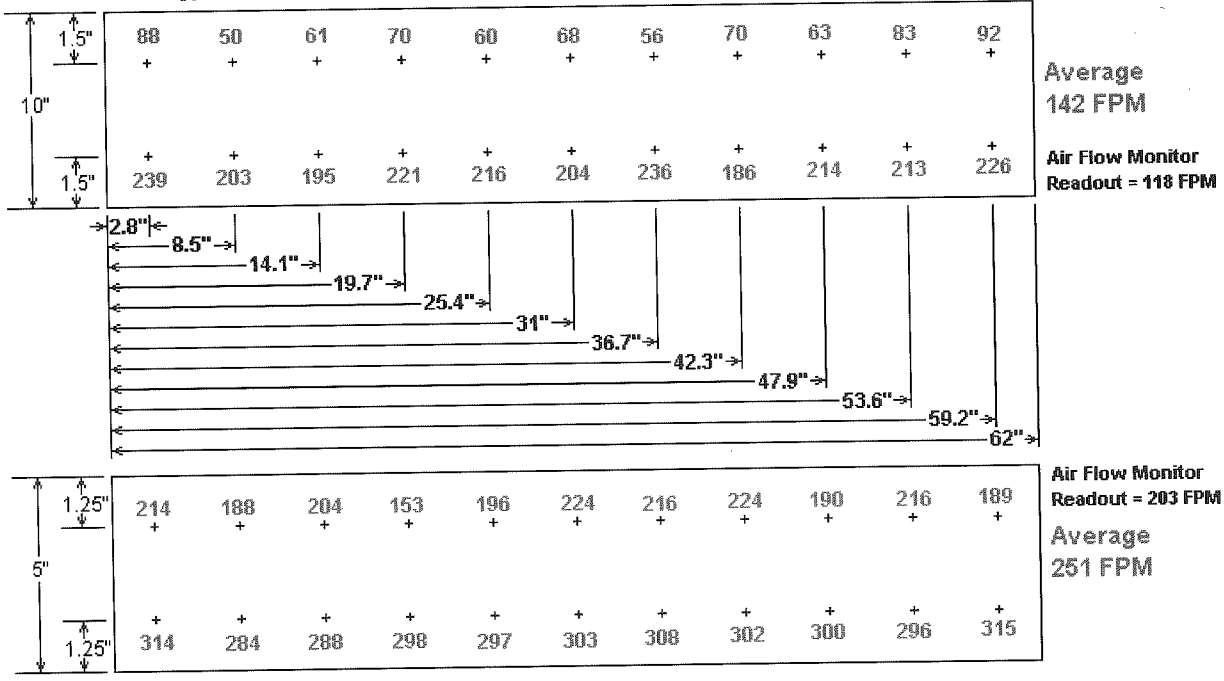
Fume Hood Components



Note: Supply fan set for 60 FPM "Downflow Velocity". Readings were taken and recorded 2" and 6" below the perferated diffusion panel, using a Shortridge meter with the "Velgrid" adapter.

FUME HOOD #1

Typical "Face Velocity Profile" (FPM) with Sash at 10" and 5" opening.



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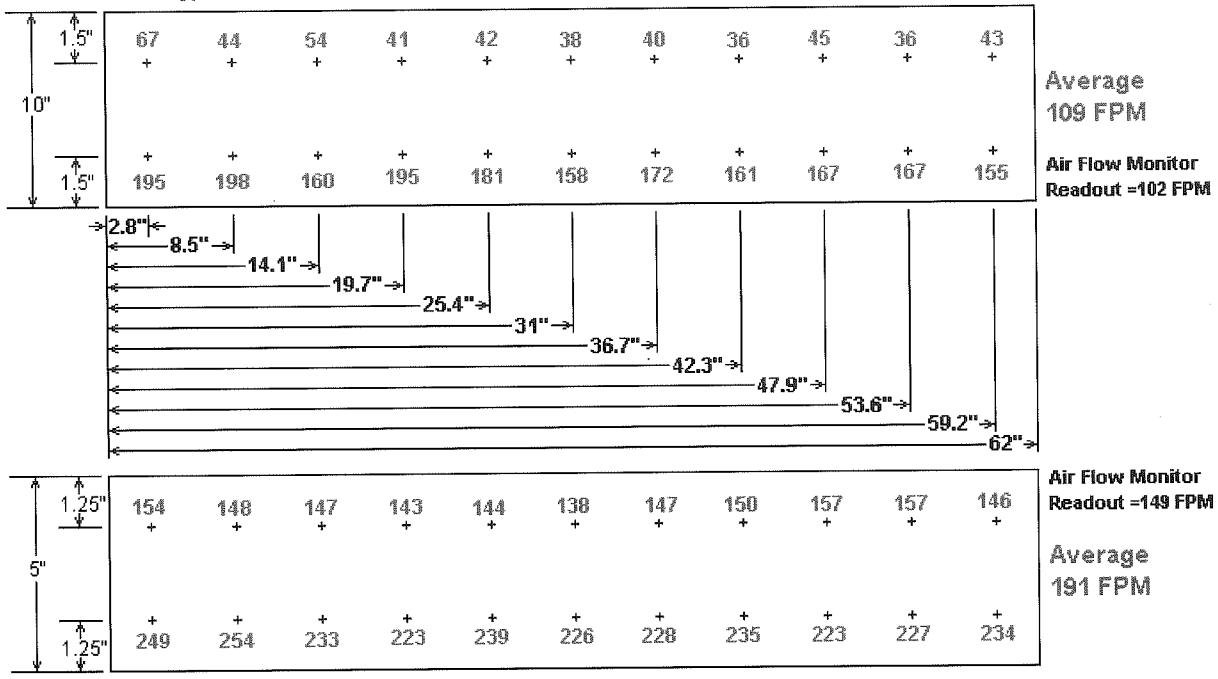
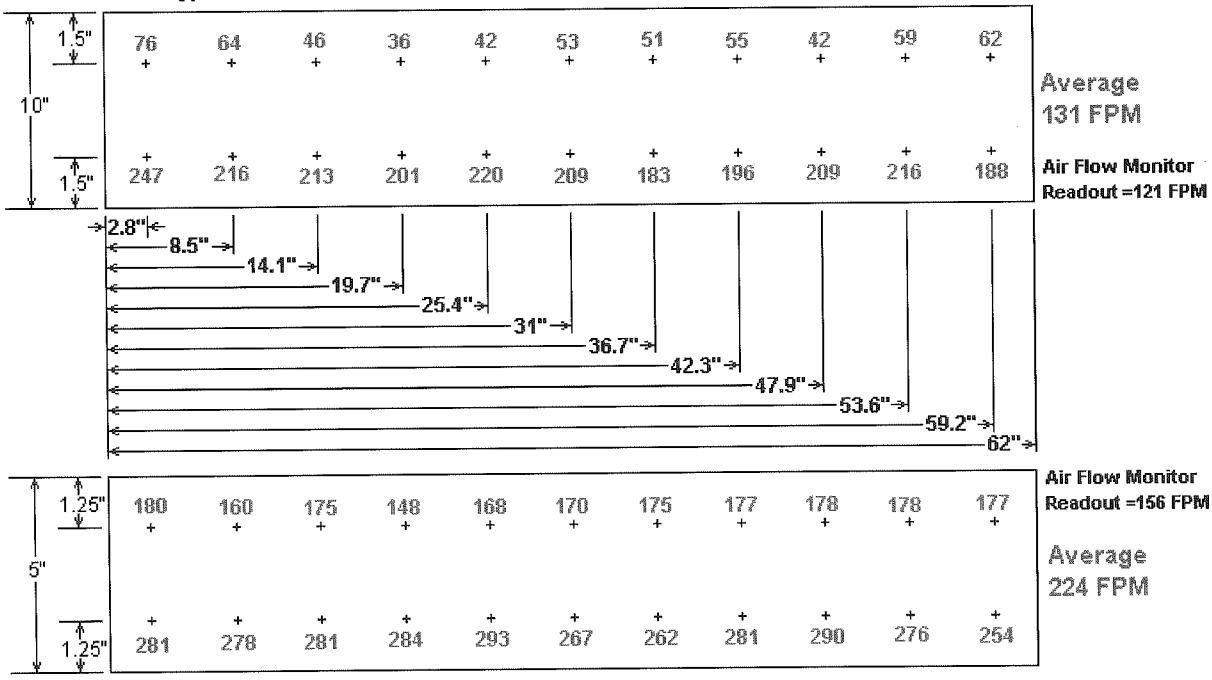
FUME HOOD #2

Typical "Face Velocity Profile" (FPM) with Sash at 10" and 5" opening.



FUME HOOD #3

Typical "Face Velocity Profile" (FPM) with Sash at 10" and 5" opening.



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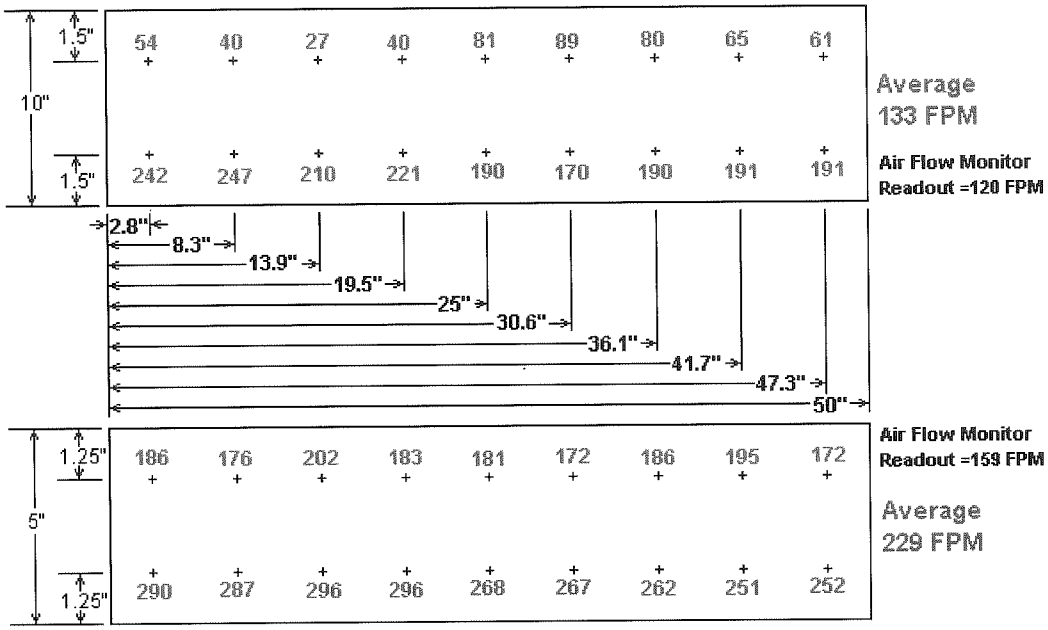
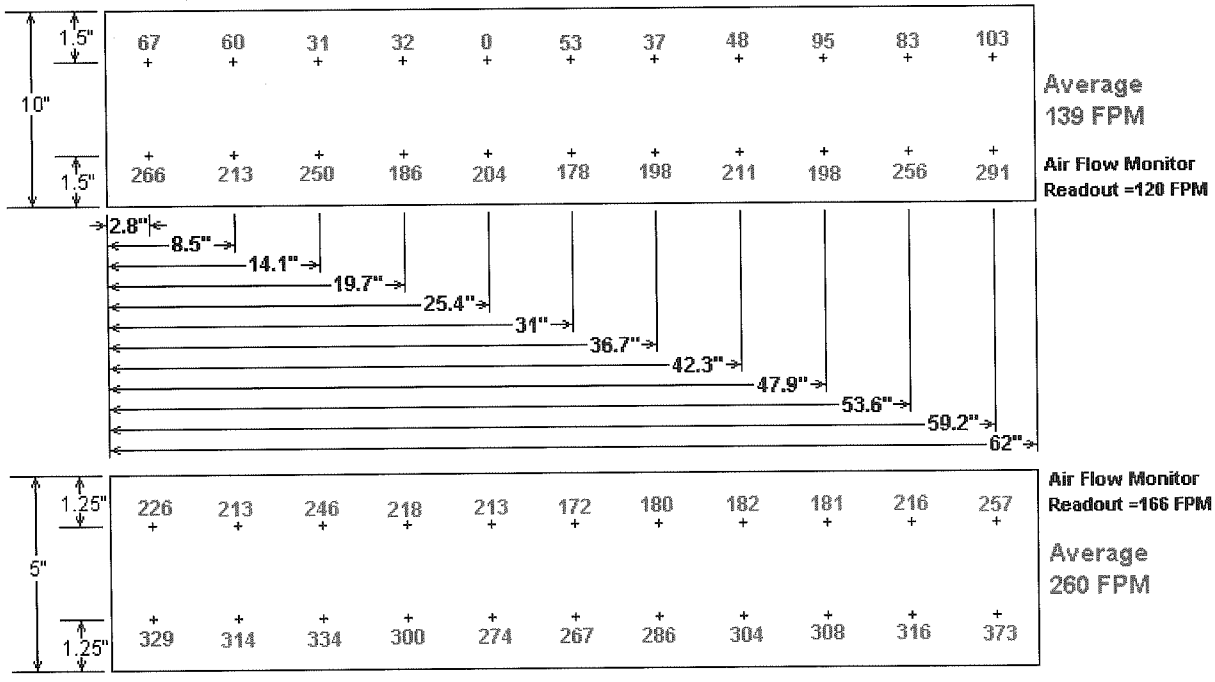
FUME HOOD #4

Typical "Face Velocity Profile" (FPM) with Sash at 10" and 5" opening.



FUME HOOD #5

Typical "Face Velocity Profile" (FPM) with Sash at 10" and 5" opening.



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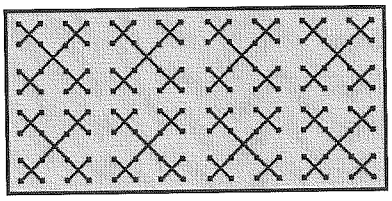

Supply Air in Hood Read with 1'x1' Shortridge Velgrid (Readings taken in FPM)
Readings taken in 8 locations shown above on Fume Hoods 1, 2, 3, and 5
Readings taken in 6 locations on Fume Hood 4
Readings taken at 2" and 6" from the "Perforated Diffusion Panel"

Hood #1

2" from Perforated Panel

37	57	57	38
47	68	70	53

Average= 53

6" from Perforated Panel

48	53	55	43
47	58	50	45

Average= 50

Hood #2

47	50	63	48
48	72	69	39

Average= 55

44	54	52	52
67	72	63	50

Average= 57

Hood #3

42	54	78	45
59	68	70	62

Average= 60

53	57	58	55
55	58	65	52

Average= 57

Hood #4

57	65	42
63	68	53

Average= 58

59	65	52
61	71	53

Average= 60

Hood #5

38	62	41	30
45	71	52	40

Average= 47

53	59	54	52
48	63	57	53

Average= 55

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Precision Balancing No. 2774		Contractor No. Vt. Mech. # DLR750006201	
Contract No.	Job Name: Delehanty Hall, UVM		Technician: TC & TW
Project: 2774ef6	Location: Burlington, Vermont		Date: 10-2-15

Air Apparatus Test Report

System/Unit: EF-6

UNIT DATA

Make	Greenheck	Class/Discharge	/
Model No.	8-BISW-41-X-10-1	Tag No.	EF
Serial No.	11221500 0802	Location	Rooftop

MOTOR DATA

Make	WEG	Model / Part No.	1UTOICGNXX1/204E	RPM	1750
Frame	B56	Volts / Phase /Hz	208-230-460, 3, 60	S.F.	1.25
H.P.	1/2	Full Load Amps	2.21 - 2.0 - 1.0	Flac	/
Measured Volts	206.2 - 206.3 - 206.5	Measured Amps	1.6 - 1.6 - 1.61	BHP	/

DRIVE DATA

Fan Data			Motor Data		
Sheave Size / Make	AK34 x QT		Sheave Size / Make	AK44	
Bushing / Bore Size	QT x 1"		Bushing / Bore Size	5/8"	
No. Belts / Make / Size	1 / Carlisle / 4L300R		Sheave C to C	8 3/4"	
Fan Design RPM	1808	Fan Actual RPM	2,210	Motor Actual RPM	1,773

AIR DATA

	Design	Actual		Design	Actual
Total CFM	575	541	Total S.P.	1.5"	.56"
O.A. CFM	/	Exh. Fan	Disch. S. P.	/	.01" Neg.
Ret. Air CFM	/	Exh. Fan	Suc. S. P.	/	.57" Neg.

Pre-Heat S.P. Drop	/	Cooling Coil S.P. Drop	/	Re-Heat S.P. Drop	/
Pre-Filter S.P. Drop	/	Hi Eff. Filter S.P. Drop	/		
Vortex Damp. Pos.	/	O.A. Damper Pos.	/	Ret. Air Damp Pos.	/

NOTES

1.) Exhaust set to room pressure.

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Precision Balancing No. 2774		Contractor No. Vt. Mech. # DLR750006201	
Contract No.	Job Name: Delehanty Hall, UVM		Technician: TC & TW
Project: 2774ef6d	Location: Burlington, Vermont		Date: 10-2-15

Diffuser, Register, & Grille Test Report

System/Unit: E.F. 6

Area Served	Outlet Number	Type	Size	"K" Factor	Design FPM	Design CFM	Pre CFM	Final FPM	Final CFM	%Diff CFM	Refer to Note
	1	CE	12"x12"	1	200	200		85	85	-57.5%	
	2	CE	12"x12"	1	375	375		456	456	21.6%	2,3

Total from Previous Page(s)		Previous Total	
Total	575	Total	541

NOTES

1.) Refer to drawing for exhaust location.

2.) Take-off damper is full open.

3.) Exhaust set to room pressure.

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Precision Balancing No. 2774		Contractor No. Vt. Mech. # DLR750006201	
Contract No.	Job Name: Delehanty Hall, UVM		Technician: TC & TW
Project: 2774EF7F	Location: Burlington, Vermont		Date: 10-2-15

Air Apparatus Test Report

System/Unit: EF-7

UNIT DATA

Make	Twin City Fan	Class/Discharge	Class 1 / Size 105
Model No.	Type BCJ - SW	Tag No.	EF-7
Serial No.	15-545098-1-1	Location	Rooftop

MOTOR DATA

Make	Twin City Fan	Model / Part No.	YC4814C	RPM	1750
Frame	48	Volts / Phase /Hz	115-208-230 / 1/ 60	S.F.	1.15
H.P.	1/4	Full Load Amps	4.2 - 2.1	Flac	/
Measured Volts	206.7	Measured Amps	1.97	BHP	/

DRIVE DATA

Fan Data				Motor Data			
Sheave Size / Make	AK39H			Sheave Size / Make	1VL40		
Bushing / Bore Size	H 1"			Bushing / Bore Size	5/8"		
No. Belts / Make / Size	1 / Browning / 3L260			Sheave C to C	8 3/4"		
Fan Design RPM	Not Given	Fan Actual RPM	1,654	Motor Actual RPM	1,694		

AIR DATA

	Design	Actual		Design	Actual
Total CFM	400	370	Total S.P.	/	N/A
O.A. CFM	Exhaust	Fan	Disch. S. P.	/	Atmospheric
Ret. Air CFM	Exhaust	Fan	Suc. S. P.	/	1.1" Neg.

Pre-Heat S.P. Drop	/	Cooling Coil S.P. Drop	/	Re-Heat S.P. Drop	/
Pre-Filter S.P. Drop	/	Hi Eff. Filter S.P. Drop	/		
Vortex Damp. Pos.	/	O.A. Damper Pos.	/	Ret. Air Damp Pos.	/

NOTES

1.) Adjustable sheave on motor set near minimum position.

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Contract No.	Job Name: Delehanty Hall, UVM		Technician: TC & TW
Project: 2774EF7DF	Location: Burlington, Vermont		Date: 10-2-15

Diffuser, Register, & Grille Test Report

System/Unit: E.F. 7

Area Served	Outlet Number	Type	Size	"K" Factor	Design		Pre CFM	Final		%Diff	Refer to Note
					FPM	CFM		FPM	CFM	CFM	
	1	SS	4"	.087	2299	200		2222	193	-3.5%	
	2	SS	4"	.087	2299	200		2035	177	-11.5%	

Total from Previous Page(s)		**Previous Total**	
Total	400	**Total**	370

NOTES

1.) Refer to drawing for exhaust location.

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AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION

Customer ID: 011144 S/N: M951030
Customer: PRECISION BALANCING LLC City: ESSEX JUNCTION State: VT
As-Received Model #: ADM-870 Converted to Model #: Order #: R150980
PO #: Customer Eqpt ID#: Calibration Due Date:

This instrument has been calibrated using Calibration Standards which are traceable to NIST (National Institute of Standards and Technology). Quality Assurance Program and calibration procedures meet the requirements for ANSI/NCSL Z540-1, ISO 17025, MIL-STD 45662A and manufacturer's specifications. Calibration accuracy is certified when meters are used with properly functioning accessories only. All Uncertainties are expressed in expanded terms (twice the calculated uncertainty). This report shall not be reproduced, except in full, without the written approval of Shortridge Instruments, Inc. Results relate only to the item calibrated. For limitations on use, see Shortridge Instruments, Inc. Instruction Manual for the use of AirData Multimeters. Procedure used: Procedure for Differential Pressure, Absolute Pressure and Temperature Recalibration of AirData Multimeters SIP-CP02 Revision: 28 Dated: 07/31/14

Calibration Technician(s): C Kastard L Laulmeier Calibration Date: 03/30/2015

Calibration Approved by: D Babb Title: Asst. Cal Supv Date: 03/31/2015

As-Received Test performed after minor repair: Yes (No)

AS-Received By CK
Date 03/24/15 Rh 30 %
Ambient Temperature 74 °F
Barometric Pressure 28.51 in Hg
All within spec (YES) NO NA

Final Test By LL
Date 03/30/15 Rh 22 %
Ambient Temperature 75 °F
Barometric Pressure 28.47 in Hg
All within spec (YES) NO

Test By
Date Rh %
Ambient Temperature °F
Barometric Pressure in Hg
All within spec YES NO

ABSOLUTE PRESSURE TEST (in Hg)

TEST METER TOLERANCE = ± 2.0 % ± .1 in Hg AS-RECEIVED TEST WITHIN SPEC (YES) NO N/A See Notes

Pressure Standard: Heise #02-R S/N: 41741/42451 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #04-R S/N: 41743/42453 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #06-R S/N: 41742/42452 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #08-R S/N: 42186/43328 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #10-R S/N: 42203/43352 (As-Rcvd) Test 2 Test 3
Pressure Standard: Heise #12-R S/N: 43166/44731 As-Rcvd (Test 2) Test 3
Pressure Standard: Heise #14-R S/N: 43412/45043 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #16-R S/N: 43413/45044 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #18-R S/N: 44581/46845 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #20-R S/N: 44582/46847 As-Rcvd Test 2 Test 3

Approx Set Pt	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff
14.0	14.19	14.2	.07	14.38	14.4	.14			
28.4	28.51	28.4	-.39	28.47	28.4	-.25	NA		
40.0	40.15	40.0	-.37	40.82	40.6	-.54			

DIFFERENTIAL PRESSURE TEST (in wc)

TEST METER TOLERANCE = ± 2.0 % ± 0.001 in wc AS-RECEIVED TEST WITHIN SPEC (YES) NO N/A See Notes

Pressure Standard: Heise #01-L S/N: 41739/42449 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #01-R S/N: 41739/42446 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #02-L S/N: 41741/42454 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #03-L S/N: 41738/42448 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #03-R S/N: 41738/42445 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #04-L S/N: 41743/42456 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #05-L S/N: 41740/42450 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #05-R S/N: 41740/42447 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #06-L S/N: 41742/42455 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #07-L S/N: 42185/42186 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #07-R S/N: 42185/43326 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #08-L S/N: 42186/43329 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #09-L S/N: 42202/43351 (As-Rcvd) Test 2 Test 3
Pressure Standard: Heise #09-R S/N: 42202/43350 (As-Rcvd) Test 2 Test 3
Pressure Standard: Heise #10-L S/N: 42203/43353 (As-Rcvd) Test 2 Test 3
Pressure Standard: Heise #11-L S/N: 43165/44551 As-Rcvd (Test 2) Test 3
Pressure Standard: Heise #11-R S/N: 43165/44730 As-Rcvd (Test 2) Test 3
Pressure Standard: Heise #12-L S/N: 43166/44732 As-Rcvd (Test 2) Test 3
Pressure Standard: Heise #13-L S/N: 43415/45041 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #13-R S/N: 43415/45039 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #14-L S/N: 43412/45045 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #15-L S/N: 43416/45042 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #15-R S/N: 43416/45040 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #16-L S/N: 43413/45046 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #17-L S/N: 44579/46842 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #17-R S/N: 44579/46841 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #18-L S/N: 44581/46846 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #19-L S/N: 44580/46844 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #19-R S/N: 44580/46843 As-Rcvd Test 2 Test 3
Pressure Standard: Heise #20-L S/N: 44582/46848 As-Rcvd Test 2 Test 3

Approx Set Pt	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff
.0500	.0504	.0505	.20	.0524	.0522	-.38			
.1250	.1265	.1263	-.16	.1247	.1241	-.48			
.2250	.2266	.2263	-.13	.2274	.2261	-.57			
.2700	.2706	.2710	.15	.2739	.2741	.07	NA		
2.000	2.010	2.015	.25	2.022	2.017	-.25			
3.600	3.615	3.602	-.36	3.604	3.591	-.36			
4.400	4.415	4.454	.88	4.426	4.426	0			
27.00	27.19	27.29	.37	27.35	27.34	-.04			
50.00	50.29	50.23	-.12	49.81	49.64	-.34			
Overange	NA	✓	NA	NA	✓	NA	NA		NA

Shortridge Instruments, Inc.
7855 East Redfield Road Scottsdale, Arizona 85260
(480) 991-6744 • Fax (480) 443-1267 • www.shortridge.com

AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION

S/N: M951030
Order #: R150980

LOW VELOCITY CONFIRMATION (FPM)

TEST METER TOLERANCE = ± 3.0% ± 7 FPM AS-RECEIVED TEST WITHIN SPEC (YES) NO N/A See Notes

Vel Eqv Trans Std: S/N: M02009	As-Rcvd	Test 2	Test 3	Vel Eqv Trans Std: S/N: M10840	(As-Rcvd)	Test 2	Test 3
Vel Eqv Trans Std: S/N: M02803	As-Rcvd	Test 2	Test 3	Vel Eqv Trans Std: S/N: M10897	As-Rcvd	Test 2	Test 3
Vel Eqv Trans Std: S/N: M02903	As-Rcvd	(Test 2)	Test 3	Vel Eqv Trans Std: S/N: M10901	As-Rcvd	Test 2	Test 3
Vel Eqv Trans Std: S/N: M10839	As-Rcvd	Test 2	Test 3	Vel Eqv Trans Std: S/N: M13492	As-Rcvd	Test 2	Test 3

Approx Set Point	Standard	Test Meter	Diff	Standard	Test Meter	Diff	Standard	Test Meter	Diff
100	104	106	2	101.7	103	1.3			
500	514	516	2	518.0	517	-1.0			

ADM-880C, ADM-870/870C and ADM-860/860C models are read in AirFoil Mode. ADM-850/850L models are read in Pitot Tube Mode.

TEMPERATURE TEST - AIRDATA MULTIMETER (° F)

TEST METER TOLERANCE = ± 0.2° F AS-RECEIVED TEST WITHIN SPEC (YES) NO N/A See Notes

RTD Simulator: S/N 249	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 250	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 253	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 254	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 256	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 257	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 292	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 293	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 294	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 313	(As-Rcvd)	(Test 2)	Test 3	Set Point: (35.6° F)	95° F	154.4° F
RTD Simulator: S/N 314	(As-Rcvd)	(Test 2)	Test 3	Set Point: 35.6° F	(95° F)	154.4° F
RTD Simulator: S/N 315	(As-Rcvd)	(Test 2)	Test 3	Set Point: 35.6° F	95° F	(154.4° F)
RTD Simulator: S/N 316	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 317	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 318	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F

RTD Simulator Temperature Equivalent Set Point	Test Meter	Difference	Test Meter	Difference	Test Meter	Difference
35.60	35.6	0	35.6	0		
95.00	95.0	0	95.0	0		
154.40	154.5	.1	154.5	.1		

Minor Repair(s) performed prior to As-Received Test.

Pushed dislodged ribbon cable assy back into its socket ____
Replaced internal battery clip or wire ____
Repaired broken wires that power the display ____
Replaced keypad / On, Mode or Read key nonfunctional ____
Pushed dislodged IC back into its socket ____
Replaced a display that cannot be read ____
Repaired broken wire that signals the flaps jack ____
Pushed dislodged J4 connector back into its socket ____

NOTES:_____

The enclosed ADM Calibration Standards for Pressure and Temperature form(s) is/are an integral part of this calibration and must remain with this Certificate of Calibration. Note: There may be more than one such form included that pertains to this calibration.

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AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION

S/N: M951030
Order #: R150980

LOW VELOCITY CONFIRMATION (FPM)

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Vel Eqv Trans Std: S/N: M02803	As-Rcvd	Test 2	Test 3	Vel Eqv Trans Std: S/N: M10897	As-Rcvd	Test 2	Test 3
Vel Eqv Trans Std: S/N: M02903	As-Rcvd	(Test 2)	Test 3	Vel Eqv Trans Std: S/N: M10901	As-Rcvd	Test 2	Test 3
Vel Eqv Trans Std: S/N: M10839	As-Rcvd	Test 2	Test 3	Vel Eqv Trans Std: S/N: M13492	As-Rcvd	Test 2	Test 3

Approx Set Point	Standard	Test Meter	Diff	Standard	Test Meter	Diff	Standard	Test Meter	Diff
100	104	106	2	101.7	103	1.3			
500	514	516	2	518.0	517	-1.0			

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TEST METER TOLERANCE = ± 0.2° F AS-RECEIVED TEST WITHIN SPEC (YES) NO N/A See Notes

RTD Simulator: S/N 249	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 250	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 253	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 254	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 256	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 257	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 292	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 293	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 294	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 313	(As-Rcvd)	(Test 2)	Test 3	Set Point: (35.6° F)	95° F	154.4° F
RTD Simulator: S/N 314	(As-Rcvd)	(Test 2)	Test 3	Set Point: 35.6° F	(95° F)	154.4° F
RTD Simulator: S/N 315	(As-Rcvd)	(Test 2)	Test 3	Set Point: 35.6° F	95° F	(154.4° F)
RTD Simulator: S/N 316	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 317	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F
RTD Simulator: S/N 318	As-Rcvd	Test 2	Test 3	Set Point: 35.6° F	95° F	154.4° F

RTD Simulator Temperature Equivalent Set Point	Test Meter	Difference	Test Meter	Difference	Test Meter	Difference
35.60	35.6	0	35.6	0		
95.00	95.0	0	95.0	0		
154.40	154.5	.1	154.5	.1		

Minor Repair(s) performed prior to As-Received Test.

Pushed dislodged ribbon cable assy back into its socket ____
Replaced internal battery clip or wire ____
Repaired broken wires that power the display ____
Replaced keypad / On, Mode or Read key nonfunctional ____
Pushed dislodged IC back into its socket ____
Replaced a display that cannot be read ____
Repaired broken wire that signals the flaps jack ____
Pushed dislodged J4 connector back into its socket ____

NOTES:_____

The enclosed ADM Calibration Standards for Pressure and Temperature form(s) is/are an integral part of this calibration and must remain with this Certificate of Calibration. Note: There may be more than one such form included that pertains to this calibration.

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AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION

Customer ID: 011144 S/N: M951030

Customer: PRECISION BALANCING LLC City: ESSEX JUNCTION State: VT

As-Received Model #: ADM-870 Converted to Model #: Order #: R150980

PO #: Customer Eqpt ID#: Calibration Due Date:

This instrument has been calibrated using Calibration Standards which are traceable to NIST (National Institute of Standards and Technology). Quality Assurance Program and calibration procedures meet the requirements for ANSI/NCSL Z540-1, ISO 17025, MIL-STD 45662A and manufacturer's specifications. Calibration accuracy is certified when meters are used with properly functioning accessories only. All Uncertainties are expressed in expanded terms (twice the calculated uncertainty). This report shall not be reproduced, except in full, without the written approval of Shortridge Instruments, Inc. Results relate only to the item calibrated. For limitations on use, see Shortridge Instruments, Inc. Instruction Manual for the use of AirData Multimeters. Procedure used: Procedure for Differential Pressure, Absolute Pressure and Temperature Recalibration of AirData Multimeters SIP-CP02 Revision: 28 Dated: 07/31/14

Calibration Technician(s): C Kastard L Laubmeier Calibration Date: 03/30/2015

Calibration Approved by: D Babb Title: Asst. Cal. Supv. Date: 03/31/2015

As-Received Test performed after minor repair: Yes (No)

AS-Received	FINAL Test	_____ Test
By CK	By LL	By
Date 03/24/15	Date 03/30/15	Date
Rh 30 %	Rh 22 %	Rh %
Ambient Temperature 74 °F	Ambient Temperature 75 °F	Ambient Temperature N/A °F
Barometric Pressure 28.51 in Hg	Barometric Pressure 28.47 in Hg	Barometric Pressure in Hg
All within spec (YES) NO NA	All within spec (YES) NO	All within spec YES NO

ABSOLUTE PRESSURE TEST (in Hg)

TEST METER TOLERANCE = ± 2.0 % ± .1 in Hg AS-RECEIVED TEST WITHIN SPEC (YES) NO N/A See Notes

Pressure Standard: Heise #02-R S/N: 41741/42451 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #04-R S/N: 41743/42453 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #06-R S/N: 41742/42452 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #08-R S/N: 42186/43328 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #10-R S/N: 42203/43352 (As-Rcvd) Test 2 Test 3

Pressure Standard: Heise #12-R S/N: 43166/44731 As-Rcvd (Test 2) Test 3

Pressure Standard: Heise #14-R S/N: 43412/45043 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #16-R S/N: 43413/45044 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #18-R S/N: 44581/46845 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #20-R S/N: 44582/46847 As-Rcvd Test 2 Test 3

Approx Set Pt	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff
14.0	14.19	14.2	.07	14.38	14.4	.14			
28.4	28.51	28.4	-.39	28.47	28.4	-.25	N/A		
40.0	40.15	40.0	-.37	40.82	40.6	-.54			

DIFFERENTIAL PRESSURE TEST (in wc)

TEST METER TOLERANCE = ± 2.0 % ± 0.001 in wc AS-RECEIVED TEST WITHIN SPEC (YES) NO N/A See Notes

Pressure Standard: Heise #01-L S/N: 41739/42449 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #01-R S/N: 41739/42446 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #02-L S/N: 41741/42454 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #03-L S/N: 41738/42448 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #03-R S/N: 41738/42445 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #04-L S/N: 41743/42456 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #05-L S/N: 41740/42450 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #05-R S/N: 41740/42447 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #06-L S/N: 41742/42455 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #07-L S/N: 42185/42186 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #07-R S/N: 42185/43326 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #08-L S/N: 42186/43329 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #09-L S/N: 42202/43351 (As-Rcvd) Test 2 Test 3

Pressure Standard: Heise #09-R S/N: 42202/43350 (As-Rcvd) Test 2 Test 3

Pressure Standard: Heise #10-L S/N: 42203/43353 (As-Rcvd) Test 2 Test 3

Pressure Standard: Heise #11-L S/N: 43165/44551 As-Rcvd (Test 2) Test 3

Pressure Standard: Heise #11-R S/N: 43165/44730 As-Rcvd (Test 2) Test 3

Pressure Standard: Heise #12-L S/N: 43166/44732 As-Rcvd (Test 2) Test 3

Pressure Standard: Heise #13-L S/N: 43415/45041 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #13-R S/N: 43415/45039 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #14-L S/N: 43412/45045 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #15-L S/N: 43416/45042 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #15-R S/N: 43416/45040 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #16-L S/N: 43413/45046 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #17-L S/N: 44579/46842 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #17-R S/N: 44579/46841 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #18-L S/N: 44581/46846 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #19-L S/N: 44580/46844 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #19-R S/N: 44580/46843 As-Rcvd Test 2 Test 3

Pressure Standard: Heise #20-L S/N: 44582/46848 As-Rcvd Test 2 Test 3

Approx Set Pt	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff	Standard	Test Meter	% Diff
.0500	.0504	.0505	.20	.0524	.0522	-.38			
.1250	.1265	.1263	-.16	.1247	.1241	-.48			
.2250	.2266	.2263	-.13	.2274	.2261	-.57			
.2700	.2706	.2710	.15	.2739	.2741	.07	N/A		
2.000	2.010	2.015	.25	2.022	2.017	-.25			
3.600	3.615	3.602	-.36	3.604	3.591	-.36			
4.400	4.415	4.454	.88	4.426	4.426	0			
27.00	27.19	27.29	.37	27.35	27.34	-.04			
50.00	50.29	50.23	-.12	49.81	49.64	-.34			
Overange	NA	✓	NA	NA	✓	NA	NA		NA

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— NIST —

Calibration Certificate

Certificate No:	S26973	**Date Calibrated:**	05/04/2015
Manufacturer:	Nidec-Shimpo America Corp.	**Next Date Due:**	05/04/2016
Model:	DT-315EB	**Calibrated by:**	S.BLYAKHMAN
Description:	Digital Stroboscope		
Serial No:	22169412	**Conditions**	
Range:	54.0 to 33,000 FPM	**Degrees Fahrenheit:**	74.4°F
Tolerance:	±0.01% of reading	**Relative Humidity:**	42%RH

This certificate attests that this instrument has been calibrated under the standard conditions with standards traceable to the National Institute of Standards and Technology (NIST). Evidence of traceability is included and also maintained on file at our laboratory. An acceptable accuracy ratio between the standard and the item calibrated has been maintained.

Accuracy of standard used for certification is equal to or greater than the accuracy of the certified instrument. Calibration is in conformance with manufacture's specification.

Standard Used:	Netech Non-contact Tachometer
Model:	MT-200
Serial No:	B3CB9039
Accuracy:	Certificate No. 1293116

Check Point (STD)	+ Limit (FPM)	– Limit (FPM)	Unit Reads (FPM)
1,000.0	1 ,000.1	999.9	1,000.1
4,999.7	5,000.2	4 ,999.2	5,000
10,000	10,001	9,999	10,001
15,000	15,002	14,998	15,001
20,000	20,002	19,998	20,002
25,000	25,003	24,997	25,002
32,997	33,000	32,994	32,999

SHIMPO INSTRUMENTS
1701 Glenlake Avenue
Itasca, IL 60143

Mechanical

DRAWING	TITLE			REV	DATE
M-1A	MECHANICAL	FLOOR PLAN AND	CEILING PLAN	0	05/28/2015
M-2A	MECHANICAL	ROOF PLAN		0	05/28/2015
M-5A	MECHANICAL	CONTROL DIAGRAMS		0	05/28/2015
M-5B	MECHANICAL	ALARM MATRIX		0	05/28/2015
M-5C	MECHANICAL	LAB HVAC	SEQUENCE OF OPERATIONS PART 1 OF 2	0	05/28/2015
M-5D	MECHANICAL	LAB HVAC	SEQUENCE OF OPERATIONS PART 2 OF 2	0	05/28/2015
M-7A	MECHANICAL	DETAILS		0	05/28/2015

Electrical

E-2A-	ELECTRICAL	ROOF LEVEL	POWER PLAN	0	05/28/2015
E-5	ELECTRICAL	INSTALLATION DETAILS		0	05/28/2015

The UNIVERSITY of VERMONT

PROPOSED NEW CONSTRUCTION

COSMOGENIC NUCLIDE LABORATORY
DEPARTMENT OF GEOLOGY

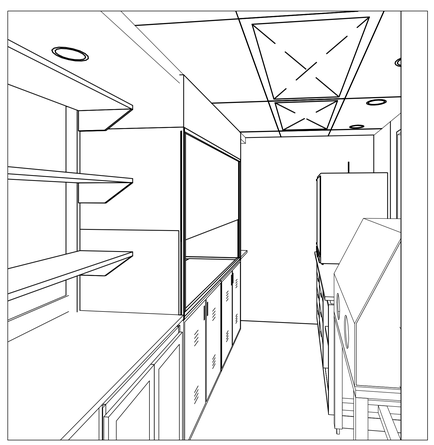
DELEHANTY HALL
180 COLCHESTER AVENUE
BURLINGTON VERMONT 05405

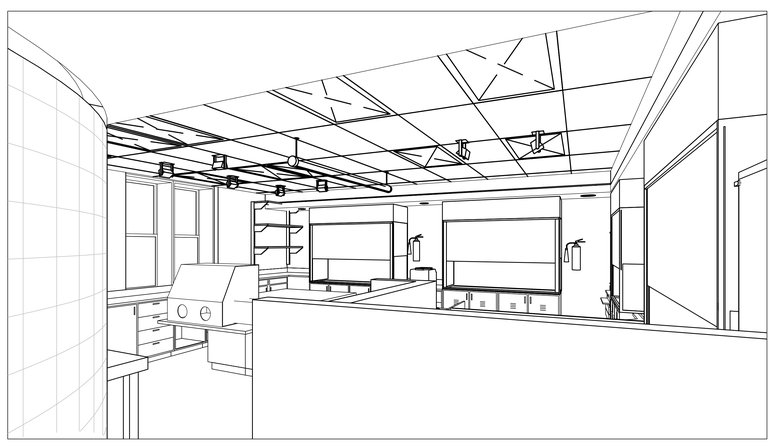
AS-BUILT

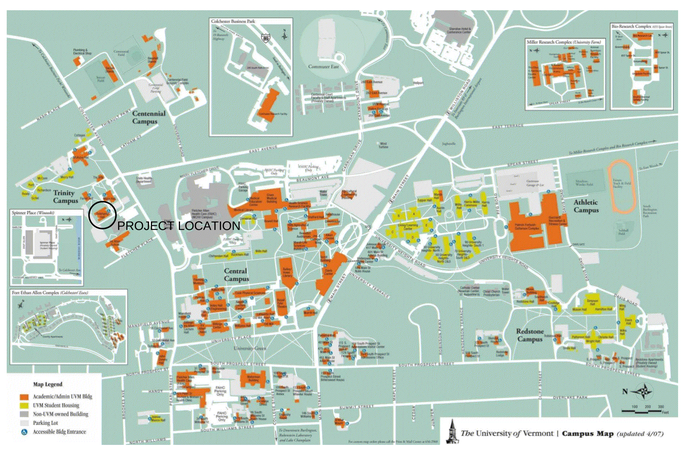
DATE ISSUED
05/28/15

IDC ARCHITECTS

400 Industry Drive, Suite 100
Pittsburgh, Pennsylvania 15275
www.idcarchitects.com







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REFER ALSO TO FINAL BALANCE REPORT

KEYED NOTES CONT.:

3 VERIFY LAB HOOD FLOWS ADJUST AS REQUIRED, AND PROVIDE PERFORMANCE TESTING OF LAB HOODS PER ANSI/ASHAE STANDARDS 110. REFER TO SPECIFICATION 23 05 93 FOR ADDITIONAL REQUIREMENTS.

4 ULPA FILTER; BALANCE TO 430 CFM. TYP OF 10.

5 ULPA FILTER; BALANCE TO 380 CFM. TYP OF 3.

6 3" EA DOWN TO BASE CABINET. BALANCE TO 30 CFM.

7 12"ø DOWN FROM ROOF TRANSITION TO 7"ø BELOW ROOF TO BENCHTOP HOOD CONNECTION. BALANCE TO 200 CFM.

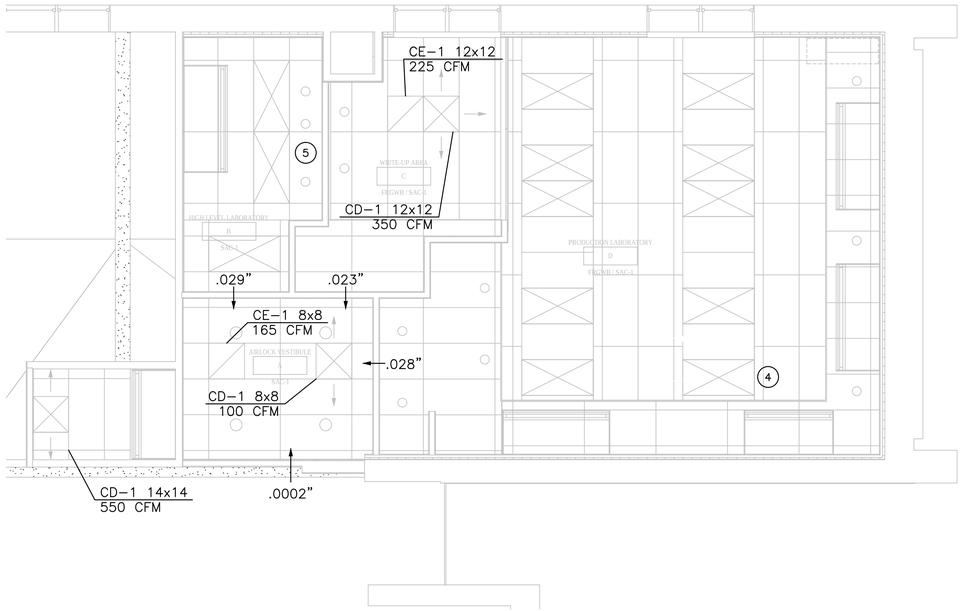
8 6"ø FROM OVEN CONNECTION. BALANCE TO 50 CFM.

9 7"ø FROM BENCHTOP HOOD CONNECTION UP THROUGH ROOF. BALANCE TO 200 CFM.

10 FOLLOWING CONTROL SYSTEM AND EXHAUST SYSTEM MODIFICATIONS RE-BALANCE ENTIRE LAB SUPPLY AND EXHAUST SYSTEM FLOWS TO ORIGINAL BALANCED FLOWS AND THE PRESSURE RELATIONSHIPS AS MEASURED. (KEYED NOTE). ENSURE INTERNAL HOOD FANS ARE RUNNING FOR THIS.

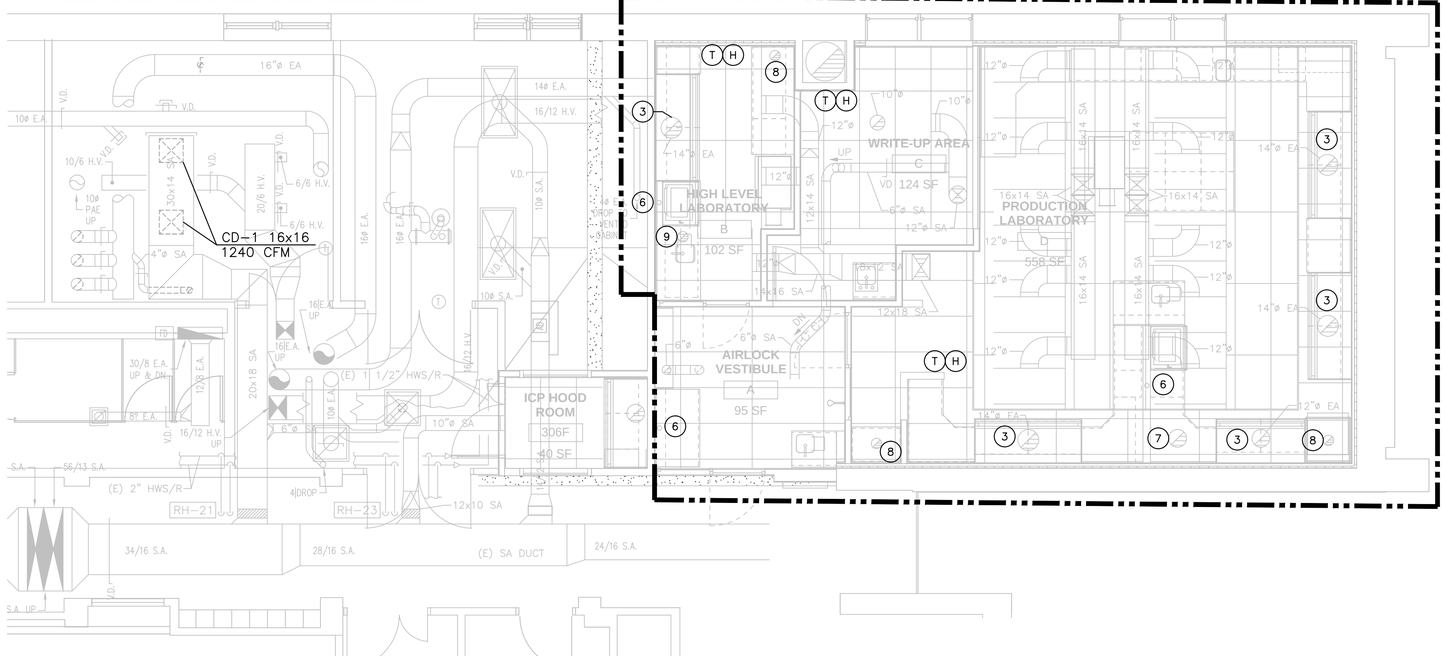
11 BALANCE SUPPLY AND EXHAUST AIR SYSTEMS TO DETERMINE FAN SPEED SETPOINTS FOR OPERATION IN THE "HIBERNATION" MODE WITH REDUCED FLOWS. MAINTAIN THE SAME PRESSURE RELATIONSHIP BETWEEN THE SPACES AS INDICATED FOR NORMAL OPERATION. INTERNAL HOOD FANS ARE NOT RUNNING IN THIS MODE AND SET POINT MUST REMOVE MOST FUMES FROM HOOD USING VISUAL TEST.

12 PROVIDE ASSISTANCE DURING SYSTEM START-UP, TESTING AND COMMISSIONING TO TEST, ADJUST AND BALANCE SYSTEM FOR THE VARIOUS MODES OF OPERATION INCLUDING TESTING OF SYSTEM INTERLOCKS AND SAFETIES AS INDICATED IN THE NEW SEQUENCE OF OPERATION (SOO).



1 — MECHANICAL CEILING PLAN
SCALE: 1/4"=1'-0"

AREA OF WORK (1)(10)(11)(12)



2 — MECHANICAL FLOOR PLAN
SCALE: 1/4"=1'-0"

NORTH

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IDC PROJECT NO.: 661342 CLIENT PROJECT NO.:

DRAWN: – REVIEWED: –

DESIGNED: – APPROVED: –

NOTICE: STAMP:

GENERAL NOTES:

A ALL BALANCING WORK SHALL BE DONE WITHOUT REMOVING CEILING TILES IN EITHER THE PRODUCTION LAB OR THE HIGH LEVEL LAB.

KEYED NOTES:

1 PRIOR TO ANY SYSTEM MODIFICATIONS, PERFORM BASELINE READINGS OF LAB SUPPLY AND EXHAUST AIR SYSTEMS INCLUDING AIR HANDLING UNIT, EXHAUST FANS, LAB HOODS, ULPA FILTERS, CEILING DIFFUSERS AND EXHAUST REGISTERS. PROVIDE READINGS OF PRESSURE RELATIONSHIPS BETWEEN THE LAB SPACES AND THE AIRLOCK/VESTIBULE AND BETWEEN THE AIRLOCK/VESTIBULE AND THE ADJACENT CORRIDOR. REFER TO SPECIFICATION 23 05 93 FOR MORE INFORMATION.

2 KEYED NOTES 4 THRU 9 BELOW AND FLOWS & PRESSURES NOTED ON PLANS INDICATE THE ORIGINAL DESIGN AND ARE FOR INFORMATION ONLY.

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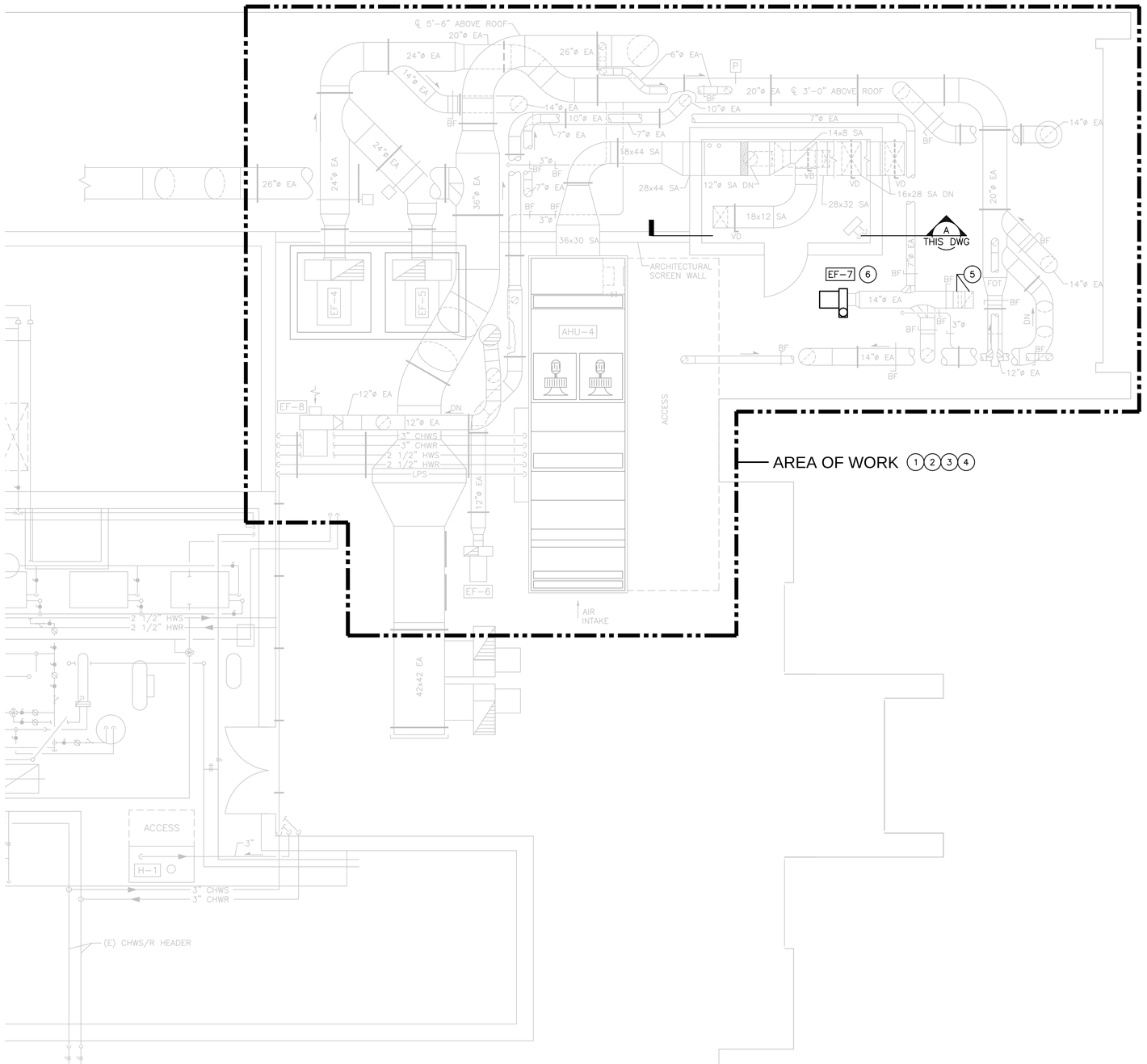
Cosmogenic Nuclide Laboratory

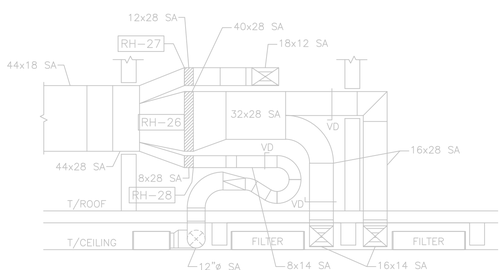
TITLE:
MECHANICAL FLOOR PLAN AND CEILING PLAN
–

DATE ISSUED: – DRAWING SCALE: –
ACAD FILE: – EQUIPMENT CODE:

DRAWING NUMBER:
M-1A
– –

Name: M-1A.dwg User: nyurkows Date: 28/May/15 - 1:57pm





A SECTION
1/4"=1'-0"

1 — MECHANICAL ROOF PLAN
SCALE: 1/4"=1'-0"

NORTH

KEYED NOTES CONT.:

3 BALANCE SUPPLY AND EXHAUST AIR SYSTEMS TO DETERMINE FAN SPEED SETPOINTS FOR OPERATION IN THE "HIBERNATION" MODE WITH REDUCED FLOWS. MAINTAIN THE SAME PRESSURE RELATIONSHIP BETWEEN THE SPACES AS INDICATED FOR NORMAL OPERATION.

4 PROVIDE ASSISTANCE DURING SYSTEM START-UP, TESTING AND COMMISSIONING TO TEST, ADJUST AND BALANCE SYSTEM FOR THE VARIOUS MODES OF OPERATION INCLUDING TESTING OF SYSTEM INTERLOCKS AND SAFETIES AS INDICATED IN THE NEW SEQUENCE OF OPERATION (SOO).

5 CLOSE BUTTERFLY DAMPER ON BLEED AIR DUCT AND CAP AND SEAL OPEN END OF DUCT.

6 REMOVE EXISTING EXHAUST FAN EF-7 AND REPLACE WITH NEW EXHAUST FAN EF-7 PER SPECIFICATION 23 24 16 SEE DETAIL 1 ON DRAWING M-7A.

AREA OF WORK

KEYED NOTES:

1 PRIOR TO ANY SYSTEM MODIFICATIONS, PERFORM BASELINE READINGS OF LAB SUPPLY AND EXHAUST AIR SYSTEMS INCLUDING AIR HANDLING UNIT, EXHAUST FANS, LAB HOODS, ULPA FILTERS, CEILING DIFFUSERS AND EXHAUST REGISTERS. PROVIDE READINGS OF PRESSURE RELATIONSHIPS BETWEEN THE LAB SPACES AND OF THE AIRLOCK/VESTIBULE AND BETWEEN THE AIRLOCK/VESTIBULE AND THE ADJACENT CORRIDOR. REFER TO SPECIFICATION 23 05 93 FOR MORE INFORMATION.

2 FOLLOWING CONTROL SYSTEM AND EXHAUST SYSTEM MODIFICATIONS RE-BALANCE ENTIRE LAB SUPPLY AND EXHAUST SYSTEM FLOWS TO ORIGINAL BALANCED FLOWS AND THE PRESSURE RELATIONSHIPS AS MEASURED. (KEYED NOTE 1).

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Suite 100
Pittsburgh, PA 15275
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TITLE:
MECHANICAL ROOF PLAN
–
–

DATE ISSUED: –
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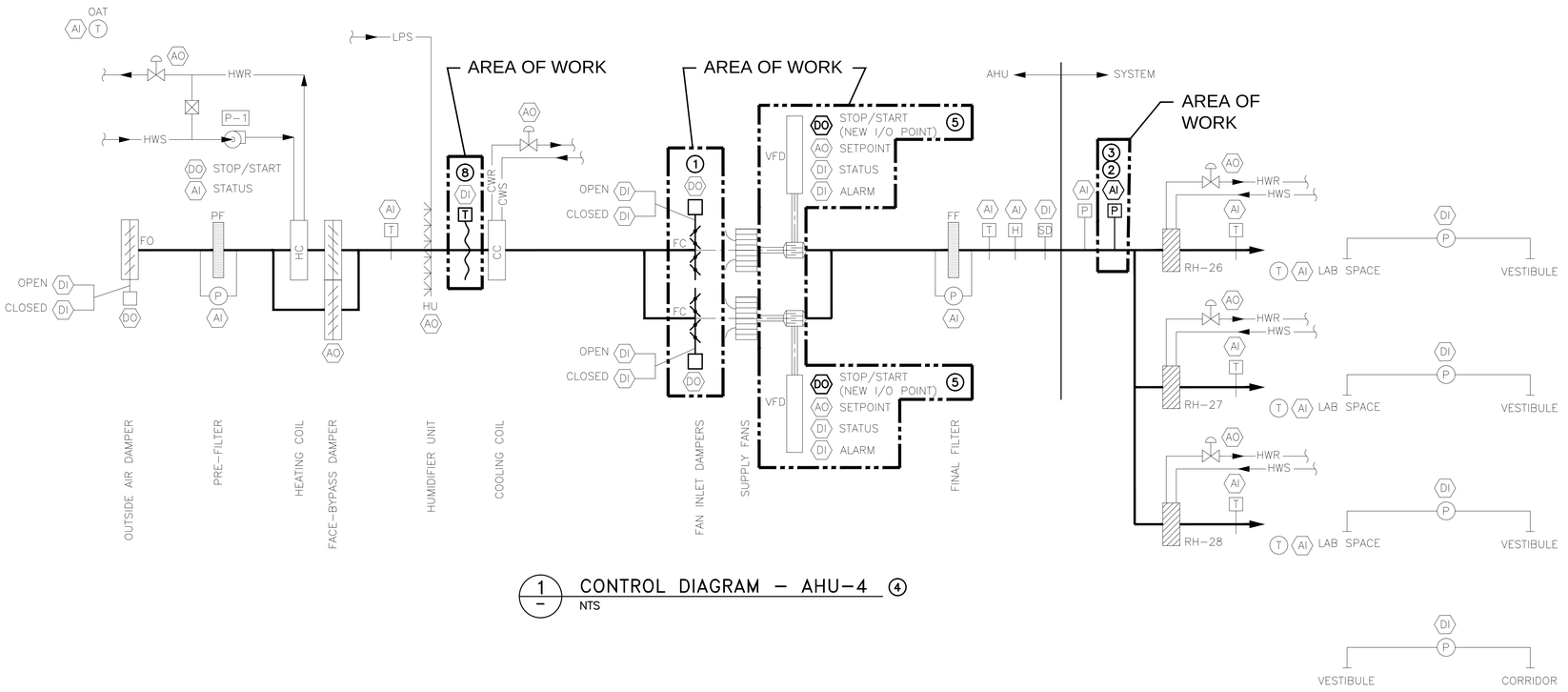
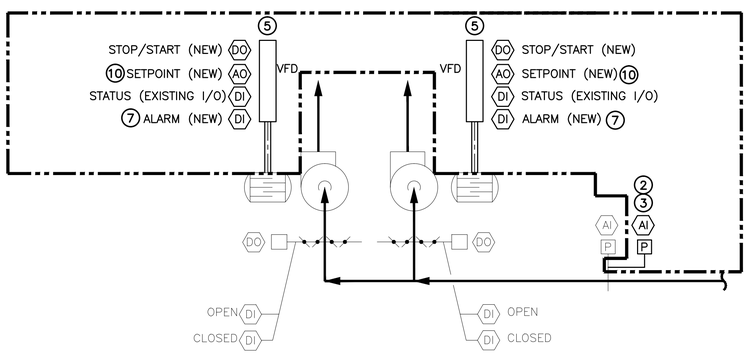
ACAD FILE: –
EQUIPMENT CODE:

DRAWING NUMBER:
M-2A
– –

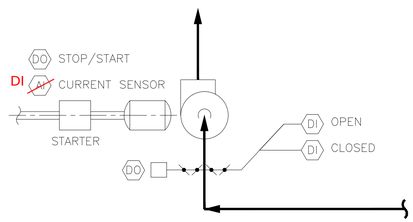
Name: M-2A.dwg User: nyurkows Date: 27/May/15 – 9:46am



1 – CONTROL DIAGRAM – AHU-4 ④
NTS



2 – CONTROL DIAGRAM – EF-4, 5
NTS



NOTES:

EF-7 SIMILAR EXCEPT WITHOUT ISOLATION DAMPER.

3 – CONTROL DIAGRAM – EF-6 & EF-7 ⑨
NTS

AREA OF WORK

KEYED NOTES:

1 REPLACE DAMPER ACTUATOR WITH NEMA 4 ACTUATOR. BELIMO MODEL #AFBUP-SN4 180 IN-LBS WITH 2 LIMIT SWITCHES. INCLUDE ACCESSORIES AS REQUIRED.

2 PROVIDE SECOND PRESSURE TRANSMITTER AND NEW ANALOG INPUTS AT LAB DDC. SPARE I/O AVAILABLE. COORDINATE WITH OWNER.

3 SETRA MODEL 2671005 W011A1HD, RANGE 0-5" W.C. / D

4 DEMO EXISTING CONTROL CONDUITS AND REPLACE WITH NEW CONDUIT AND WIRING.

5 DECOUPLE FAN START FROM DAMPER. EXISTING DISCRETE OUTPUT WILL OPEN DAMPER. NEW DISCRETE OUTPUT WILL START FAN. REWORK RELAY LOGIC AS REQUIRED. SPARE I/O AVAILABLE AT LAB DDC. COORDINATE WITH OWNER.

6 MOUNT TWO POSITION / NKK / CKM12AFW01 MAINTAINED KEYED SWITCH ~~A-B-800T-E~~ AND INDICATING CUSTOM EXIT SIGN IN CORRIDOR AT ENTRANCE TO THE LAB, HANGING FROM THE CEILING ABOVE OPERATING DOOR PANEL. SIGN MANUFACTURED BY THE EXIT SIGN COMPANY OR APPROVED EQUAL. COORDINATE WITH OWNER FOR SIGN LAYOUT.

NO SPACE AVAILABLE FOR MODULE IN XL500 PANEL. A SPARE ANALOG INPUT WAS RECONFIGURED AS A DIGITAL INSTEAD.

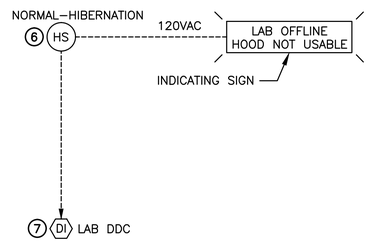
7 ~~PROVIDE NEW DISCRETE INPUT MODULE XLF-524 IN AVAILABLE SLOT FOR NEW DISCRETE INPUT.~~

8 REPLACE FREEZESTAT WITH JOHNSON CONTROLS A70GA-1C (15-55°F, 5° DIFFERENTIAL), WITH AUTOMATIC RESET.

EXISTING IS CURRENT SWITCH, NOT TRANSMITTER (DIGITAL VS. ANALOG) NOT REPLACED.

9 ~~REPLACE CURRENT TRANSMITTER FOR EF-7. NEW CURRENT TRANSMITTER NK TECHNOLOGIES MODEL ATO-420-24L SP RANGE 0-5 AMPS.~~

10 SPARE AO AVAILABLE AT LAB DDC. COORDINATE WITH OWNER.



4 – HIBERNATION MODE CONTROL DIAGRAM
NTS

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Suite 100
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IDC PROJECT NO.: 661342 CLIENT PROJECT NO.:

DRAWN: C. STAUB REVIEWED: G. BORRETTI
DESIGNED: C. STAUB APPROVED: M. MORRISSEY
NOTICE: STAMP:

LEGEND:

- AI DENOTES ANALOG INPUT TO PLC
- AO DENOTES ANALOG OUTPUT TO PLC
- DI DENOTES DISCRETE INPUT TO PLC
- DO DENOTES DISCRETE OUTPUT TO PLC

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TITLE: MECHANICAL CONTROL DIAGRAMS

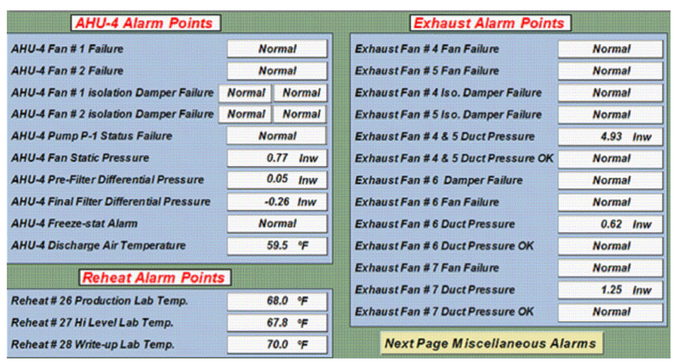
DATE ISSUED: 05/28/2015 DRAWING SCALE: NONE
ACAD FILE: M-5A EQUIPMENT CODE:

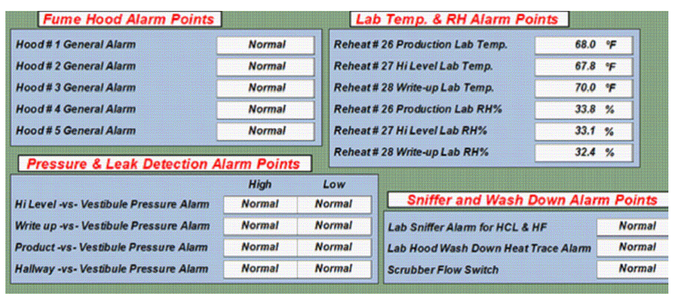
DRAWING NUMBER: M-5A

Name: M-5A.dwg User: 2784 Date: 27/May/15 - 1:52pm

EQUIPMENT	ALARM	CAUSE	ALARM LIGHT R=RED Y=YELLOW	SHUNT TRIP OF FUME HOODS	REDUCED AHU-4 SPEED	REDUCED EF-4/5 SPEED	HARD STOP-AHU-4 AND ALL EXHAUST FANS SHUTDOWN	MISCELLANEOUS
AHU-4	AHU LEAD FAN FAIL	LOSS OF RUN STATUS	Y	X				LAG FAN STARTS/ KEEP SYSTEM ONLINE/MANUAL RESET OF FAN REQUIRED
		VFD FAILURE	Y	X				LAG FAN STARTS/ KEEP SYSTEM ONLINE/MANUAL RESET OF FAN REQUIRED
		BOTH PRESSURE TRANSMITTERS LOW-LEAD FAN ONLINE	Y	X				LAG FAN STARTS/ KEEP SYSTEM ONLINE/MANUAL RESET OF FAN REQUIRED
AHU-4	LOSS OF SUPPLY AIR	BOTH FANS FAIL (LEAD AND LAG)	R	X		X		EXHAUST FANS GO TO REDUCE SPEED/ MANUAL RESET REQUIRED TO GO BACK ONLINE/DAMPERS REMAIN OPEN/SYSTEM OFFLINE AFTER COOLDOWN TO MAINTAIN LAB CLEANLINESS
		OUTSIDE AIR DAMPER CLOSED (Switches Indicate Fully Closed)	R	X		X		EXHAUST FANS GO TO REDUCE SPEED/ MANUAL RESET REQUIRED TO GO BACK ONLINE/DAMPERS REMAIN OPEN/SYSTEM OFFLINE AFTER COOLDOWN TO MAINTAIN LAB CLEANLINESS
		BOTH PRESSURE TRANSMITTERS LOW-LAG FAN ONLINE	R	X		X		EXHAUST FANS GO TO REDUCE SPEED/ MANUAL RESET REQUIRED TO GO BACK ONLINE/DAMPERS REMAIN OPEN/SYSTEM OFFLINE AFTER COOLDOWN TO MAINTAIN LAB CLEANLINESS
AHU-4	FREEZESTAT		R	X	X	X		REDUCE HVAC-SUPPLY AND EXHAUST FAN @REDUCED SPEED/ MANUAL RESET REQUIRED
	SMOKE DETECTION		R	X		X		MAU SHUTDOWN /MAU DAMPERS OPEN/EF-4/5 REDUCE SPEED/SYSTEM OFFLINE AFTER COOLDOWN TO MAINTAIN CLEANLINESS
	PREFILTER ALARM		Y	X				
	FINAL FILTER ALARM		Y	X				
	OUTSIDE DAMPER INCORRECT POSITION	(Switches Indicate Not Fully Open)	Y	X				CAUSES LOW FLOW CONDITION ON AHU - SYSTEM GOES TO REDUCED FLOW MODE
	FAN INLET DAMPER INCORRECT POSITION	(Switches Indicate Not Fully Open)	Y	X				
	HOT WATER PUMP FAIL	LOSS OF CURRENT						ALARM ONLY
	HUMIDIFIER GENERAL ALARM							ALARM ONLY
SUPPLY AIR	DISCH PRESS HI	BOTH TRANSMITTERS	Y	X				RED LIGHT INDICATION AT LOCAL PANEL/ SINGLE TRANSMITTER ALARM ONLY
	DISCH PRESS LO	BOTH TRANSMITTERS	Y	X				RED LIGHT INDICATION AT LOCAL PANEL/ SINGLE TRANSMITTER ALARM ONLY
	DISCH PRESS TRANSMITTER COMPARE							ALARM ONLY
	DISCHARGE TEMP HI							ALARM ONLY
	DISCHARGE TEMP LO							ALARM ONLY
EF-4/5	EF-4/5 AHU LEAD FAN FAIL	LOSS OF RUN STATUS	✓ R	X				LAG FAN STARTS/ KEEP SYSTEM ONLINE/MANUAL RESET OF FAN REQUIRED
		VFD FAILURE	✓ R	X				LAG FAN STARTS/ KEEP SYSTEM ONLINE/MANUAL RESET OF FAN REQUIRED
		BOTH PRESSURE TRANSMITTERS LOW-LEAD FAN ONLINE	✓ R	X				LAG FAN STARTS/ KEEP SYSTEM ONLINE/MANUAL RESET OF FAN REQUIRED
EF-4/5	LOSS OF EXHAUST AIR	BOTH FANS FAIL (LEAD AND LAG)	R	X			X	MANUAL RESET REQUIRED
		BOTH PRESSURE TRANSMITTERS LOW-LAG FAN ONLINE	R	X			X	MANUAL RESET REQUIRED
EF-4/5	INCORRECT DAMPER POSITION		Y	X				
EXH AIR	SUCTION PRESS HI	BOTH TRANSMITTERS	Y	X				RED LIGHT INDICATION AT LOCAL PANEL/ SINGLE TRANSMITTER ALARM ONLY
	SUCTION PRESS LO	BOTH TRANSMITTERS	Y	X				RED LIGHT INDICATION AT LOCAL PANEL/ SINGLE TRANSMITTER ALARM ONLY
	SUCTION PRESS TRANSMITTER COMPARE							ALARM ONLY
EF-6	FAN FAILURE	LOSS OF CURRENT	Y	X				MANUAL RESET/ AHU-4 REDUCE SPEED THROUGH PRESSURE CONTROL LOOP/EF-4/5 AND EF-7 REMAIN ONLINE
		EXHAUST PRESSURE LOW	Y	X				MANUAL RESET/ AHU-4 REDUCE SPEED THROUGH PRESSURE CONTROL LOOP/EF-4/5 AND EF-7 REMAIN ONLINE
	INCORRECT DAMPER POSITION		Y	X				MANUAL RESET/ AHU-4 REDUCE SPEED THROUGH PRESSURECONTROL LOOP/EF-4/5 AND EF-7 REMAIN ONLINE
EF-7	FAN FAILURE	LOSS OF CURRENT	Y	X				MANUAL RESET/ AHU-4 REDUCE SPEED THROUGH PRESSURE CONTROL LOOP/EF-4/5 AND EF-6 REMAIN ONLINE
		EXHAUST PRESSURE LOW	Y	X				MANUAL RESET/ AHU-4 REDUCE SPEED THROUGH PRESSURECONTROL LOOP/EF-4/5 AND EF-6 REMAIN ONLINE
MISC ALARMS	INDIVIDUAL FUME HOOD ALARM		Y					5 ALARMS TOTAL-INDICATION AT ALARM PANEL
	HF ALARM	SNIFFER HIGH ALARM	R	X				HVAC REMAINS ONLINE/EF- 7 GOES ONLINE IF PREVIOUSLY OFFLINE/RED LIGHT INDICATION AT LOCAL PANEL
	HCL ALARM	SNIFFER HIGH ALARM	R	X				HVAC REMAINS ONLINE/EF- 7 GOES ONLINE IF PREVIOUSLY OFFLINE/RED LIGHT INDICATION AT LOCAL PANEL
LAB ALARMS	DIFFERENTIAL PRESSURE	HI LEVEL PRODUCTION VS VESTIBULE	Y					RED LIGHT INDICATION AT LOCAL PANEL
	DIFFERENTIAL PRESSURE	WRITE UP VS VESTIBULE	Y					RED LIGHT INDICATION AT LOCAL PANEL
	DIFFERENTIAL PRESSURE	PRODUCTION VS VESTIBULE	Y					RED LIGHT INDICATION AT LOCAL PANEL
	DIFFERENTIAL PRESSURE	CORRIDOR VS VESTIBULE	Y					RED LIGHT INDICATION AT LOCAL PANEL
	TEMPERATURE	PRODUCTION LAB						
	TEMPERATURE	HIGH LEVEL LAB						
	TEMPERATURE	WRITE UP LAB						
	RELATIVE HUMIDITY	PRODUCTION LAB						
	RELATIVE HUMIDITY	HIGH LEVEL LAB						
	RELATIVE HUMIDITY	WRITE UP LAB						
	TEMPERATURE	RH-26 DISCHARGE						
	TEMPERATURE	RH-27 DISCHARGE						
	TEMPERATURE	RH-28 DISCHARGE						
	SHUNT TRIP ALARMS WILL PAGE AND EMAIL DR. BIERMAN AND PPD (PHYSICAL PLANT DEPT)							
	ALARMS AND ANALOG READINGS PROVIDED TO MAIN CAMPUS ACROSS BACNET							

DELEHANTY HALL COSMOS ALARM MATRIX ①





MAIN CAMPUS COSMOS ALARM SCREENS ② REFER TO MAIN CAMPUS ALARM SCREENS FOR AS_BUILT CONDITION

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Suite 100
Pittsburgh, PA 15275
www.idcarchitects.com

IDC PROJECT NO.: 661342 CLIENT PROJECT NO.:

DRAWN: C. STAUB REVIEWED: G. BORRETTI

DESIGNED: C. STAUB APPROVED: M. MORRISSEY

NOTICE: STAMP:

1 WORK ALARM MATRIX WITH SEQUENCE OF OPERATIONS FOR PROGRAMMING UPGRADES TO DELEHANTY HALL HVAC SYSTEM.

2 UPDATE MAIN CAMPUS ALARM PAGE FOR NEW ALARMS, NEW TRANSMITTERS, AND HIBERNATION MODE INDICATION.

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TITLE: MECHANICAL ALARM MATRIX & ALARM SCREENS

DATE ISSUED: 05/28/2015 DRAWING SCALE: NONE

ACAD FILE: M-5B EQUIPMENT CODE:

DRAWING NUMBER: M-5B

Name: M-5B.dwg User: 2784 Date: 27/May/15 - 1:52pm

DELEHANTY HALL COSMOGENIC LAB HVAC SEQUENCE OF OPERATION

GENERAL

THE HVAC SYSTEM WILL OPERATE AT ALL TIMES THE LAB IS IN OPERATION. THE HVAC SYSTEM WILL ALSO OPERATE AT A REDUCED LOAD WHEN THE LAB IS NOT IN USE (I.E. HIBERNATION MODE). AHU-4 PROVIDES TEMPERED AIR AND VENTILATION AIR TO THE LAB. EXHAUST FANS EF-4 AND EF-5 PROVIDE EXHAUST FROM THE 5 CRITICAL ACID FUME HOODS IN THE LAB. EF-6 PROVIDES EXHAUST FROM THE WRITE UP AREA AND THE VESTIBULE. EF-7 PROVIDES EXHAUST FROM THE TWO SNORKEL HOODS. ONE HOOD IS LOCATED IN THE PRODUCTION LAB AND THE SECOND HOOD IS LOCATED IN HIGH LEVEL LAB.

HVAC SYSTEM REDUNDANCY IS PROVIDED WITH TWO MAKE UP AIR SUPPLY FANS AND TWO DEDICATED EXHAUST FANS FOR THE ACID FUME HOODS. REDUNDANT SUPPLY AND EXHAUST STATIC PRESSURE TRANSMITTERS ARE ALSO PROVIDED FOR CONTROL AND MONITORING OF THE HVAC SYSTEM. THIS REDUNDANCY WILL ALLOW FOR THE SAFE OPERATION AND ORDERLY SHUTDOWN OF THE HVAC SYSTEM.

A FAILURE WITHIN THE HVAC SYSTEM WILL SHUT DOWN THE 5 CRITICAL ACID HOODS THROUGH A SHUNT TRIP. THE SHUNT TRIP KILLS THE POWER TO THE FUME HOODS AND ALSO DISABLES THE ELECTRIC HOT PLATES AND BLOWERS IN THE HOOD. THE HOT PLATES REQUIRE APPROXIMATELY 2 HOURS TO COOL DOWN WHEN NORMAL CONDITIONS ARE PRESENT. IN SOME CASES, A FAILURE ALARM WILL REQUIRE THE HVAC SYSTEM TO RUN AT A REDUCED SPEED WHICH WILL PROLONG THE TIME FOR COOL DOWN. THE HVAC SYSTEM WILL CONTINUE TO PROVIDE VENTILATION DURING THE COOL DOWN PERIOD TO FACILITATE THE REMOVAL OF ACID FUMES WITHIN THE LAB EITHER AT FULL FLOW OR REDUCED FLOW. THE ONE EXCEPTION IS THE LOSS OF THE ACID EXHAUST SYSTEM WHICH WILL REQUIRE A HARD SHUTDOWN OF THE ENTIRE HVAC SYSTEM.

THE LAB CAN BE PUT INTO A REDUCED HVAC STATE (I.E. HIBERNATION MODE) THROUGH A KEYED SWITCH WHEN NOT IN USE FOR ENERGY SAVINGS. THE ACID FUME HOODS ARE NOT OPERATIONAL VIA THE SHUNT TRIP DURING THIS MODE. SIGNAGE IS PROVIDED AT THE ENTRANCE TO THE LAB STATING "LAB OFFLINE-HOODS NOT USABLE". WHILE IN HIBERNATION MODE, THE HVAC SYSTEM WILL RESPOND TO ALARM CONDITIONS IN THE SAME MANNER AS WHEN ON NORMAL OPERATION WITH THE ONE EXCEPTION THAT THE SHUNT TRIP ALREADY OCCURRED AND THE ACID FUME HOODS ARE OFFLINE. THE SUPPLY AND EXHAUST FAN SPEED SETTINGS FOR HIBERNATION MODE WILL ALSO BE USED WHEN THE HVAC SYSTEM NEEDS TO GO TO A REDUCED SPEED DUE TO VARIOUS HVAC ALARMS.

DIGITAL ALARMS (E.G. FREEZE STAT, SMOKE DETECTION, ETC.) WILL HAVE A 3 SECOND TIME DELAY IN SOFTWARE. ANALOG ALARMS (E.G. LOW EXHAUST PRESSURE, LOW SUPPLY PRESSURE) WILL HAVE A 15 SECOND TIME DELAY IN SOFTWARE.

SETPOINTS AND TIME SETTINGS DISCUSSED BELOW ARE EITHER PRELIMINARY OR IDENTIFIED WITH XX. ALL SETPOINTS AND TIME SETTINGS ARE OPERATOR ADJUSTABLE THROUGH THE CONTROL SYSTEM. ALL SETPOINTS AND TIME SETTINGS WILL BE FINALIZED DURING SYSTEM TESTING.

HVAC GLOBAL START

A LAB HVAC GLOBAL START WILL BE INITIATED WHEN THE LAB HVAC SYSTEM IS REQUIRED TO BE BROUGHT ONLINE (I.E. AFTER A SHUTDOWN, SCHEDULED PM, ETC.). THIS GLOBAL START WILL BE INITIATED AFTER ALL ALARMS THAT MIGHT HAVE CONTRIBUTED TO THE HVAC GLOBAL SHUTDOWN HAVE BEEN INVESTIGATED, CORRECTED AND THE LAB IS READY TO GO BACK INTO OPERATION. THE GLOBAL START WILL START AHU-4 FIRST AND THEN LEAD EXHAUST FAN EF-4 OR 5, EF-6 AND EF-7 AFTER A SLIGHT TIME DELAY.

DURING THE HVAC GLOBAL START, THE SUPPLY AND EXHAUST PRESSURE ALARMS ARE TEMPORARILY DISABLED FOR ~~XX~~ 3 MINUTES. DURING THE HVAC GLOBAL START, THE LAB DIFFERENTIAL PRESSURE ALARMS ARE TEMPORARILY DISABLED FOR ~~XX~~ 2 MINUTES. THIS WILL PREVENT NUISANCE ALARMS.

AHU-4 FAN CONTROL

UPON A COMMAND TO START, THE UNIT OUTSIDE AIR DAMPER OPENS AND IS VERIFIED OPEN THROUGH OPEN AND CLOSE LIMIT SWITCHES. THE DAMPER IS CONSIDERED OPEN ONCE THE CLOSED LIMIT SWITCH POSITION IS NOT PRESENT. THE OPEN LIMIT SWITCH WILL PROVIDE INDICATION THAT THE OUTSIDE DAMPER IS FULL OPEN. AN INCORRECT DAMPER POSITION ALARM IS PROVIDED IF THE OPEN LIMIT SWITCH IS NOT CONFIRMED WITHIN ~~XX SECONDS~~ 5 MINUTES. UPON CONFIRMATION OF THE OUTSIDE DAMPER NOT CLOSED POSITION, THE LEAD SUPPLY FAN IS STARTED. ~~AFTER A TIME DELAY (XX SECONDS),~~ NO DELAY THE FAN INLET DAMPER IS COMMANDED OPEN. THE LEAD FAN RAMPS UP TO PRESET SPEED (E.G. 66% FOR XX MINUTES) AND THEN IS RELEASED TO CONTROL TO THE STATIC PRESSURE PID CONTROL LOOP. THE LEAD FAN WILL RUN CONTINUOUSLY AND MAINTAIN THE STATIC PRESSURE FOR THE SUPPLY AIR SYSTEM.

66% FOR 30 SECONDS

THE FAN INLET DAMPER IS CONSIDERED OPEN ONCE THE CLOSED LIMIT SWITCH POSITION IS NOT PRESENT. THE OPEN LIMIT SWITCH WILL PROVIDE INDICATION THAT THE DAMPER IS FULL OPEN. AN INCORRECT DAMPER POSITION ALARM IS PROVIDED IF THE OPEN LIMIT SWITCH IS NOT CONFIRMED WITHIN XX SECONDS. THE LEAD FAN WILL CONTINUE TO RUN WHEN AN INCORRECT DAMPER POSITION ALARM IS PRESENT. AN INCORRECT DAMPER POSITION ALARM FROM EITHER THE OUTSIDE AIR DAMPER OR FAN INLET DAMPER WILL INITIATE A SHUNT TRIP OF THE ACID FUME HOODS.

AN INDIVIDUAL FAN WILL SHUT DOWN ON ONE OF THE FOLLOWING CONDITIONS: FAN FAILURE AS DETERMINED BY VFD, LOSS OF RUN STATUS OR BOTH SUPPLY PRESSURE TRANSMITTERS ARE IN LOW ALARM. THE LOSS OF THE FAN WILL INITIATE A SHUNT TRIP TO TAKE THE ACID FUME HOODS OFFLINE AND START THE STANDBY FAN (IF AVAILABLE).

ON LOSS OF THE LEAD FAN, THE STANDBY FAN IS STARTED AND THEN THE FAN INLET DAMPER IS COMMANDED OPEN ~~AFTER A SLIGHT TIME DELAY (XX SECONDS)~~ NO DELAY. THE STANDBY FAN IMMEDIATELY RAMPS TO 66% OF SETPOINT WHILE THE FAILED LEAD FAN RAMPS DOWN AND ~~AFTER XX SECONDS~~ NO DELAY, THE STANDBY FAN IS RELEASED TO MAINTAIN SETPOINT OF THE PID STATIC PRESSURE CONTROL LOOP. THE STANDBY FAN WILL OPERATE TO ALLOW FOR THE COOL DOWN MODE OF THE HOTPLATES AND SAFE VENTILATION OF THE ACID FUMES. THE HVAC SYSTEM WILL REMAIN RUNNING UNTIL MANUALLY SHUTDOWN BY THE OPERATORS. THE SUPPLY PRESSURE ALARMS WILL BE DISABLED FOR ~~XX~~ 30 SECONDS DURING SWITCHOVER SO AS TO NOT SHUTDOWN STANDBY FAN WHILE RAMPING UP TO SPEED.

A LOSS OF SUPPLY AIR WILL OCCUR IF BOTH FANS FAIL, THE OUTSIDE DAMPER GOES TO CLOSE POSITION OR BOTH SUPPLY PRESSURE TRANSMITTERS ARE IN LOW ALARM WHILE THE STANDBY FAN IS RUNNING. A LOSS OF SUPPLY AIR WILL INITIATE A SHUNT TRIP TO TAKE THE ACID FUME HOODS OFFLINE. THE HOODS SHOULD ALREADY BE OFFLINE DUE TO THE LEAD FAN FAILURE. THE ACID FUME EXHAUST FANS (EITHER EF-4 OR EF-5) WILL ALSO GO TO THE HIBERNATION MODE REDUCE SPEED (XX %) TO PROVIDE SOME REMOVAL OF FUMES WITHIN THE LAB. THE OUTSIDE AIR DAMPER AND FAN INLET DAMPER SHALL REMAIN OPEN TO ALLOW PASSIVE VENTILATION FOR THE LAB. THE HVAC SYSTEM WILL REMAIN RUNNING TO ALLOW FOR COOL DOWN OF THE ELECTRIC PLATES IN THE ACID FUME HOODS (APPROXIMATELY 120 MINUTES) AND THEN THE ENTIRE SYSTEM WILL SHUT DOWN. THIS WILL HELP MINIMIZE CONTAMINATION OF THE LAB FROM SURROUNDING AREAS. THE OPTIMUM TIME REQUIRED FOR COOL DOWN WITH PASSIVE SUPPLY AIR VENTILATION WILL BE DETERMINED DURING COMMISSIONING AND STARTUP TESTING.

THE SUPPLY FAN WILL GO INTO THE HIBERNATION MODE REDUCED SPEED ON LOW TEMPERATURE ALARM (FREEZESTAT TRIP AT ~~20~~ 38 DEG. F). THIS WILL INITIATE A SHUNT TRIP TO TAKE THE ACID FUME HOODS OFFLINE. THE ACID FUME HOOD LEAD EXHAUST FAN (EITHER EF-4 OR EF-5) WILL ALSO GO TO THE HIBERNATION MODE (I.E. REDUCED SPEED). WHILE IN THIS REDUCED STATE, THE PRESSURE ALARMS (SUPPLY AND EXHAUST) ARE TEMPORARILY RESET TO THE HIBERNATION MODE ALARM SETPOINTS. THE REDUCED SPEED FOR THE AHU SUPPLY FAN INSTEAD OF A COMPLETE SHUTDOWN IS POSSIBLE DUE TO THE PERCENTAGE OF GLYCOL PRESENT IN THE HEATING AND COOLING WATER SYSTEMS. THE FREEZESTAT WILL BE RESET AUTOMATICALLY ONCE THE DEADBAND IS MET (~~5 DEG. F~~) AND HEATING PUMP FAILURE ALARM IS NOT PRESENT. BASED ON THE FINAL SUPPLY FAN AND EXHAUST FAN SETTINGS, THE LAB MAY BECOME SLIGHTLY NEGATIVE. THE OPTIMUM SUPPLY AND EXHAUST FAN SPEEDS AND TIME REQUIRED FOR COOL DOWN WITH REDUCED VENTILATION WILL BE DETERMINED DURING COMMISSIONING AND STARTUP TESTING. THE HVAC SYSTEM WILL REMAIN RUNNING UNTIL MANUALLY SHUTDOWN BY THE OPERATORS

a function of the freeze-stat. (not adjustable)

SMOKE DETECTION IS PROVIDED AT THE DISCHARGE OF THE AHU. THE SMOKE DETECTOR WILL SHUT DOWN THE AHU BUT THE DAMPERS WILL REMAIN OPEN FOR PASSIVE VENTILATION. THE SMOKE ALARM WILL INITIATE A SHUNT TRIP TO TAKE THE ACID FUME HOODS OFFLINE. THE ACID FUME HOOD LEAD EXHAUST FAN (EF-4/5) WILL RUN AT A REDUCED HIBERNATION SPEED. THE LEAD EXHAUST FAN WILL CONTINUE TO RUN TO ACCOMMODATE THE COOL DOWN OF ELECTRIC HOT PLATES IN THE LAB. THE HVAC SYSTEM WILL REMAIN RUNNING TO ALLOW FOR COOL DOWN OF THE ELECTRIC PLATES IN THE ACID FUME HOODS (APPROXIMATELY 120 MINUTES) AND THEN THE ENTIRE SYSTEM WILL SHUT DOWN. THIS WILL HELP MINIMIZE CONTAMINATION OF THE LAB FROM SURROUNDING AREAS. THE OPTIMUM TIME REQUIRED FOR COOL DOWN WITH PASSIVE SUPPLY AIR VENTILATION WILL BE DETERMINED DURING COMMISSIONING AND STARTUP TESTING.

THE SUPPLY FAN START SEQUENCE WILL ALLOW THE FAN TO START AND BEGIN TO RAMP UP BEFORE THE INLET DAMPER STARTS TO OPEN. A FAN STOP SEQUENCE WILL ALLOW THE FAN TO RAMP DOWN AND STOP BEFORE CLOSING THE ASSOCIATED INLET DAMPER. A FAN FAILURE ALARM WILL LOCK OUT THE FAN FROM THE CONTROL SEQUENCE AND REQUIRE A MANUAL RESET BY THE OPERATOR THROUGH THE CONTROL SYSTEM TO PUT BACK ONLINE

WHEN THE HVAC SYSTEM GOES INTO HIBERNATION MODE/REDUCED OPERATING STATE DUE TO HVAC ALARM CONDITIONS, THE PRESSURE ALARMS (SUPPLY AND EXHAUST) ARE TEMPORARILY RESET TO THE HIBERNATION MODE ALARM SETPOINTS. THE PRESSURE ALARMS ARE DISABLED IF BOTH SUPPLY FANS OR BOTH EXHAUST FANS ARE OFFLINE DUE TO EITHER EQUIPMENT FAILURE OR SYSTEM ALARM RESPONSE REQUIRES THE FANS TO GO OFFLINE.

AHU-4 FAN PRESSURE CONTROL

REDUNDANT PRESSURE TRANSMITTERS ARE PROVIDED ON THE DISCHARGE OF THE AHU. THE TRANSMITTERS PROVIDE THE PROCESS VARIABLE FOR THE FAN STATIC PRESSURE CONTROL LOOP. THE OPERATOR SELECTS WHICH TRANSMITTER IS THE CONTROL VARIABLE. ON FAILURE OF THE TRANSMITTER, THE SECOND TRANSMITTER WILL BECOME THE CONTROL VARIABLE. A TRANSMITTER FAILURE OCCURS WHEN ITS READING IS OUTSIDE THE 4-20 MA RANGE. .55 .18

DURING NORMAL OPERATION, THE STATIC PRESSURE SET POINT IS XXX IN. WATER COLUMN. DURING HIBERNATION MODE OPERATION, THE STATIC PRESSURE SETPOINT IS XXX IN. WATER COLUMN.
EACH TRANSMITTER PROVIDES HIGH (PRESET VARIANCE FROM SETPOINT XX IN. WATER COLUMN FOR XX SECONDS AND LOW (PRESET VARIANCE XX IN. WATER COLUMN FOR XX SECONDS) PRESSURE ALARMS AS WELL AS CONTINUOUS READING. +.50 30 -.50 30

WITH THE LEAD FAN RUNNING, IF BOTH TRANSMITTERS ARE IN LOW OR HIGH ALARM, A SHUNT TRIP WILL BE INITIATED AND THE STANDBY FAN WILL COME ONLINE. WITH THE LAG FAN RUNNING, IF BOTH TRANSMITTERS ARE IN LOW OR HIGH ALARM, THE AHU GOES OFFLINE WITH ITS DAMPERS OPEN AND THE EXHAUST FANS (EF-4/5) GO TO REDUCED SPEED.

BOTH TRANSMITTER READINGS ARE ALSO COMPARED AND ALARMS IF THE READINGS ARE GREATER THAN 10% APART FOR ~~XX MINUTE~~ 30seconds. AN ALARM ONLY IS PROVIDED IF ONLY ONE TRANSMITTER IS IN LOW OR HIGH ALARM.

AHU-4 TEMPERATURE CONTROL

A DISCHARGE TEMPERATURE TRANSMITTER WILL BE THE PROCESS VARIABLE FOR THE AHU DISCHARGE TEMPERATURE COOLING LOOP TO MAINTAIN THE AHU DISCHARGE TEMPERATURE OF 60°F (OPERATOR ADJUSTABLE). THE COOLING COIL WILL MODULATE TO MAINTAIN THE AHU DISCHARGE SETPOINT. THE HEATING SECTION WILL OPERATE TO MAINTAIN THE HEATING COIL DISCHARGE HEATING SETPOINT (2°F BELOW THE AHU DISCHARGE SETPOINT) AS FOLLOWS: THE HEATING COIL PUMP (P-1) WILL BE COMMANDED ON WHEN THE OUTSIDE AIR TEMPERATURE IS BELOW 40°F. ~~WHEN THE OUTSIDE AIR TEMPERATURE IS ABOVE 35°F THE FACE AND BYPASS DAMPERS WILL REMAIN 100% OPEN TO THE FACE (COIL5)~~ AND THE HEATING VALVE WILL MODULATE TO MAINTAIN THE DISCHARGE HEATING SETPOINT. ~~WHEN THE OUTSIDE AIR TEMPERATURE IS BELOW 35°F THE FACE AND BYPASS DAMPERS WILL MODULATE TO MAINTAIN THE DISCHARGE HEATING SETPOINT AND THE HEATING VALVE WILL REMAIN 100% OPEN.~~

SET TO -80° TO NOT ALLOW SWITCHING F+B DAMPERS

THE DISCHARGE DUCT TEMPERATURE TRANSMITTER PROVIDES HIGH (~~PRESET VARIANCE FROM SETPOINT XX DEGREES F FOR XX SECONDS~~) AND LOW (~~PRESET VARIANCE FROM SETPOINT XX DEGREES F FOR XX SECONDS OPERATOR ADJUSTABLE~~) TEMPERATURE ALARMS AS WELL AS CONTINUOUS READING.
HIGH ALARM = 140° LOW ALARM = 45° 15 SECOND DELAY TO ALARM

HEATING COIL PUMP CURRENT IS CONTINUALLY MONITORED TO PROVIDE PUMP STATUS. A HEATING COIL PUMP ALARM IS PROVIDED IF THE PUMP IS COMMANDED ON AND CURRENT IS NOT PRESENT.

ON A FREEZESTAT ALARM, THE HEATING COIL CONTINUES TO CONTROL TO ITS PID LOOP AND THE COOLING CONTROL VALVE GOES TO 25% OPEN.

AHU-4 RELATIVE HUMIDITY CONTROL

THE HUMIDIFIER WILL MODULATE (WHEN FAN RUN STATUS IS DETECTED) TO MAINTAIN THE HUMIDITY WITHIN THE LAB. THE HUMIDITY SENSOR LOCATED IN THE PRODUCTION LAB IS THE PROCESS VARIABLE TO MAINTAIN THE HUMIDITY CONTROL LOOP AT 25-30 %. BESIDES THE MAIN PRODUCTION LAB, HUMIDITY SENSORS ARE ALSO PROVIDED IN THE HIGH LEVEL LAB AND WRITE UP AREA. ALL THREE TRANSMITTERS PROVIDE CONTINUOUS MONITORING OF LAB RELATIVE HUMIDITY. THESE READINGS DO NOT PROVIDE HIGH AND LOW ALARMS. PAUL Requested 35%

A DUCT RELATIVE HUMIDITY TRANSMITTER PROVIDES HIGH (~~PRESET VARIANCE FROM SETPOINT XX % FOR XX SECONDS~~) AND LOW (~~PRESET VARIANCE FROM SETPOINT XX % FOR XX SECONDS~~) RELATIVE HUMIDITY ALARMS AS WELL AS CONTINUOUS READING.
HIGH ALARM = 95 % LOW ALARM = 0 % HONEYWELL DOES NOT CONTROL HUMIDITY DIRECTLY. SET POINT ON LOCAL HUMIDIFIER UNIT CONTROL. STAND ALONE NO DDC.

THE PACKAGED HUMIDIFIER CONTROLS INCLUDE AN AIRFLOW SWITCH AND HIGH HUMIDITY LIMIT SWITCH THAT PROVIDES A LOCAL INTERLOCK FOR THE HUMIDIFIER.

REHEAT CONTROL

TEMPERATURE TRANSMITTERS ARE PROVIDED AT THE MAIN PRODUCTION LAB, HIGH LEVEL LAB AND WRITE UP AREA. ALL THREE TRANSMITTERS PROVIDE HIGH (PRESET VARIANCE FROM ROOM SETPOINT XX DEGREES F FOR XX SECONDS) AND LOW (PRESET VARIANCE FROM ROOM SETPOINT XX DEGREES F FOR XX SECONDS) TEMPERATURE ALARMS AS WELL AS CONTINUOUS READING.

EACH LAB HAS A DEDICATED REHEAT COIL WITH HOT WATER CONTROL VALVE. THE LAB AREA TEMPERATURE TRANSMITTER WILL BE THE PROCESS VARIABLE FOR THE CORRESPONDING REHEAT TEMPERATURE CONTROL LOOP TO MAINTAIN THE INDIVIDUAL LAB TEMPERATURE.

A DUCT TEMPERATURE TRANSMITTER PROVIDES HIGH (~~PRESET VARIANCE FROM DISCHARGE SETPOINT XX DEGREES F FOR XX SECONDS~~) AND LOW (~~PRESET VARIANCE FROM DISCHARGE SETPOINT XX DEGREES F FOR XX SECONDS~~) TEMPERATURE ALARMS AS WELL AS CONTINUOUS READING AT THE DISCHARGE OF EACH REHEAT COIL.
HIGH ALARM = 130° LOW ALARM = 50° 15 SECOND TO DELAY ALARM

LAB DEWPOINT MONITORING

THE THREE LAB SPACES (HI LEVEL LAB, WRITE UP LAB AND PRODUCTION LAB) HAVE TEMPERATURE AND HUMIDITY TRANSMITTER MONITORING THE AREA. THE DEWPOINT WILL BE CALCULATED AND PROVIDED IN THE CONTROL SYSTEM FOR MONITORING.

LAB DIFFERENTIAL PRESSURE MONITORING

THE THREE LAB SPACES (HI LEVEL LAB, WRITE UP LAB AND PRODUCTION LAB) HAVE PHOTOHELICS THAT MONITOR AND ALARM DIFFERENTIAL PRESSURE ACROSS THE LAB SPACE AND THE VESTIBULE. THERE IS ALSO A PHOTOHELIC TO MONITOR AND ALARM THE DIFFERENTIAL PRESSURE ACROSS THE VESTIBULE AND OUTSIDE CORRIDOR.

AHU FILTER ALARMS

THE AHU HAS A PREFILTER AND FINAL FILTER. EACH FILTER IS MONITORED WITH A DIFFERENTIAL PRESSURE TRANSMITTER. EACH TRANSMITTER PROVIDES A HIGH (~~PRESET VARIANCE FROM SETPOINT XX IN. WATER COLUMN FOR XX SECONDS~~) DIFFERENTIAL PRESSURE ALARMS AS WELL AS CONTINUOUS READING. THE HIGH DIFFERENTIAL PRESSURE ALARM SIGNIFIES A DIRTY OR CLOGGED FILTER DUE TO SNOW ON THE PREFILTER. THE HIGH DIFFERENTIAL PRESSURE ALARM SIGNIFIES A DIRTY FILTER ON THE FINAL FILTER. A PREFILTER OR FINAL FILTER ALARM WILL INITIATE A SHUNT TRIP OF THE ACID FUME HOODS.
HIGH ALARM = 1.5 INW 15 second delay to Alarm

IDC ARCHITECTS
400 Industry Drive
Suite 100
Pittsburgh, PA 15275
www.idcarchitects.com

IDC PROJECT NO.: 661342 CLIENT PROJECT NO.:

DRAWN: C. STAUB REVIEWED: G. BORRETTI
DESIGNED: C. STAUB APPROVED: M. MORRISSEY
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KEYPLAN

The UNIVERSITY of VERMONT

Delehanty Hall
Cosmogenic Nuclide
Laboratory

TITLE: MECHANICAL LAB HVAC SEQUENCE OF OPERATIONS PART 1 OF 2

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EF-4 AND EF-5
UPON A COMMAND TO START, THE LEAD FAN STARTS AND AFTER A TIMED DELAY (XX SECONDS) THE FAN INLET AIR DAMPER IS COMMANDED TO OPEN THE LEAD FAN RAMPS UP TO PRESET SPEED (E.G. 75% FOR XX MINUTES) AND THEN IS RELEASED TO CONTROL TO THE VFD SPEED CONTROL LOOP (100%). THE LEAD FAN WILL RUN CONTINUOUSLY AND MAINTAIN THE STATIC PRESSURE FOR THE EXHAUST AIR SYSTEM.

THE FAN INLET DAMPER IS CONSIDERED OPEN ONCE THE CLOSED LIMIT SWITCH POSITION IS NOT PRESENT. THE OPEN LIMIT SWITCH WILL PROVIDE INDICATION THAT THE DAMPER IS FULL OPEN. AN INCORRECT DAMPER POSITION ALARM IS PROVIDED IF THE OPEN LIMIT SWITCH IS NOT CONFIRMED WITHIN XX SECONDS. THE LEAD FAN WILL CONTINUE TO RUN WHEN AN INCORRECT DAMPER POSITION ALARM IS PRESENT. AN INCORRECT DAMPER POSITION ALARM FROM THE FAN INLET DAMPER WILL INITIATE A SHUNT TRIP OF THE ACID FUME HOODS.

AN INDIVIDUAL FAN (LEAD OR STANDBY) WILL SHUT DOWN ON ONE OF THE FOLLOWING CONDITIONS: FAN FAILURE AS DETERMINED BY VFD, LOSS OF RUN STATUS OR BOTH SUPPLY PRESSURE TRANSMITTERS ARE IN LOW ALARM. ON LOSS OF THE LEAD FAN, THE ACID FUME HOODS WILL GO OFFLINE VIA THE SHUNT TRIP AND THE STANDBY FAN WILL BE PUT ONLINE.

ON LOSS OF THE LEAD FAN, THE STANDBY FAN IS STARTED AND THEN THE FAN INLET DAMPER IS COMMANDED OPEN AFTER A SLIGHT TIME DELAY (XX SECONDS). THE STANDBY FAN IMMEDIATELY RAMPS TO ~~75% OF SETPOINT~~ WHILE THE FAILED LEAD FAN RAMPS DOWN ~~AND AFTER XX SECONDS, THE STANDBY FAN IS RELEASED TO MAINTAIN VFD SPEED SETPOINT OF 100%~~. THE STANDBY FAN WILL OPERATE TO ALLOW FOR THE COOL DOWN MODE OF THE HOTPLATES AND SAFE VENTILATION OF THE ACID FUMES. THE HVAC SYSTEM WILL REMAIN RUNNING UNTIL MANUALLY SHUTDOWN BY THE OPERATORS. THE EXHAUST PRESSURE ALARMS WILL BE DISABLED FOR XX SECONDS DURING SWITCHOVER SO AS TO NOT SHUTDOWN STANDBY FAN WHILE RAMPING UP TO SPEED.

A LOSS OF EXHAUST AIR WILL OCCUR IF BOTH FANS FAIL OR BOTH SUPPLY PRESSURE TRANSMITTERS ARE IN LOW ALARM WHILE THE STANDBY FAN IS RUNNING. A LOSS OF EXHAUST AIR WILL INITIATE A SHUNT TRIP TO TAKE THE ACID FUME HOODS OFFLINE. THE HOODS SHOULD ALREADY BE OFFLINE DUE TO THE LEAD FAN FAILURE. LOSS OF EXHAUST AIR WILL INITIATE A HARD SHUTDOWN OF THE HVAC SYSTEM. AHU-4, EF-6, AND EF-7 WILL ALSO SHUTDOWN. EF-7 WILL STAY ONLINE OR GO BACK ONLINE IF AN HCL OR HF SNIFFER ALARM IS PRESENT TO HELP EVACUATE THE FUMES.

THE EXHAUST FAN START SEQUENCE WILL ALLOW THE FAN TO START AND BEGIN TO RAMP UP BEFORE THE FAN INLET DAMPER STARTS TO OPEN. A FAN STOP SEQUENCE WILL ALLOW THE FAN TO RAMP DOWN AND STOP BEFORE CLOSING THE ASSOCIATED INLET DAMPER. A FAN FAILURE ALARM WILL LOCK OUT THE FAN FROM THE CONTROL SEQUENCE AND REQUIRE A MANUAL RESET BY THE OPERATOR THROUGH THE CONTROL SYSTEM TO PUT BACK ONLINE.

WHEN THE HVAC SYSTEM GOES INTO HIBERNATION MODE/REDUCED OPERATING STATE DUE TO HVAC ALARM CONDITIONS, THE PRESSURE ALARMS (SUPPLY AND EXHAUST) ARE TEMPORARILY RESET TO THE HIBERNATION MODE ALARM SETPOINTS. THE PRESSURE ALARMS ARE DISABLED IF BOTH SUPPLY FANS OR EXHAUST FANS ARE OFFLINE DUE TO EITHER EQUIPMENT FAILURE OR SYSTEM ALARM RESPONSE REQUIRES THE FANS TO GO OFFLINE.

EF-4 AND EF-5 FAN SPEED CONTROL/PRESSURE MONITORING
REDUNDANT PRESSURE TRANSMITTERS ARE PROVIDED ON THE COMMON EXHAUST DUCT INLET TO THE FANS. DURING NORMAL OPERATION, ~~THE STATIC PRESSURE SETPOINT IS XX IN. WATER COLUMN.~~ DURING HIBERNATION MODE OPERATION, ~~THE STATIC PRESSURE SETPOINT IS XX IN. WATER COLUMN~~.
BOTH TRANSMITTER READINGS ARE ALSO COMPARED AND ALARMS IF THE READINGS ARE OFF GREATER THAN 10% FOR 1 MINUTE. AN ALARM ONLY IS PROVIDED IF ONLY ONE TRANSMITTER IS IN LOW OR HIGH ALARM.

NO SET POINT FANS RUN AT 100% THE FAN SPEED = 50% DURING HIBERNATION

WITH THE LEAD FAN RUNNING, IF BOTH TRANSMITTERS ARE IN LOW OR HIGH ALARM, A SHUNT TRIP WILL BE INITIATED AND THE STANDBY FAN WILL COME ONLINE. WITH THE LAG FAN RUNNING, IF BOTH TRANSMITTERS ARE IN LOW OR HIGH ALARM, THE HVAC SYSTEM GOES INTO A HARD SHUTDOWN WHICH STOPS THE STANDBY EXHAUST FAN, AHU-4, EF-6 AND EF-7. EF-7 WILL STAY ONLINE OR GO BACK ONLINE IF AN HCL OR HF SNIFFER ALARM IS PRESENT TO HELP EVACUATE THE FUMES

EF-6
UPON A COMMAND TO START, THE INLET DAMPER IS COMMANDED OPEN AND EXHAUST FAN IS STARTED. THE EXHAUST FAN IS CONSTANT SPEED. THE FAN WILL SHUT DOWN ON ONE OF THE FOLLOWING CONDITIONS: FAN FAILURE AS DETERMINED BY CURRENT ~~TRANSMITTER~~ SWITCH, INLET DAMPER CLOSE POSITION OR LOSS OF EXHAUST FROM INLET STATIC PRESSURE TRANSMITTER. ON A FAN SHUTDOWN, A SHUNT TRIP WILL BE INITIATED AND ACID FUME HOODS WILL GO OFFLINE. THE HVAC SYSTEM WILL CONTINUE TO MAINTAIN PRESENT OPERATING CONDITIONS.

LOW ALARM = .40 INW 60 SECOND DELAY TO ALARM

THE TRANSMITTER PROVIDES ~~HIGH (PRESET VARIANCE FROM SETPOINT XX IN. WATER COLUMN FOR XX SECONDS)~~ AND LOW (~~PRESET VARIANCE FROM SETPOINT XX IN. WATER COLUMN FOR XX SECONDS PRESSURE ALARMS~~) AS WELL AS CONTINUOUS READING. A FAN FAILURE ALARM WILL LOCK OUT THE FAN FROM THE CONTROL SEQUENCE AND REQUIRE A MANUAL RESET BY THE OPERATOR THROUGH THE CONTROL SYSTEM TO PUT BACK ONLINE.

EF-7
UPON A COMMAND TO START, THE EXHAUST FAN IS STARTED. THE EXHAUST FAN IS CONSTANT SPEED, THE FAN WILL SHUT DOWN ON ONE OF THE FOLLOWING CONDITIONS: FAN FAILURE AS DETERMINED BY CURRENT TRANSMITTER, OR LOSS OF EXHAUST FROM INLET STATIC PRESSURE TRANSMITTER. ON A FAN SHUTDOWN, A SHUNT TRIP WILL BE INITIATED AND ACID FUME HOODS WILL GO OFFLINE. THE HVAC SYSTEM WILL CONTINUE TO MAINTAIN PRESENT OPERATING CONDITIONS.

LOW ALARM = .80 INW 60 Second delay to Alarm

THE TRANSMITTER PROVIDES ~~HIGH (PRESET VARIANCE FROM SETPOINT XX IN. WATER COLUMN FOR XX SECONDS OPERATOR ADJUSTABLE)~~ AND LOW (~~PRESET VARIANCE FROM SETPOINT XX IN. WATER COLUMN FOR XX SECONDS OPERATOR ADJUSTABLE~~) PRESSURE ALARMS AS WELL AS CONTINUOUS READING.

A FAN FAILURE ALARM WILL LOCK OUT THE FAN FROM THE CONTROL SEQUENCE AND REQUIRE A MANUAL RESET BY THE OPERATOR THROUGH THE CONTROL SYSTEM TO PUT BACK ONLINE.

IF EF-7 IS OFFLINE DUE TO A HARD HVAC SHUTDOWN (I.E. LOSS OF EXHAUST AIR) IT WILL GO BACK ONLINE ON A HIGH HF OR HCL ALARM

HOOD ALARM CONTACTS
THE CONTROL SYSTEM WILL MONITOR THE HOOD PACKAGED ALARMS FOR ALARM REPORTING. EACH HOOD HAS AN INDIVIDUAL ALARM.

HOOD WASH-DOWN SEQUENCE
THE WASH-DOWN PUSHBUTTON ACTIVATES THIS SEQUENCE. THE FIVE WASH-DOWN VALVES WILL OPEN IN SEQUENCE (ONLY 1 VALVE OPEN AT A TIME) FOR AN ADJUSTABLE PERIOD OF TIME, THEN CLOSE. THE SEQUENCE CONTINUES UNTIL ALL 5 VALVES HAVE CYCLED OPEN. WHEN WASH- DOWN IS NOT ACTIVATED AND A VALVE CLOSED END SWITCH STATUS IS NOT DETECTED AFTER 30 SECOND DELAY, A VALVE CLOSURE FAILURE ALARM WILL BE INITIATED.

SHUNT TRIP
DURING NORMAL OPERATION, FUME HOODS 1 THROUGH 5 WILL HAVE 120V AVAILABLE TO SUPPLY POWER TO THE ACID EVAPORATION HOT PLATES, HOOD LIGHTS AND INTERNAL HOOD BLOWER. DURING ANY OF THE BELOW EVENTS, THE SHUNT TRIP WILL INTERRUPT POWER TO ALL THE FUME HOODS. THE SHUNT IS MANUALLY RESET AT THE ELECTRICAL BREAKER PANEL ONCE THE ALARM CONDITION IS CLEARED. THE SHUNT TRIP TURNS OFF THE HOT PLATES AND HOOD LIGHTS AND STOPS THE HOOD BLOWERS.

EVENTS THAT CAUSE A SHUNT TRIP: LOSS OF LEAD SUPPLY OR EXHAUST FAN, LOSS OF SUPPLY OR EXHAUST AIR, LOSS OF EITHER EF-6 OR 7, AHU ALARMS (FREEZESTAT, SMOKE DETECTION, PREFILTER, FINAL FILTER, INCORRECT DAMPER POSITION), PRESSURE ALARMS (SUPPLY OR EXHAUST), INCORRECT DAMPER POSITION, HCL OR HF ALARMS AND HIBERNATION MODE.

ALL ALARMS THAT CAUSE A SHUNT TRIP WILL INITIATE A PAGE AND EMAIL TO DR. BIERMAN

HCL/HF SNIFFER ALARM
A HCL/HF SNIFFER ALARM WILL INITIATE A SHUNT TRIP OF THE ACID FUMES HOODS WHILE THE HVAC SYSTEM REMAINS RUNNING. THE HF/HCL ALARM WILL ALSO START EF-7 IF THE FAN IS OFFLINE DUE TO A SYSTEM COMMAND AND NOT A FAN FAILURE.

HIBERNATION MODE
THERE ARE TIMES WHEN THE LAB WILL NOT BE IN USE, THE LAB CAN BE PUT INTO HIBERNATION MODE THROUGH A KEYED SWITCH AT THE LAB ENTRANCE. AN INDICATING SIGN- LAB OFFLINE-HOODS NOT USABLE WILL ALSO BE PROVIDED AT THE LAB ENTRANCE TO NOTIFY WHEN THE LAB IS IN A REDUCED HVAC OPERATING STATE. THE EXHAUST HOODS ARE SHUT DOWN BEFORE HIBERNATION MODE CAN BE INITIATED. IN HIBERNATION MODE, THE SUPPLY FANS RUN AT A REDUCED SETPOINT (OPERATOR ADJUSTABLE). REDUCED SETPOINT WILL BE BASED ON FAN SPEED (I.E. 50%). EXHAUST FANS EF-4 AND EF-5 ALSO RUN AT A REDUCED SETPOINT BASED ON FAN SPEED. THE OPTIMUM SUPPLY AND EXHAUST FAN SPEED WILL BE DETERMINED DURING COMMISSIONING AND STARTUP TESTING. DURING HIBERNATION MODE, THE PHOTOHELIC ALARMS FOR PRESSURE DIFFERENTIAL WILL CONTINUE TO MONITOR. NOTE- ALTHOUGH THE AMOUNT OF AIR WITHIN THE LAB FOR PRESSURIZATION SHALL REMAIN CONSTANT, THERE MAY BE SOME DIFFERENCES WITHIN THE AIR SUPPLY OF INDIVIDUAL ROOMS WHICH MAY CAUSE SOME PRESSURE ALARMS. THIS WILL BE REVIEWED DURING TESTING. WHEN THE LAB IS READY TO GO BACK INTO USE, THE HIBERNATION MODE WILL BE DISABLED, THE SUPPLY AND RETURN FANS WILL GO TO NORMAL OPERATING SETPOINTS AND THE EXHAUST HOODS WILL BE TURNED ON. IN HIBERNATION MODE, THE EXHAUST HOOD SASHES MAY BE LOWERED TO A MINIMUM SETTING.

30 Seconds

DURING HIBERNATION MODE, THE HVAC SYSTEM WILL OPERATE AT A REDUCED SPEED BUT WILL OPERATE WITH SAME ALARM PARAMETERS AND RESULTING ACTIONS. THE ONE CHANGE IS THAT THE PRESSURE SETPOINTS WILL BE LOWER DURING HIBERNATION MODE.

THE OPERATOR WILL MANUALLY PUT THE HVAC SYSTEM BACK INTO NORMAL OPERATION WHEN THE LAB IS READY TO GO BACK TO NORMAL USE. THE LAB CANNOT GO BACK TO NORMAL OPERATION IF AN HVAC EQUIPMENT FAILURE IS PRESENT (I.E. DURING HIBERNATION MODE, A FAILURE OCCURRED).

HVAC EQUIPMENT ROTATION
THE LEAD AND STANDBY SUPPLY FAN WILL AUTOMATICALLY ROTATE OPERATION AT 7AM MONDAY MORNING THROUGH THE SOFTWARE PROGRAM. DURING THE ROTATION, THE STANDBY FAN WILL COME ONLINE AND BECOME THE LEAD FAN. THE FAN THAT WAS ONLINE THE PREVIOUS WEEK WILL GO OFFLINE AND BECOME THE STANDBY FAN. ON A ROTATION OF EQUIPMENT, THE STANDBY FAN IS STARTED AND THEN THE INLET DAMPER IS COMMANDED OPEN AFTER A SLIGHT TIME DELAY (XX SECONDS). THE LEAD FAN IS COMMANDED OFFLINE AND RAMPS DOWN. THE STANDBY FAN IMMEDIATELY RAMPS TO 60% OF SETPOINT AND AFTER XX SECONDS, THE FAN IS RELEASED TO MAINTAIN SETPOINT. DURING THE ROTATION, THE SUPPLY PRESSURE ALARMS WILL BE DISABLED FOR ~~X~~ MINUTES.

7:10AM 3 MINUTES 2 Seconds 100% SPEED 30 Seconds

UPON COMPLETION OF THE SUPPLY FAN ROTATION, EF-4 AND EF-5 WILL START THEIR ROTATION IN A SIMILAR MANNER. THE EXHAUST STANDBY FAN WILL RAMP TO ~~90% OF SETPOINT~~. DURING THE ROTATION, THE EXHAUST PRESSURE ALARMS WILL BE DISABLED FOR ~~XX MINUTES~~.

DURING HIBERNATION MODE, IF THE STANDBY FAN IS IN A FAILED CONDITION, THE ROTATION WILL NOT OCCUR.

REMOTE PANEL AND ALARM MONITORING
THERE IS AN INDICATING PANEL PROVIDED IN THE CORRIDOR AND COMPUTER SCREEN IN ROOM 307 (DR. BIERMAN'S OFFICE). THE SPACE DIFFERENTIAL PRESSURE IS MONITORED WITH PHOTOHELIC SWITCHES MOUNTED IN THE CORRIDOR PANEL. A TOUCH SCREEN PC IS MOUNTED IN THE PANEL FACE. THE PC HAS A HONEYWELL "SYMMETRE" CLIENT TO ALLOW REVIEW AND ACCESS OF THE SYSTEM ALARMS.

ALARMS ARE CONSIDERED NON CRITICAL (YELLOW STROBE) OR CRITICAL/LIFE SAFETY (RED STROBE). CRITICAL LIFE SAFETY ALARMS ALSO ANNUNCIATE A HORN THAT CAN BE SILENCED. WHEN THE SILENCE BUTTON IS PUSHED ON THE CORRIDOR PANEL OR INITIATED FROM THE COMPUTER SCREEN, THE HORN WILL BE DEACTIVATED BUT THE INDICATING LIGHT WILL REMAIN ON AS LONG AS THE ASSOCIATED POINT IS IN ALARM CONDITION. THE HORN WILL BE ACTIVATED AGAIN WITH ANY SEQUENTIAL CRITICAL/LIFE SAFETY ALARM CONDITION.

ALL ALARMS AND ANALOG INPUTS ARE TRANSMITTED ACROSS BACNET TO THE MAIN CAMPUS CONTROL SYSTEM.

IDC ARCHITECTS
400 Industry Drive
Suite 100
Pittsburgh, PA 15275
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IDC PROJECT NO.: 661342 CLIENT PROJECT NO.:

DRAWN: C. STAUB REVIEWED: G. BORRETTI
DESIGNED: C. STAUB APPROVED: M. MORRISSEY
NOTICE: STAMP:

STATE OF VERMONT JOSEPH R. KUNKEL NO. 0046 Mechanical LICENSED PROFESSIONAL ENGINEER 5/28/15

NO.	REVISION OR ISSUE	DATE	BY
0	ISSUE FOR CONSTRUCTION	05/28/15	IDCA

AS-BUILT

KEYPLAN

The UNIVERSITY of VERMONT
Delehanty Hall
Cosmogenic Nuclide Laboratory

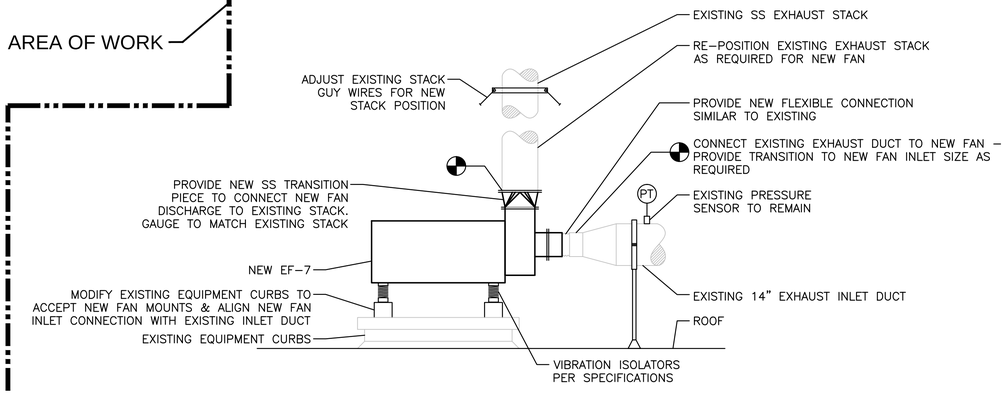
TITLE:
MECHANICAL
LAB HVAC
SEQUENCE OF OPERATIONS
PART 2 OF 2

DATE ISSUED: 05/28/2015 DRAWING SCALE: NONE
ACAD FILE: M-5D EQUIPMENT CODE:

DRAWING NUMBER:
M-5D

File Name: M-5D.dwg User: 2784 Date: 27/May/15 - 1:52pm

AREA OF WORK



1/– DETAIL – NEW EF–7 INSTALLATION
1/2"=1'–0"

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400 Industry Drive
Suite 100
Pittsburgh, PA 15275
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IDC PROJECT NO.: 661342 CLIENT PROJECT NO.:

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KEYPLAN

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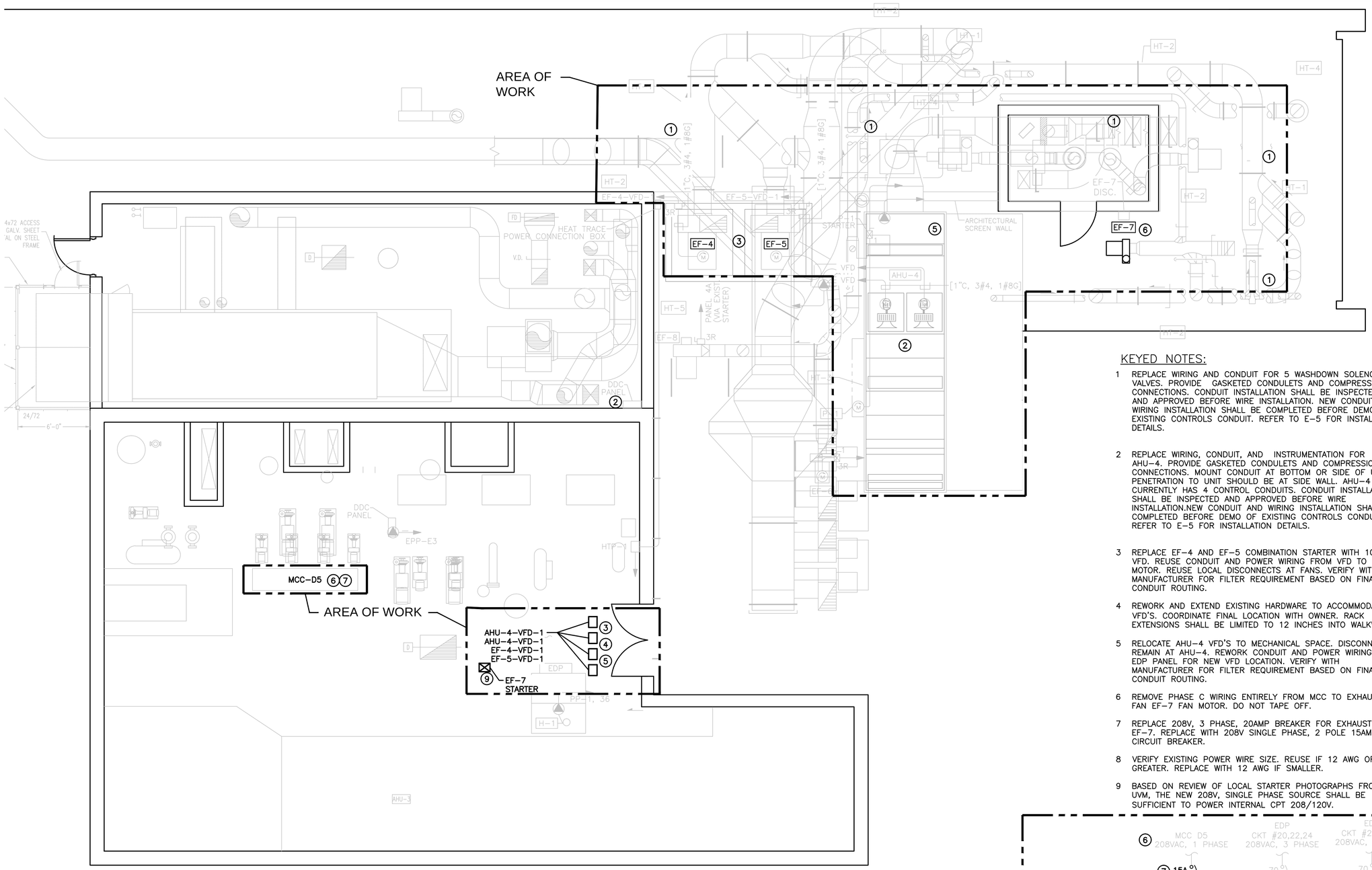
TITLE:
MECHANICAL DETAILS

DATE ISSUED: 05/28/2015 DRAWING SCALE: NONE
ACAD FILE: M–7A EQUIPMENT CODE:

DRAWING NUMBER:
M–7A
– –

Name: M–7A.dwg User: nyurkows Date: 28/May/15 – 2:04pm



1 — ELECTRICAL ROOF PLAN
SCALE: 1/4"=1'-0"

KEYED NOTES:

1 REPLACE WIRING AND CONDUIT FOR 5 WASHDOWN SOLENOID VALVES. PROVIDE GASKETED CONDULETS AND COMPRESSION CONNECTIONS. CONDUIT INSTALLATION SHALL BE INSPECTED AND APPROVED BEFORE WIRE INSTALLATION. NEW CONDUIT AND WIRING INSTALLATION SHALL BE COMPLETED BEFORE DEMO OF EXISTING CONTROLS CONDUIT. REFER TO E-5 FOR INSTALLATION DETAILS.

2 REPLACE WIRING, CONDUIT, AND INSTRUMENTATION FOR AHU-4. PROVIDE GASKETED CONDULETS AND COMPRESSION CONNECTIONS. MOUNT CONDUIT AT BOTTOM OR SIDE OF UNIT. PENETRATION TO UNIT SHOULD BE AT SIDE WALL. AHU-4 CURRENTLY HAS 4 CONTROL CONDUITS. CONDUIT INSTALLATION SHALL BE INSPECTED AND APPROVED BEFORE WIRE INSTALLATION.NEW CONDUIT AND WIRING INSTALLATION SHALL BE COMPLETED BEFORE DEMO OF EXISTING CONTROLS CONDUIT. REFER TO E-5 FOR INSTALLATION DETAILS.

3 REPLACE EF-4 AND EF-5 COMBINATION STARTER WITH 10HP VFD. REUSE CONDUIT AND POWER WIRING FROM VFD TO FAN MOTOR. REUSE LOCAL DISCONNECTS AT FANS. VERIFY WITH MANUFACTURER FOR FILTER REQUIREMENT BASED ON FINAL CONDUIT ROUTING.

4 REWORK AND EXTEND EXISTING HARDWARE TO ACCOMMODATE 4 VFD'S. COORDINATE FINAL LOCATION WITH OWNER. RACK EXTENSIONS SHALL BE LIMITED TO 12 INCHES INTO WALKWAY.

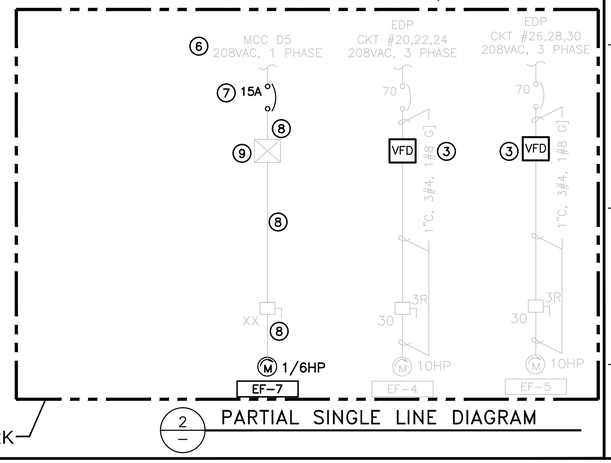
5 RELOCATE AHU-4 VFD'S TO MECHANICAL SPACE. DISCONNECTS REMAIN AT AHU-4. REWORK CONDUIT AND POWER WIRING FROM EDP PANEL FOR NEW VFD LOCATION. VERIFY WITH MANUFACTURER FOR FILTER REQUIREMENT BASED ON FINAL CONDUIT ROUTING.

6 REMOVE PHASE C WIRING ENTIRELY FROM MCC TO EXHAUST FAN EF-7 FAN MOTOR. DO NOT TAPE OFF.

7 REPLACE 208V, 3 PHASE, 20AMP BREAKER FOR EXHAUST FAN EF-7. REPLACE WITH 208V SINGLE PHASE, 2 POLE 15AMP CIRCUIT BREAKER.

8 VERIFY EXISTING POWER WIRE SIZE. REUSE IF 12 AWG OR GREATER. REPLACE WITH 12 AWG IF SMALLER.

9 BASED ON REVIEW OF LOCAL STARTER PHOTOGRAPHS FROM UVM, THE NEW 208V, SINGLE PHASE SOURCE SHALL BE SUFFICIENT TO POWER INTERNAL CPT 208/120V.



2 — PARTIAL SINGLE LINE DIAGRAM

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DRAWN: C. STAUB REVIEWED: G. BORRETTI
DESIGNED: C. STAUB APPROVED: M. MORRISSEY
NOTICE: STAMP:

STATE OF VERMONT RUSSELL E. PAULEY NO. 8987 ELECTRICAL LICENSED PROFESSIONAL ENGINEER 5/27/15

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KEYPLAN

The UNIVERSITY of VERMONT

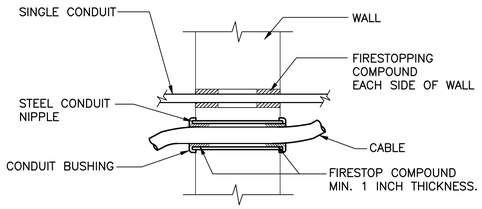
Delehanty Hall
Cosmogenic Nuclide Laboratory

TITLE: ELECTRICAL ROOF LEVEL POWER PLAN

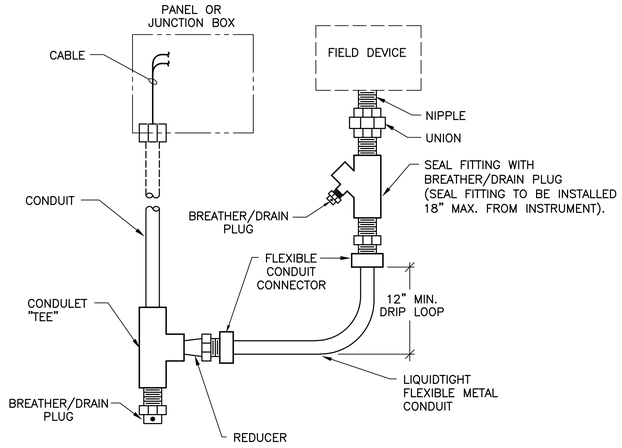
DATE ISSUED: 05/28/2015 DRAWING SCALE: AS NOTED
ACAD FILE: E-2A EQUIPMENT CODE:

DRAWING NUMBER: E-2A

Name: E-2A.DWG User: AI023851 Date: 28/May/15 - 11:37am



1 – FIRESTOP FOR CONDUIT/CABLE THRU WALL DETAIL
NTS



2 – FIELD MOUNTED INSTRUMENT CONDUIT INSTALLATION DETAIL
NTS

GENERAL NOTES:

1 CONDUIT TO BE RIGIDLY SUPPORTED AT BOTTOM, TOP, AND AT 5 FOOT INTERVALS.

2 INSTRUMENT TO BE MOUNTED AT HIGHER ELEVATION THAN CONDUIT TEE (MINIMUM 6").

3 SEALS WILL BE FILLED AFTER E & I CHECKOUT BUT PRIOR TO SYSTEM START–UP.

4 NO CABLE SPLICES TO OCCUR BEYOND INSTRUMENT UNLESS NOTED OTHERWISE AND NEVER BEYOND CONDUIT SEAL IN CLASSIFIED AREAS.

IDC ARCHITECTS
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Pittsburgh, PA 15275
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IDC PROJECT NO.: 661342 CLIENT PROJECT NO.:

DRAWN: C. STAUB REVIEWED: G. BORRETTI

DESIGNED: C. STAUB APPROVED: M. MORRISSEY

NOTICE:

STAMP: STATE OF VERMONT RUSSELL E. FAUCHER NO. 8387 ELECTRICAL LICENSED PROFESSIONAL ENGINEER 5/27/15

NO.	REVISION OR ISSUE	DATE	BY
0	ISSUE FOR CONSTRUCTION	05/28/15	IDCA

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KEYPLAN

The UNIVERSITY of VERMONT

Delehanty Hall Cosmogenic Nuclide Laboratory

TITLE: ELECTRICAL INSTALLATION DETAILS

DATE ISSUED: 05/28/2015 DRAWING SCALE: AS NOTED

ACAD FILE: E–5 EQUIPMENT CODE:

DRAWING NUMBER: E–5

Name: E-5.DWG User: AI023851 Date: 28/May/15 – 11:41am

The University of Vermont

Component Verification Checklist

Project: Delehanty Cosmogenic Nuclide Laboratory

Checked By: David Slade – Slade Engineering *(DCS)*

Item Description	Specified Make /Model	Approved Make /Model	Installed Make /Model	Notes	Date	Initials
Exhaust Fan for snorkel hoods (EF-7)	Twin City / BCJ 400 CFM @ 1.2" w.c. 208V, 1 ph, 60 hz Motor HP: not specified Motor Type: TEFC Motor Make/Model: not specified	Twin City / BCJ 400 CFM @ 1.2" w.c. 208V, 1 ph, 60 hz Motor HP: ¼ HP Motor Type: TEFC Motor S.F: 1.35 Motor Make/Model: Baldor / L3403	Twin City / BCJ 400 CFM @ 1.2" w.c. 208V, 1 ph, 60 hz Motor HP: ¼ HP Motor Type: TEFC Motor S.F: 1.15 Motor Make/Model: Twin City / YC4814C	Fan body as specified and approved. Motor does not match submittal and is to be replaced under warranty.	1/14/16	*(DCS)*
Freezestat for AHU-4	Johnson Controls / A70GA-1C	Johnson Controls / A70GA-1C	Johnson Controls / A70GA-1	"C" suffix is a Johnson Controls sales designation that has no impact product specification.	1/14/16	*(DCS)*
Actuator for Outdoor Air Damper	(Not scheduled for replacement in design documents.)	Belimo / AFBUP-SN4H	Belimo / AFBUP-SN4H	"H" suffix indicates internal heater for additional condensation protection.	1/14/16	*(DCS)*
Actuators for Supply Fan Dampers	Belimo / AFBUP-SN4	Belimo / AFBUP-SN4	Belimo / AFBUP-SN4		1/14/16	*(DCS)*
Pressure Transmitter (AHU-4 Supply)	Setra / 2671005 WO11A1HD	Setra / 2671005 WD11A1HD	Setra / 2671005 WD11A1HD	Specified model # was incorrect by 1 digit. Corrected during submittal review.	1/14/16	*(DCS)*
Pressure Transmitters (EF-4&5 Suction)	Setra / 2671005 WO11A1HD	Setra / 2671005 WD11A1HD	Setra / 2671005 WD11A1HD	Specified model # was incorrect by 1 digit. Corrected during submittal review.	1/14/16	*(DCS)*
Variable Frequency Drives (VFDs) for EF-4&5)	Yaskawa / A1000 -or- ABB / ACH	Yaskawa / PU2A0030FAA	CIMR-PU2A0030FAA	"CIMR" is a Yaskawa standard designation that has no impact product specification.	1/14/16	*(DCS)*
Key Switch for Hibernation Mode	AB / 800T-E	NKK / CKM12AFW01	NKK / CKM12AFW01	Specified model # was incorrect for the application. Corrected during submittal review.	1/14/16	*(DCS)*
Lab Status Illuminated Sign	(No specific make / model specified)	i-Signs / Slim-line SBL824R-J533	Ser. No. 3951-FB12-D55A	Custom sign so not labeled with model #. Sign meets specification.	1/14/16	*(DCS)*

VERMONT MECHANICAL INCORPORATED

P. O. Box 728
Williston, VT 05495
Ph : (802) 862-5900

Submittal

Job: DLR75-000
Delehanty Hal @ UVM
180 Colchester Ave
Burlington, VT 05405

Spec Section No: 23 3416
Submittal No: 1
Revision No: 0
Sent Date: 7/18/2015
Due Date: 7/25/2015

Spec Section Title: Centrifugal Fans
Submittal Title: EF-7 Fan

VMI PO #: CM2595

Contractor:
Vermont Mechanical, Inc.
Chantal Bitzer

Lead time after approval: 4 Weeks
Date items required at project:

Contractor

This submittal has been checked for general conformance with the information given in the contract documents. Final quantities, measurements, and coordination with other trades shall take place in the field.

This submittal will now go to the General Contractor, Architect, and Engineer for final approval.

Architect

Review Status

"Reviewed": Submittal has been reviewed with no comments. Item(s) may be released for procurement.

X "Reviewed As Noted": Submittal has been reviewed and comments have been provided. Item(s) may be released for procurement provided all comments are addressed by Contractor.

"Revise and Resubmit": Submittal has been reviewed and significant issues/comments have been discovered. Submittal must be revised and resubmitted prior to item(s) being released for procurement.

"Rejected": Submittal is substantially incomplete, incorrect, or otherwise does not meet the project requirements. A new submittal shall be generated and submitted for review.

Submittals have been reviewed for general compliance with contract documents, project requirements, and code requirements. This review is not intended to modify, replace, or relieve Contractor from complying with all contract documents, project requirements, and code requirements. Contractor is fully responsible for coordinating item(s) covered under this submittal with all other trades including, but not limited to, field verification of all dimensions, clearances, quantities, and utility requirements. All systems and components shall be installed in strict compliance with manufacturer's instructions.

Review Comments Compiled By:
David C. Slade - Project Manager

Engineer No Comments Provided

REVIEW COMMENTS:

1) Provide extended grease lines as specified.

RF PECK
Commercial HVAC Equipment
22 Computer Drive West
Albany, NY 12205
PHONE (518) 869-3541

Equipment Submittal

project	UVM Delehanty Hall Lab Burlington, Vermont
architect	IDC Architects
engineer	CHZMHILL
contractor	Vermont Mechanical Williston, Vermont
submitted by	Michael Bronder R. F. Peck Co., Inc. Date: July 17, 2015 Albany, New York

Manufacturer's Representatives for
Heating, Ventilating and
Air Conditioning Equipment

Contents: Twin City Fans – Exhaust Fan

FAN DETAILS

Job Name: UVM DELEHANTY

Fans & Blowers
Twin City

Tag: EF-7
Customer: Vermont Mechanical
Job ID: 071515A
Date: July 15, 2015

Description

Quantity	1
Model	BCJ
Size	105
Width	SWSI
Arrangement	10
Class	I
Rotation	W/A
Discharge	W/A
Wheel Diameter (in)	10.50
Drive method	Belt
Percentage width	100%
Percentage diameter	100%
Motor position	--

Performance

Volumetric Flow CFM	400
Operating SP (in WC)	1.200
Standard SP (in WC)	1.200
RPM	1712
Tip Speed (FPM)	4706
Oper. Power BHP	0.14
Standard Power BHP	0.14
Outlet Area (sq.ft)	0.653
Outlet Velocity (FPM)	613
Max RPM for Class	3682
Static Efficiency	55.72%
Total Efficiency	56.81%

Air/Gas Properties

Altitude above sea level (ft)	0
Inlet Pressure (in WC)	0.000
Inlet Temperature(°F)	70
Design Temperature (°F)	70
Gas Type	Standard air
Estimated Density (lb/ft³)	0.075

Motor Data

Power (HP)	1/4
Enclosure	TEFC
Speed (RPM)	1800
Voltage	208-230V
Phase	1
Frequency	60Hz
Frame Size	48

Sound

Octave Bands	1	2	3	4	5	6	7	8	LwA
Level at Inlet	60	65	66	67	67	64	59	50	71

Sound Power Levels in dB re.10^{-12} Watts:

Distance in ft	1	3	5
dBA at inlet	70	61	56

Estimated sound pressure level in dBA (re: 0.0002 microbar) based on a single * ducted installation:

*To estimate dBA level for ducted inlet and ducted outlet (into and out of the room) type installation, deduct 20 from the LwA value shown. Using a directivity factor of 1. Estimated Sound Pressure based on free field, spherical (Q = 1) radiation at stated distance.

Definitions:

LwA The overall (single value) fan sound power level, 'A' weighted.

dBA The environment for each fan installation influences its measured sound value, therefore dBA levels cannot be guaranteed. Consult AMCA Publication 303 for further details. A fan's dBA is influenced by nearby reflective surfaces.

FAN DETAILS

Job Name: UVM DELEHANTY

Fans & Blowers
Twin City

Tag: EF-7
Customer: Vermont Mechanical
Job ID: 071515A
Date: July 15, 2015

Pricing Detail

BCJ 105, Class I, Arrangement 10 Bare fan	55lb
Access Door - Bolted	0 lb
Drain W/ Plug	0 lb
Flange - Inlet, Punched	0 lb
Flange - Inlet, Companion	4 lb
Flange - Outlet, Punched	0 lb
Flange - Outlet, Companion	2 lb
Weather Cover - Std Type	23 lb
Vibration Isolators - RIS	0 lb
Fixed Speed Drive, 1.2 SF	12 lb
Motor 1/4 HP, 1800 RPM, 208-230V, 1Ph, 60Hz , TEFC - Standard , 48	9 lb
Mount TCF Motor	0 lb
Each Weight	105 lb
Extended Weight	105 lb

SUBMITTAL

Job Name: UVM DELEHANTY

Fans & Blowers
Twin City

Tag: EF-7
Customer: Vermont Mechanical
Job ID: 071515A
Date: July 15, 2015

BCJ - Backward Inclined Junior Utility Set

Construction Features

- Non-overloading, backward inclined wheels
- Fan housings are of heavy-gauge, continuously welded construction and are available constructed of steel, aluminum, or stainless steel.
- Adjustable pitch V-belt drives are used so capacity corrections can be readily made when needed.
- Support base provides easy access for electrical wiring and adjustment of the drives

See Attached Centrifugal Drawing

Description	Qty	Model	Size	Width	Wt (lb)
	1	BCJ	105	SWSI	105

Approximate weight each, includes fan, motor and accessories.

Configuration	Class	Rotation	Arr	Disch	M. Pos	Disch Dir
	I	W/A	10	W/A	--	Irrelevant

Performance	CFM	SP (in WC)	RPM	Oper. BHP
	400	1.200	1,712	0.14

Temperature: 70 °F Altitude: 0 ft

Motor Data	HP	RPM	Volt/Ph/Hz	Enclosure
	1/4	1,800	208-230V/1/60	TEFC

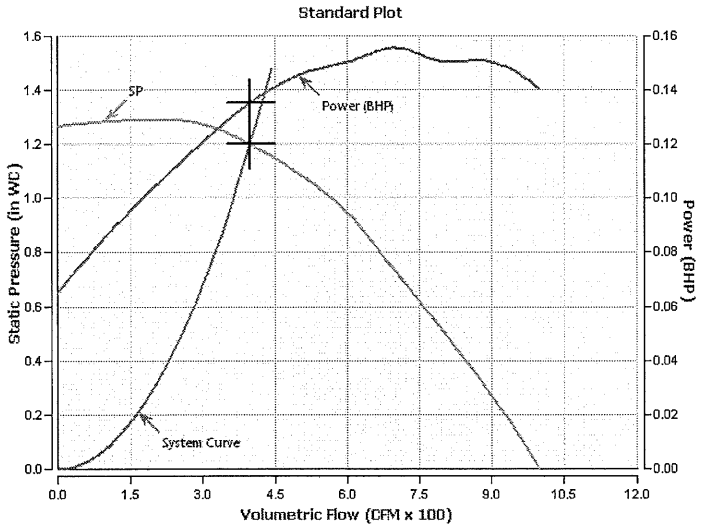
Efficiency: Standard

Sound Data	Octave Bands	1	2	3	4	5	6	7	8	LwA	dBA	Sones
	Level at Inlet	60	65	66	67	67	64	59	50	71	56	8.8

LwA: The overall (single value) fan sound power level in dB re. 10^{-12} Watts, 'A' weighted.
dBA: Estimated sound pressure level (re:0.0002 microbar) based on a single ducted installation at 5 ft., using a directivity factor of 1.

Accessories Included

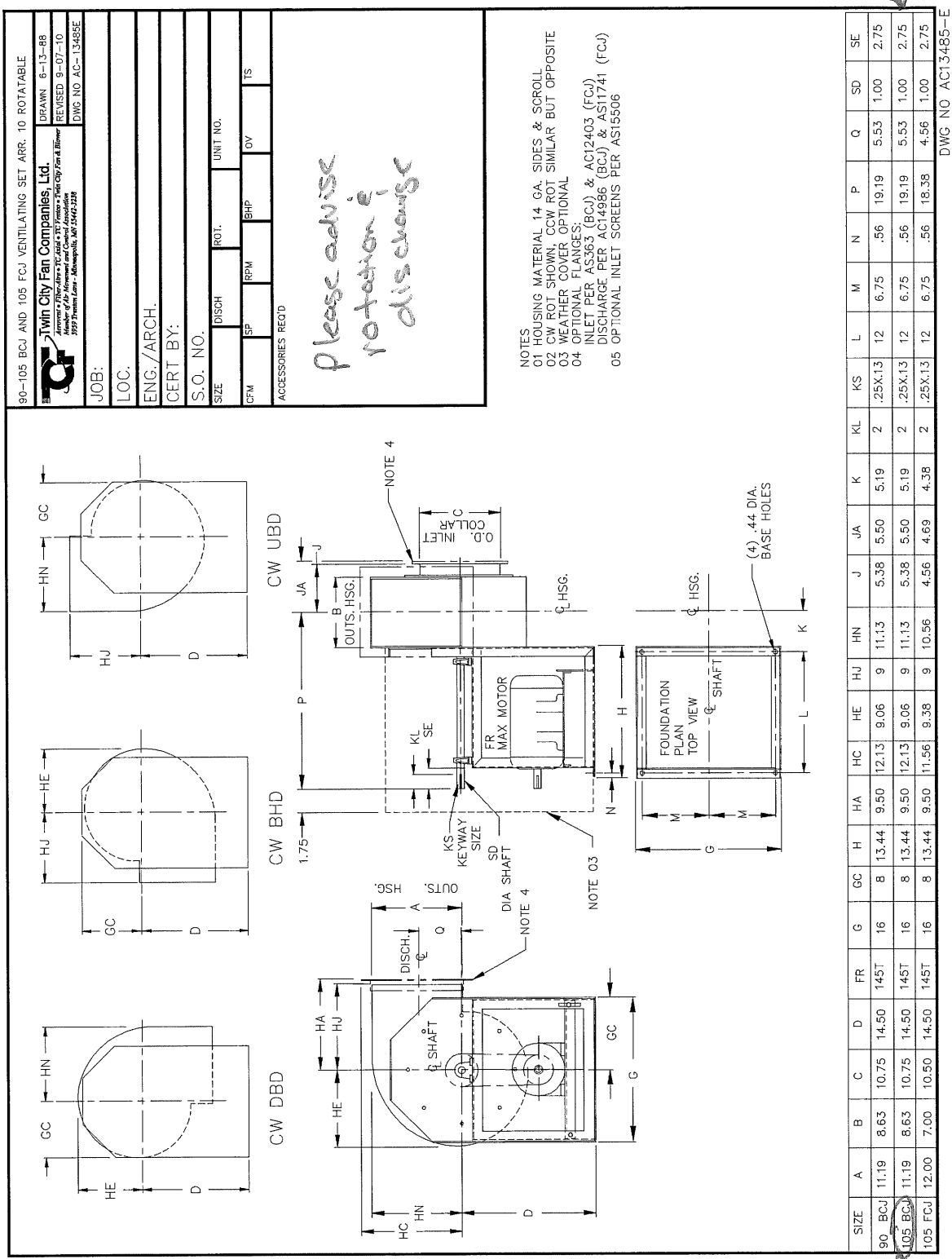
Access Door - Bolted
Drain W/ Plug
Fixed Speed Drive, 1.2 SF
Flange - Inlet, Companion
Flange - Inlet, Punched
Flange - Outlet, Companion
Flange - Outlet, Punched
Mount TCF Motor
Vibration Isolators - RIS
Weather Cover - Std Type



Job Name: UVM DELEHANTY

Fans & Blowers
Twin City

Tag: EF-7
Customer: Vermont Mechanical
Job ID: 071515A
Date: July 15, 2015



SIZE	A	B	C	D	FR	G	GC	H	HA	HC	HE	HJ	HN	J	JA	K	KL	KS	L	M	N	P	Q	SD	SE
90 BCJ	11.19	8.63	10.75	14.50	145T	16	8	13.44	9.50	12.13	9.06	9	11.13	5.38	5.50	5.19	2	.25X.13	12	6.75	.56	19.19	5.53	1.00	2.75
105 BCJ	11.19	8.63	10.75	14.50	145T	16	8	13.44	9.50	12.13	9.06	9	11.13	5.38	5.50	5.19	2	.25X.13	12	6.75	.56	19.19	5.53	1.00	2.75
105 FCJ	12.00	7.00	10.50	14.50	145T	16	8	13.44	9.50	11.56	9.38	9	10.56	4.56	4.69	4.38	2	.25X.13	12	6.75	.56	18.38	4.56	1.00	2.75

SPECIFICATION

Job Name: UVM DELEHANTY

Fans & Blowers
Twin City

Customer: Vermont Mechanical
Job ID: 071515A
Date: July 15, 2015

Model: BCJ

Fans shall be Type BCJ Backward Inclined Junior Utility Set, as manufactured by Twin City Fan & Blower, Minneapolis, Minnesota.

PERFORMANCE - Performance ratings shall conform to AMCA Standard 205 (fan efficiency grade), 211 (air performance) and 311 (sound performance). Fans shall be tested in accordance with ANSI/AMCA Standard 210 (air performance) and 300 (sound performance) in an AMCA accredited laboratory. Fans shall be licensed to bear the AMCA certified ratings seal for both sound and air, and fan efficiency grade (FEG).

Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise beyond the peak efficiency to ensure quiet and stable operation. Fans shall have a non-overloading design with self-limiting horsepower characteristics and shall reach a peak in the normal selection area. All fans shall be capable of operating over the minimum pressure class limits as specified in AMCA Standard 99.

HOUSING - Fan housings shall be of heavy gauge, continuously welded construction. Housings with lock seams or partially welded construction are not acceptable. Housings shall be suitably braced to prevent vibration or pulsation. Housings shall have tapered spun, aerodynamically designed inlet cones or funnels providing stable flow and high rigidity.

WHEEL - Backward inclined wheels shall be single thickness plate type designed for maximum efficiency and quiet operation and shall be of the non-overloading type. Wheels shall be constructed of aluminum, with blades riveted and welded to the spun wheel cone and backplate. All wheels shall be statically and dynamically balanced.

SHAFT - Shafts shall be AISI 1040 or 1045 hot rolled steel, accurately turned, ground, polished, and ring gauged for accuracy. Shafts shall be sized for the first critical speed of at least 1.43 times the maximum speed.

BEARINGS - Bearings shall be heavy duty, grease lubricated, anti-friction ball, self-aligning, pillow block type and selected for a minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum fan RPM.

DRIVE - Motor sheaves shall be cast iron, and supplied as either variable pitch or fixed pitch. Drives and belts shall be rated for a minimum of 120% of the required motor HP.

FINISH AND COATING - The entire fan assembly, excluding the shaft, shall be thoroughly degreased and deburred before application of a rust-preventative primer. After the fan is completely assembled, a finish coat of paint shall be applied to the entire assembly. The fan shaft shall be coated with a petroleum-based rust protectant.

ACCESSORIES - When specified, accessories such as belt guards, weather covers, access doors, companion flanges, discharge shutters, shaft coolers, shaft seals, inlet screens, etc., shall be provided by Twin City Fan & Blower to maintain one source responsibility.

FACTORY BALANCE AND RUN TESTING - All fan wheels shall be statically and dynamically balanced in accordance with ANSI/AMCA 204 "Balance Quality and Vibration Levels for Fans" to Fan Application Category BV-3. This corresponds to a Balance Quality Grade G6.3. All assembled fans are test run at the rated operating speed or at the maximum RPM of the fan. Vibration readings are recorded in the horizontal, vertical and axial directions on both bearings. Trim balancing is performed if necessary to maintain BV-3 vibration limits. Records shall be maintained and a written copy shall be available upon request.

Job Name: UVM DELEHANTY

Fans & Blowers
Twin City

Customer: Vermont Mechanical
Job ID: 071515A
Date: July 15, 2015

GUARANTEE - The manufacturer shall guarantee the workmanship and materials for its BCJ Backward Inclined Junior Utility Sets for at least one (1) year from startup or eighteen (18) months from shipment, whichever occurs first.

SPECIFICATION

Job Name: UVM DELEHANTY

Fans & Blowers
Twin City

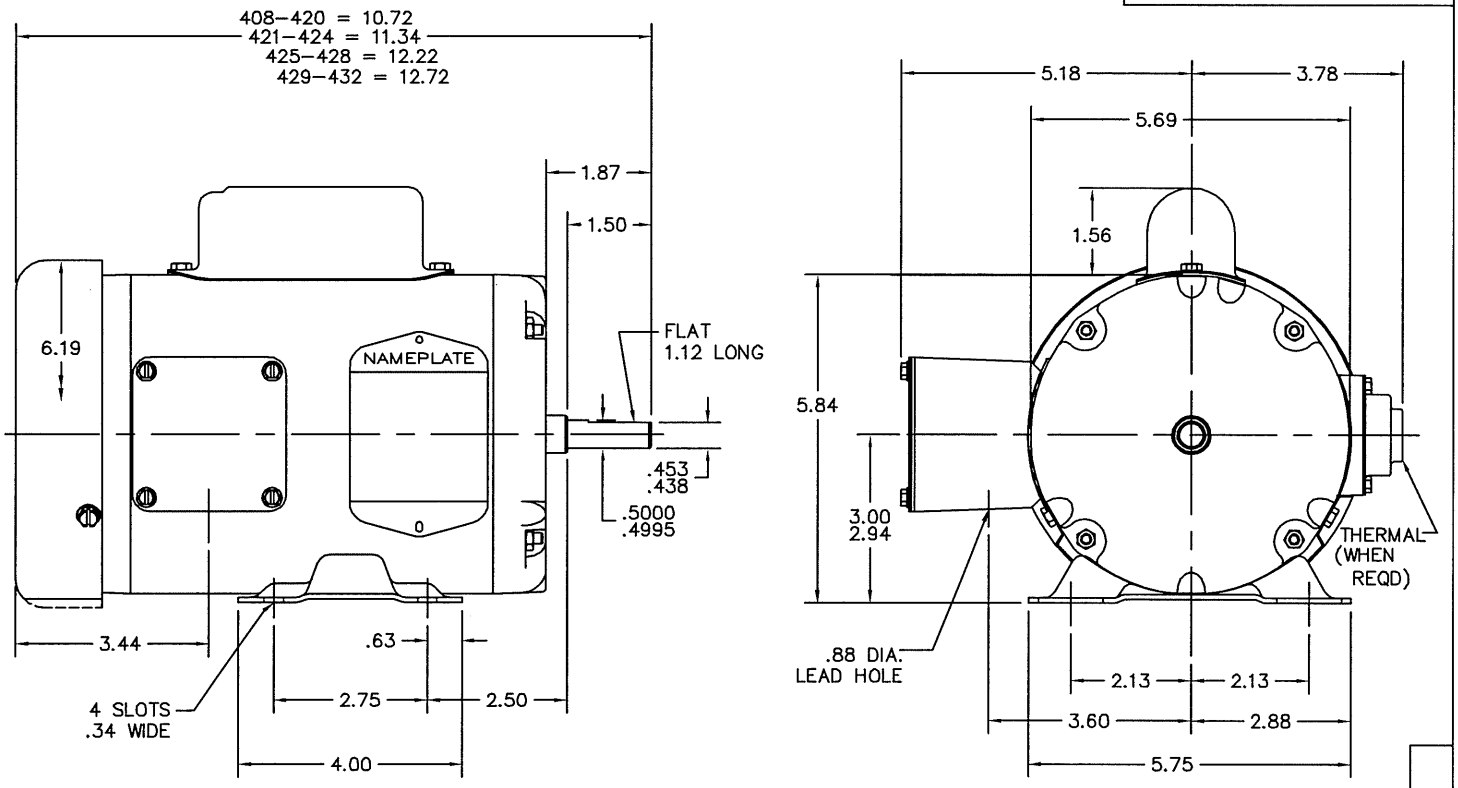
Customer: Vermont Mechanical
Job ID: 071515A
Date: July 15, 2015

AMCA Statements

Tag: EF-7

1. TCF certifies that the model BCJ is licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and AMCA Publication 311 and comply with the requirements of the AMCA Certified Ratings Program.
2. Performance certified is for Installation Type B & D: Free or ducted inlet, Ducted outlet.
3. Power rating (BHP) does not include transmission losses.
4. Performance ratings do not include the effects of appurtenances (accessories).
5. The sound power level ratings shown are in decibels, referred to 10 E-12 watts calculated per AMCA Standard 301.
6. Values shown are for inlet Lwi and LwiA sound power levels for Installation Type B: Free inlet, Ducted outlet.
7. Ratings do not include the effects of duct end correction.
8. The A-weighted sound ratings shown have been calculated per AMCA Standard 301.
9. dBA levels are not licensed by AMCA International.

34LYC051



34LYC051

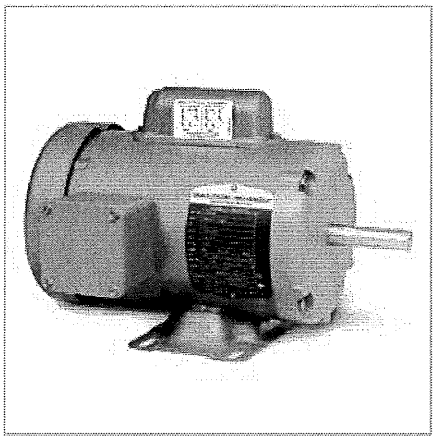
CUSTOMER IS RESPONSIBLE FOR DETERMINING THAT BALDOR'S PRODUCT WILL PERFORM SUITABLY IN THE INTENDED APPLICATION.

REV. DESC: UPDATE OVERALL LENGTHS			BALDOR
REV. LTR: L	VERSION: 04	TDR: 000000767401	
FILE: \AAA\00025\908		REVISED: 09:00:29 10/02/2012	STD HORZ MODEL 34L NEMA 48 TEFC
MTL: –		BY: ENBUCF0	SH 1 of 1

BALDOR • RELIANCE

L3403

.25HP, 1725RPM, 1PH, 60HZ, 48, 3411L, TEFC, F1



Product Information Packet PDF

List Price	344.00 USD
Multiplier Symbol	K
Ship Weight	20 LB
UPC	781568100097

SPECS | DRAWINGS | NAMEPLATE | PERFORMANCE | PARTS | ACCESSORIES

Output	0.250 hp	**KVA Code**	L
Phase	1	**Lifting Lugs**	No Lifting Lugs
Synchronous Speed	1,800 rpm	**Locked Bearing Indicator**	No Locked Bearing
Frequency	60 Hz		
Voltage	230 V 115 V	**Motor Lead Exit**	KO Box
		Motor Lead Quantity/Wire Size	6 @ 18 AWG
Enclosure	TEFC		
Frame Material	Steel	**Motor Lead Termination**	Flying Leads
Frame	48	**Motor Standards**	NEMA
XP Division	Not Applicable	**Motor Type**	3411L
Brand	Baldor-Reliance	**Mounting Arrangement**	F1
Agency Approvals	CSA UR	**Number of Poles**	4
		Overall Length	11.35 in
Ambient Temperature	40 °C	**Power Factor**	57
Auxillary Box	No Auxillary Box	**Product Family**	General Purpose

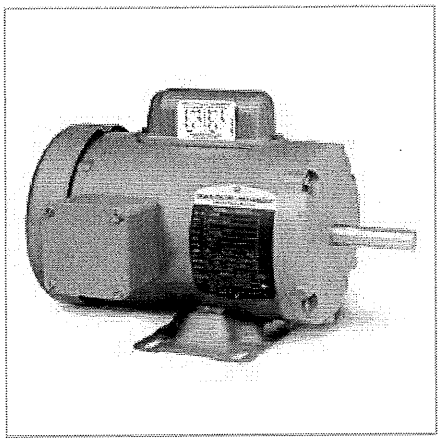
Auxillary Box Lead Termination	None
Base Indicator	Rigid
Bearing Grease Type	POLYREX EM (-20F +300F)
Blower	None
Current	5.0 A @ 115 V 3.0 A @ 208 V 2.5 A @ 230 V
Design Code	N
Drip Cover	No Drip Cover
Duty Rating	CONT
Efficiency @ 100% Load	55.0%
Electrically Isolated Bearing	No electrically isolated
Feedback Device	No feedback
Front Face Code	Standard
Front Shaft Indicator	None
Heater Indicator	No heater
High Voltage Full Load Amps	2.5 A
Insulation Class	B
Inverter Code	Not inverter

Pulley End Bearing Type	Ball Bearing
Pulley Face Code	Standard
Pulley Shaft Indicator	Standard
Rodent Screen	No Rodent Screen
Service Factor	1.35
Shaft Diameter	0.625 in
Shaft Extension Location	Pulley End
Shaft Ground Indicator	No Shaft Grounding
Shaft Rotation	Reversible
Shaft Slinger Indicator	No Slinger
Speed	1,725 rpm
Speed Code	Single Speed
Starting Method	DOL
Thermal Device - Bearing	None
Thermal Device - Winding	None
Vibration Sensor Indicator	No Vibration Sensor

BALDOR • RELIANCE

L3403

.25HP, 1725RPM, 1PH, 60HZ, 48, 3411L, TEFC, F1



Product Information Packet PDF

List Price	344.00 USD
Multiplier Symbol	K
Ship Weight	20 LB
UPC	781568100097

SPECS DRAWINGS NAMEPLATE PERFORMANCE PARTS ACCESSORIES

PERFORMANCE AT 230 V, 60 HZ, 0.25 HP

Typical performance; not guaranteed values.

General Characteristics

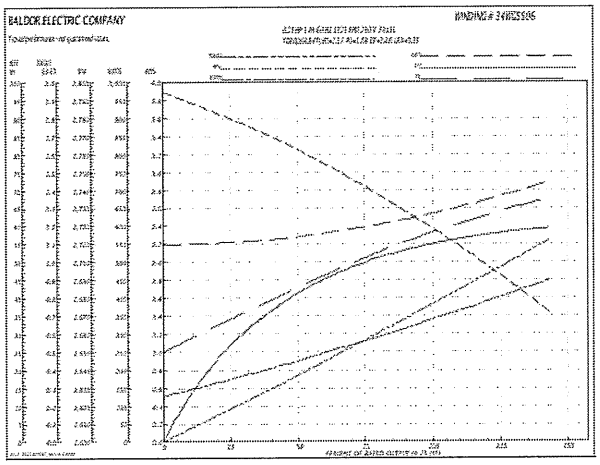
Full Load Torque	0 LB-FT	**Start Configuration**	DOL
No-Load Current	0 A	**Break-Down Torque**	2.13 LB-FT
Line-Line Res. @ 25° C	8.88 Ohms A Ph / 7.06 Ohms B Ph	**Pull-Up Torque**	1.88 LB-FT
Temp. Rise @ Rated Load	57° C	**Locked-Rotor Torque**	2.48 LB-FT
Temp. Rise @ S.F. Load	70° C	**Starting Current**	9.95 A

Load Characteristics

Rated Load	0%	25%	50%	75%	100%	125%	150%	S.F.
Power Factor	25.0	32.0	40.0	49.0	57.0	63.0	69.0	67.0
Efficiency	0.0	28.0	40.0	50.0	55.0	58.0	59.0	59.0

Rated Load	0%	25%	50%	75%	100%	125%	150%	S.F.
Speed (rpm)	1,795	1,779	1,763	1,740	1,720	1,700	1,670	1,680
Line Amps	2.20	2.20	2.30	2.40	2.50	2.70	2.90	2.80

Performance Curves



VERMONT MECHANICAL INCORPORATED

P. O. Box 728
Williston, VT 05495
Ph : (802) 862-5900

Submittal

Job: DLR75-000
Delehanty Hall @ UVM
180 Colchester Ave
Burlington, VT 05405

Spec Section No: 26 05 02
Submittal No: 1
Revision No: 0
Sent Date: 8/26/2015

Spec Section Title:

Submittal Title: Sign - For Record

VMI PO #: Subcontract

Contractor:
Vermont Mechanical, Inc.
Chantal Bitzer

Lead time after approval: 4 Weeks

Date items required at project:

Contractor

This submittal has been checked for general conformance with the information given in the contract documents. Final quantities, measurements, and coordination with other trades shall take place in the field.

This submittal will now go to the General Contractor, Architect, and Engineer for final approval.

Architect

Other:
Slade;David

General Contractor

Engineer

Size 8" x 24" with 1.75" high letters.

Slim-line Backlit LED Sign
SBL824R-J533

PRODUCT ID
37480

DIMENSIONS
8" H x 24" W x 2.5" D

CONSTRUCTION
Cabinet: 1-piece, corrosion resistant, extruded aluminum frame, 2.5" deep.
Cabinet Finish: Duranodic Bronze
Face Material: 1/8" thick, dark grey diffused acrylic
Faces: Single faced sign
Message Face: Replaceable message face

ELECTRICAL
UL/cUL Listed: Listed for wet locations
Voltage: 120-277 VAC, Amps calculated at (120 VAC)

MESSAGE
Font: Swiss 721 Bold BT
Illumination: Backlit with super bright LEDs. Message blanks out when off.
Sign Messages: See message table below
Vinyl Color: Black opaque vinyl
Vinyl Style: Vinyl is applied in a stencil cut style

NOTE: Other colors, voltages, cabinet sizes, cabinet styles and paint finishes are available upon request.

MESSAGE	LED/COLOR	HEIGHT	AMPS
LAB OFF LINE HOOD NOT USABLE	Wide Angle Red Diffused	1.75"	0.096

NOTE: Above messages are independent.

iSigns
7625 Birkmire Drive
Fairview, PA 16415
Phone: 866-437-3040

Proudly Made in the USA

Product View

NOTE: Sign image may not exactly represent the finished product. For illustration purposes only.

Please change as follows:
OFF-LINE
HOODS

VERMONT MECHANICAL INCORPORATED

P. O. Box 728
Williston, VT 05495
Ph : (802) 862-5900

Submittal

Job: DLR75-000
Delehanty Hall @ UVM
180 Colchester Ave
Burlington, VT 05405

Spec Section No: 26 0502
Submittal No: 2
Revision No: 0
Sent Date: 9/28/2015
Due Date: 10/5/2015

Spec Section Title: Basic Electrical Construction Materials & Methods

Submittal Title: Key Switch

Model No. CKM12AFW01

VMI PO #: Subcontract

Contractor:
Vermont Mechanical, Inc.
Chantal Bitzer

Lead time after approval: N/A

Date items required at project:

Contractor

This submittal has been checked for general conformance with the information given in the contract documents. Final quantities, measurements, and coordination with other trades shall take place in the field.

This submittal will now go to the General Contractor, Architect, and Engineer for final approval.

Architect

Other:
Slade;David

General Contractor

Engineer

General Specifications

Electrical Capacity (Resistive Load)

Power Level: 3A @ 250V AC

Other Ratings

Contact Resistance: 20 milliohms maximum
Insulation Resistance: 1,000 megohms minimum @ 500V DC
Dielectric Strength: 1,000V AC minimum between contacts for 1 minute minimum;
1,500V AC minimum between contacts & case for 1 minute minimum
Mechanical Life: 30,000 cycles minimum
Electrical Life: 10,000 cycles minimum
Static Capability: Withstands 15 kilovolts minimum ESD minimum (for CKM models only)
Nominal Operating Torque: 16mm Bushing (CKM models):
.04 mNm (5.67 oz•in) for Flat Key
.08 mNm (11.33 oz•in) for Tubular Key
19mm Bushing (CKL models):
.05 mNm (7.08 oz•in) for Flat Key
.07 mNm (9.91 oz•in) for Tubular Key
Contact Timing: Break-before-make
Angle of Throw: 90° for 2-position & 45° for 3-position

Materials & Finishes

Keys for CKM: Brass with nickel plating with ABS handle
Keys for CKL: Brass with nickel plating for tubular key;
brass with chrome plating for flat key
Housing/Bushing: Glass fiber reinforced PBT for CKM models;
zinc alloy with chrome plating for CKL
Base: LCP (Liquid Crystal Polymer)
Contact Terminals: Copper with silver plating
Common Terminals: Copper with silver plating
Movable Contactor: Copper
Movable Contacts: Silver

Environmental Data

Operating Temperature Range: –25°C through +70°C (–13°F through +158°F)
Humidity: 90 ~ 95% humidity for 240 hours @ 40°C (104°F) for CKM;
90 ~ 95% humidity for 96 hours @ 40°C (104°F) for CKL
Vibration: 10 ~ 55Hz with peak-to-peak amplitude of 1.5mm for CKM or 0.7mm for CKL traversing the frequency range & returning in 1 minute; 3 right angled directions for 2 hours
Shock: 50G (490m/s^2) acceleration for CKM; 30G (294m/s^2) acceleration for CKL; (CKM & CKL tested in 6 right angled directions, with 5 shocks in each direction)

Installation

Mounting Torque: 1.5 Nm (13.28 lb•in) maximum
Soldering Time & Temperature: Manual Soldering: See Profile A in Supplement section.

Distinctive Characteristics

High insulating material for 16mm CKM models withstands over 15 kilovolts of electrostatic discharge, thus providing antistatic feature.

Rugged, die cast housing 19mm CKL models designed for higher security requirements.

Vertically rotating switching mechanism combines with self-cleaning sliding contacts for high reliability and long operating life.

16mm and 19mm diameter bushings available.

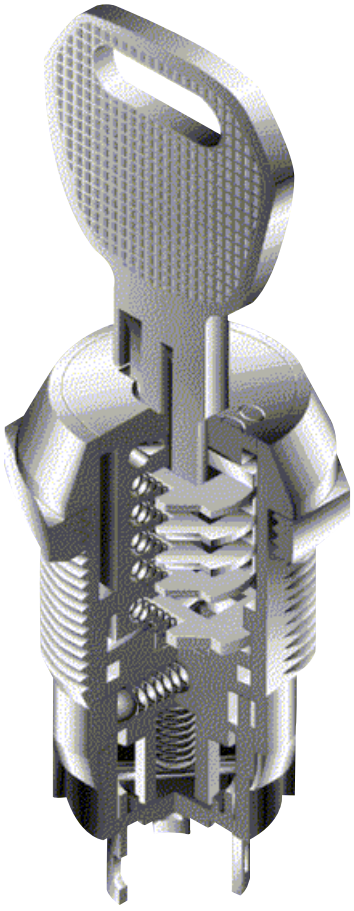
CKL and CKM on-off-on models with tubular keys have push-and-lock mechanism which allows contactor to drop and slide over stationary contacts.

Available in both flat and tubular key styles; flat key is reversible for easier setting.

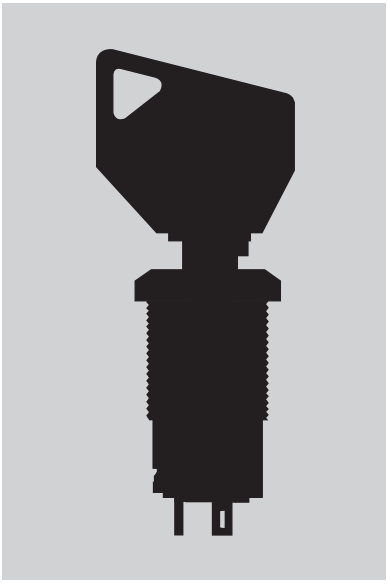
Epoxy sealed terminals prevent entry of flux and other contaminants.

Interior construction provides seal for contact area.

High dielectric strength of 1,500 volts between contacts and case.



Actual Size CKM with Tubular Key



TYPICAL SWITCH ORDERING EXAMPLE

CK M 1 2A F W 01

Bushings

M	16mm Diameter
L	19mm Diameter

Poles

1	SPDT

Keys

F	Flat
T	Tubular

Terminals

01	Solder Lug *

* Wire harness & cable assemblies offered only in Americas

Circuits & Key-Removable Positions

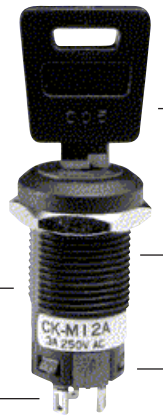
Code	Pos. 1	Pos. 2	Pos. 3	Key Removes
2A	ON	NONE	ON	Positions 1 and 3
2B	ON	NONE	ON	Position 1
3E	ON	OFF	ON	Position 2

Contact Material

W	Silver Rated 3A @ 250V AC

DESCRIPTION FOR TYPICAL ORDERING EXAMPLE

CKM12AFW01



One key supplied with each switch

SPDT ON-NONE-ON Circuit
Key Removable in Positions 1 and 3

16mm Diameter Bushing

Solder Lug Terminals

Silver Contacts
Rated 3A @ 250V AC

POLES, CIRCUITS & KEY-REMOVABLE POSITIONS

Pole & Throw	Model	Key Positions Pos 1	Pos 2	Pos 3	Connected Terminals (Terminal numbers are on switch) Pos 1	Pos 2	Pos 3	Schematic	◉ = Key Removable • = Not Removable ◺ = Maximum Arc
SPDT	**CKM12A CKL12A**	ON	NONE	ON	COM-1	——	COM-2	COM 1 2	POS 1 3
SPDT	**CKM12B CKL12B**	ON	NONE	ON	COM-1	——	COM-2		POS 1 3
SPDT	**CKM13E CKL13E**	ON	OFF	ON	COM-1	OPEN	COM-2	COM OPEN 1 2	2 POS 1 3

KEYS

F **Flat Key**

AT4147 for CKM 16mm
Brass with Nickel Plating key base & ABS key handle
AT4153 for CKL 19mm
Brass with Chrome Plating (crosshatch texture on handle)

One key provided with each switch (no master key available)
For ordering additional keys, indicate the same key number that is engraved on the face of your switch.

Randomly assigned key number (001 through 010 for CKM models & 001 through 025 for CKL models).

Typical Key Ordering Example: AT4153-001

T **Tubular Key**
(must be pressed inward to actuate)

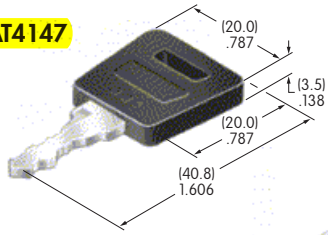
AT4146 for CKM 16mm
Brass with Nickel Plating key base & ABS key handle
AT4152 for CKL 19mm
Brass with Nickel Plating (smooth)

One key provided with each switch (no master key available)
For ordering additional keys, indicate the same key number that is engraved on the face of your switch.

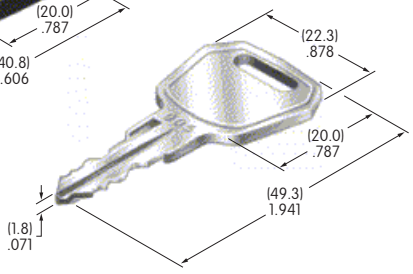
Randomly assigned key number (001 through 025 for CKM models & 001 through 050 for CKL models).

Typical Key Ordering Example: AT4146-001

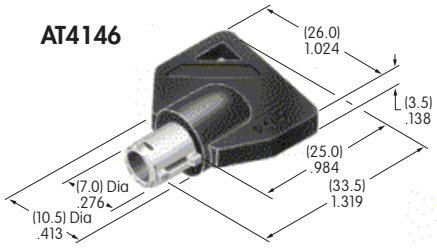
AT4147



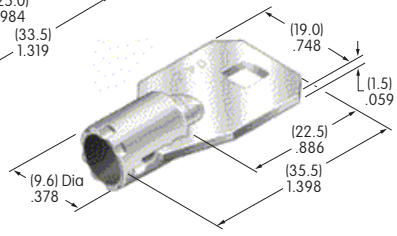
AT4153



AT4146



AT4152

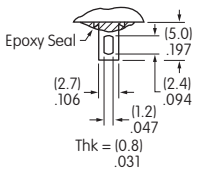


CONTACT MATERIALS, RATINGS & TERMINALS

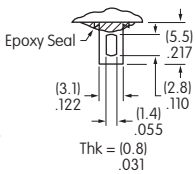
W **Silver over Silver**
Power Level 3A @ 250V AC

01 **Solder Lug Terminals**

Solder Lug Terminal for CKM



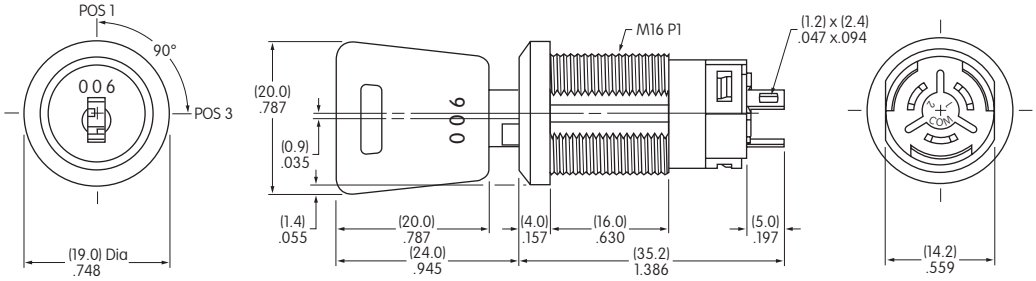
Solder Lug Terminal for CKL



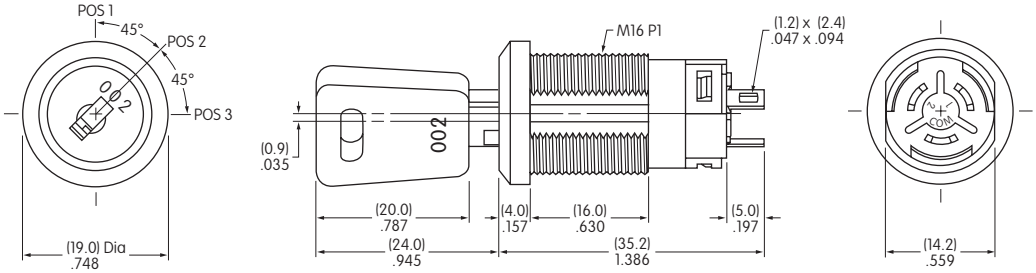
TYPICAL SWITCH DIMENSIONS

16mm Bushing • Flat Key

90° Angular Throw



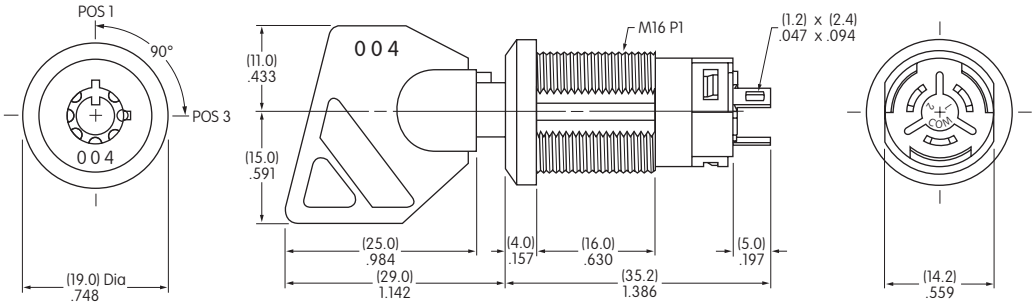
45° Angular Throw



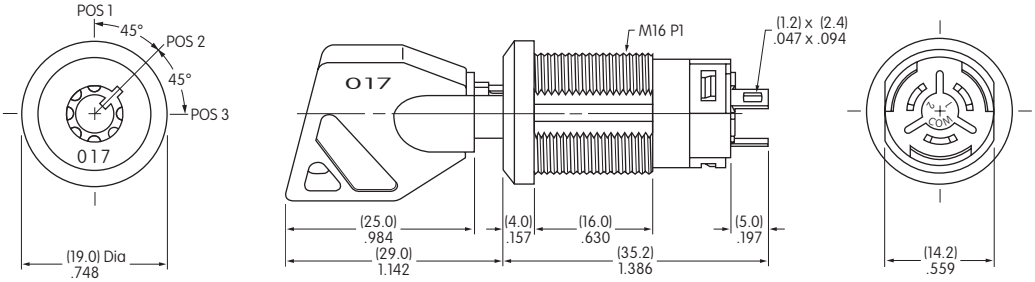
CKM12AFW01

16mm Bushing • Tubular Key

90° Angular Throw



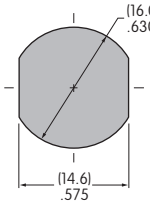
45° Angular Throw



CKM13ETW01

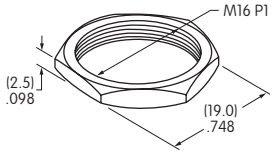
PANEL CUTOUT & STANDARD HARDWARE FOR 16MM BUSHING

Maximum Effective Panel Thickness: .469" (11.9mm)



AT016
16mm Hex Mounting Nut for CKM

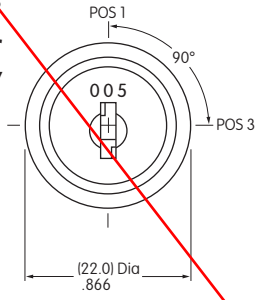
1 included with each switch
Steel

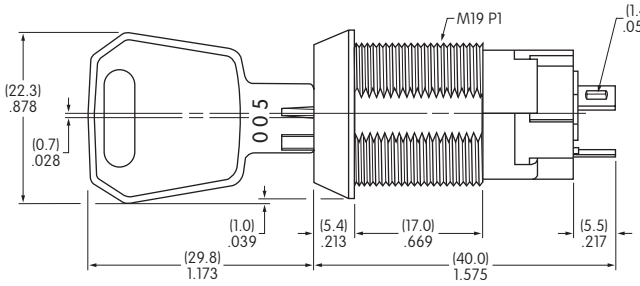


TYPICAL SWITCH DIMENSIONS

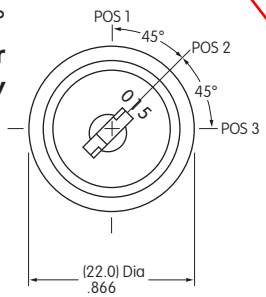
19mm Bushing • Flat Key

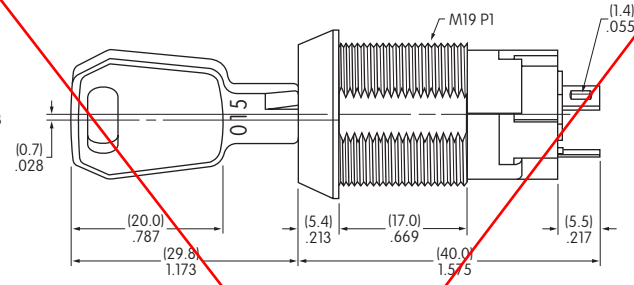
90° Angular Throw





45° Angular Throw

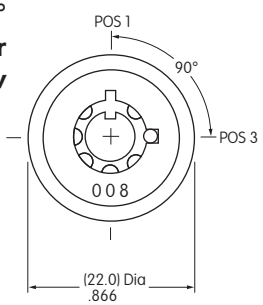


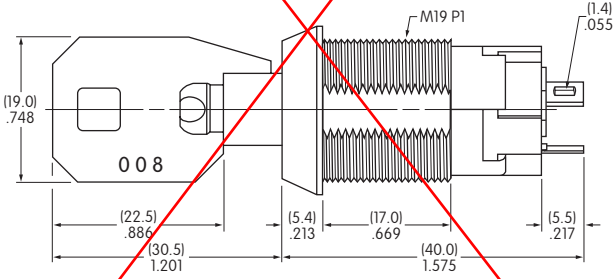


CKL12AFW01

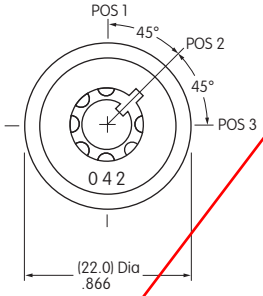
19mm Bushing • Tubular Key

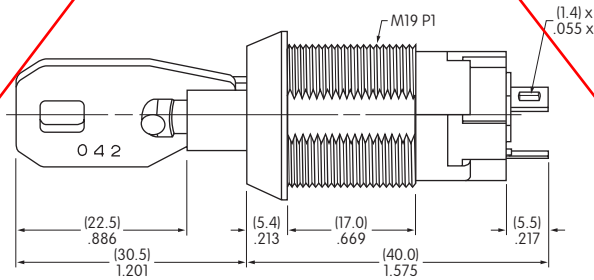
90° Angular Throw





45° Angular Throw

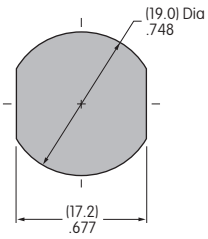




CKL13ETW01

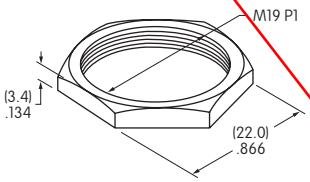
PANEL CUTOUT & STANDARD HARDWARE FOR 19MM BUSHING

Maximum Effective Panel Thickness: .496" (12.6mm)



AT019
19mm Hex Mounting Nut for CKL

1 included with each switch
Steel



VERMONT MECHANICAL INCORPORATED

P. O. Box 728
Williston, VT 05495
Ph : (802) 862-5900

Submittal

Job: DLR75-000
Delehanty Hal @ UVM
180 Colchester Ave
Burlington, VT 05405

Spec Section No: 26 2923
Submittal No: 1
Revision No: 0
Sent Date: 7/18/2015
Due Date: 7/25/2015

Spec Section Title: Variable Frequency Motor Controllers
Submittal Title: VFD's

VMI PO #: Subcontract

Contractor:
Vermont Mechanical, Inc.
Chantal Bitzer

Lead time after approval: 2 Weeks
Date items required at project:

Contractor

This submittal has been checked for general conformance with the information given in the contract documents. Final quantities, measurements, and coordination with other trades shall take place in the field.

This submittal will now go to the General Contractor, Architect, and Engineer for final approval.

Architect

Review Status

"Reviewed": Submittal has been reviewed with no comments. Item(s) may be released for procurement.

X "Reviewed As Noted": Submittal has been reviewed and comments have been provided. Item(s) may be released for procurement provided all comments are addressed by Contractor.

"Revise and Resubmit": Submittal has been reviewed and significant issues/comments have been discovered. Submittal must be revised and resubmitted prior to item(s) being released for procurement.

"Rejected": Submittal is substantially incomplete, incorrect, or otherwise does not meet the project requirements. A new submittal shall be generated and submitted for review.

Submittals have been reviewed for general compliance with contract documents, project requirements, and code requirements. This review is not intended to modify, replace, or relieve Contractor from complying with all contract documents, project requirements, and code requirements. Contractor is fully responsible for coordinating item(s) covered under this submittal with all other trades including, but not limited to, field verification of all dimensions, clearances, quantities, and utility requirements. All systems and components shall be installed in strict compliance with manufacturer's instructions.

Review Comments Compiled By:
David C. Slade - Project Manager

Engineer No Comments Provided

REVIEW COMMENTS:

1) Input and output voltage are 208VAC, 3-phase.
2) Verify with manufacturer the requirement for filters based on proposed conductor length.
3) Ensure discconencts are provided in accordance with the NEC.

YASKAWA

P1000 Industrial Fan and Pump Drive

240V Class: ¾ to 175 HP
480V Class: 1 to 1000 HP
600V Class: 2 to 250 HP

The P1000 is the next generation in Industrial Fan and Pump control, designed specifically for variable torque applications. Simple to use, intuitive, and user friendly are key features in the P1000 design. The P1000 supports a wide range of network and control options providing for the most flexible and cost-effective solution.

LCD Operator with Real Time Clock
5-line, 16-character alpha-numeric display with time and date stamping for events, along with timer controls for starting, stopping, and speed changes without the need for external controls.

Application Macros
Choose from pre-configured fan and pump setup macros to match the application for quick and easy set up.

Selectable and Custom Engineering Units
Allows for easy configuration of keypad display to match process and feedback devices such as PSI, GPM, Feet.

Underload Detection
Monitors load and will shut system down in the event of a fan belt or pump shaft breakdown.

Parameter Storage and Removable Terminal Board
Allows for easy replacement of control card without removing control wires, and stores all drive settings without the need for a copy device.

PI Process Control
Maintains a set point for closed loop control of fans and pumps for pressure, flow, or temperature regulation, and eliminates the need for a closed loop output signal from a process controller. Independent PI to control an external device in the system.

Power Quality
Built-in DC reactors (30 HP and larger) provide input harmonics benefit, and protection from input disturbances. Integrated 12 Pulse version (480V, 40 HP and larger) provides a cost-effective solution for low harmonics.

Dynamic Noise Control
Monitors the load at all times and reduces the output voltage automatically, reducing motor audible noise.

Networking Options

Industrial Communication
- Modbus RTU (built-in)
- DeviceNet
- EtherNet/IP
- Modbus TCP/IP
- PROFIBUS-DP
- PROFINET

Building Automation Networks (BAS)
- BACnet
- Lonworks
- Metasys (N2)
- Apogee (P1)

Note: All communication protocols are by option card mounted within drive.

Specifications

Overload Capacity
- 120% for 60 seconds

Output Frequency
- 0.01 to 400 Hz

Control Methods
- V/Hz Control

Enclosure Solutions
- Open Type / IP00
- NEMA Type 1 (kit required for some models)
- Flange Type (front = Open/IP00, back = NEMA Type 12)

Power Solutions
- Six Pulse (Standard)
  240V: 3/4 to 175 HP
  480V: 1 to 1000 HP
  600V: 2 to 250 HP
- Twelve Pulse (Low Harmonic)
  480V: 40 to 1000 HP

Ambient Operating Temperature
- -10°C to 40°C (14°F to 104°F)

Global Certification
- UL, CSA, CE, RoHS, C-Tick

Standard I/O
- (8) multi-function digital inputs (24Vdc)
- (3) multi-function analog inputs (0-10Vdc, 4-20 mA)
- (1) multi-function pulse input
- (1) fault relay output (form C)
- (1) multi-function relay (form C)
- (2) multi-function relay outputs (form A)
- (2) multi-function analog outputs (0 +/-10Vdc, 4-20 mA)
- Sensor feedback power supply (+24Vdc @ 150 mA supply)
- 120V converter for 8 standard digital inputs (option)

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Drives & Motion Division

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P1000 Industrial Fan and Pump Drive

240V Class: ¾ to 175 HP
480V Class: 1 to 1000 HP
600V Class: 2 to 250 HP

200-240V / 3-Phase

Model Number CIMR-PU	Rated Output Current (Amps)	HP	Dimensions (in.)		
			H	W	D
2A0004FAA	3.5	3/4	11.81	5.51	5.79
2A0006FAA	6.0	1			
2A0008FAA	8.0	2			
2A0010FAA	9.6	3			
2A0012FAA	12.0	3			6.46
2A0018FAA	17.5	5			
2A0021FAA	21.0	7.5			6.57
2A0030FAA	30.0	10			
2A0040FAA	40.0	15			
2A0056FAA	56.0	20	13.39	7.09	7.36
2A0069FAA	69.0	25	15.75	8.66	7.76
2A0081FAA	81.0	30			
2A0110FAA	110	40	21.02	10.00	10.16
2A0138FAA	138	50	24.17	10.98	
2A0169FAA	169	60	28.74	12.95	11.14
2A0211FAA	211	75			
2A0250AAA	250	100	27.76	17.72	12.99
2A0312AAA	312	125			
2A0360AAA	360	150	31.50	19.69	13.78
2A0415AAA	415	175			

380-480V / 3-Phase

Model Number CIMR-PU	Rated Output Current (Amps)	HP	Dimensions (in.)		
			H	W	D
4A0002FAA	2.1	1	11.81	5.51	5.79
4A0004FAA	4.1	2			
4A0005FAA	5.4	3			
4A0007FAA	6.9	4			6.46
4A0009FAA	8.8	5			
4A0011FAA	11.1	7.5			6.57
4A0018FAA	17.5	10			
4A0023FAA	23.0	15			
4A0031FAA	31.0	20	13.39	7.09	
4A0038FAA	38.0	25			7.36
4A0044FAA	44.0	30	15.75	8.66	7.76
4A0058FAA	58.0	40	18.31	10.00	10.16
4A0072FAA	72.0	50	20.28	10.98	
4A0088FAA	88.0	60	24.80	12.95	
4A0103FAA	103	75			
4A0139FAA	139	100	28.74		11.14
4A0165FAA	165	125			
4A0208AAA	208	150	27.76	17.95	12.99
4A0250AAA	250	200	31.50	19.84	13.78
4A0296AAA	296	250			
4A0362AAA	362	300			
4A0414AAA	414	350	37.40	19.69	14.57
4A0515AAA	515	400 - 450	44.88	26.38	
4A0675AAA	675	500 - 550			
4A0930AAA	930	600 - 800	54.33	49.21	
4A1200AAA	1200	1000			

500-600V / 3-Phase

Model Number CIMR-PU	Rated Output Current (Amps)	HP	Dimensions (in.)		
			H	W	D
5A0003FAA	2.7	1 - 2	11.81	5.51	5.79
5A0004FAA	3.9	3			
5A0006FAA	6.1	5			6.46
5A0009FAA	9.0	7.5			
5A0011FAA	11.0	10			6.57
5A0017FAA	17.5	15	13.39	7.09	7.36
5A0022FAA	22.0	20			
5A0027FAA	27.0	25	15.75	8.66	7.76
5A0032FAA	32.0	30			
5A0041FAA	41.0	40	20.28	10.98	10.16
5A0052FAA	52.0	50			
5A0062FAA	62.0	60	28.74	12.95	11.14
5A0077FAA	77.0	75			
5A0099FAA	99.0	100			
5A0125AAA	125	125	37.8	17.95	12.99
5A0144AAA	144	150			
5A0192AAA	192	200	45.98	19.84	13.78
5A0242AAA	242	250			

FREE Estimating Tools via www.yaskawa.com

- Energy Savings Predictor
- Harmonics Estimator
- Carbon Footprint Calculator

iTunes App

Energy savings app for the iPhone and the iPod touch is available at iTunes.com – search for Yaskawa.

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Schedule			Motor Data[1]			Drive Data			
Item	Qty	Tag / Equipment ID	HP	FLA	Voltage	Product ID	HP	Output Amps	Voltage
1	1	EF-4	10	23.2	230 VAC	PU2A0030FAA	10	30	230 VAC
2	1	EF-5	10	23.2	230VAC	PU2A0030FAA	10	30	230VAC

Notes: 1. AC Motor Data is per National Electrical Code Table 430.250 for typical motors used in most applications and is provided as typical data only. DC motor data is per typical industry standards. Actual motor data may vary.

Date	Customer	Job Name	P.O. / S.O.
07/15/15	UVM	DELEHANTY EF4/EF5	

Variable Frequency Drive (VFD)

P1000 Mechanical Specification Submittal

(For NEMA 1 Rated Drives)

GENERAL

The P1000 is a high performance PWM (pulse-width-modulated) AC drive. Three-phase input line power is converted to a sine-coded, variable frequency output, which provides optimum speed control of any conventional squirrel cage induction motor. The use of IGBTs (Insulated Gate Bipolar Transistors), with a carrier frequency range of 1 kHz to 15 kHz, permits quiet motor operation.

This drive has one control logic board and keypad for all horsepower ratings. Printed circuit boards employ surface mount technology, providing both high reliability, and small physical size of the printed circuit assemblies. The dual 32 bit microprocessors deliver the computing power necessary for complete three phase motor control in all variable-torque normal duty applications.

Operating Principle: Input three-phase AC line voltage is first rectified to a fixed DC voltage. Using pulse width modulation (PWM) inverter technology, the DC voltage is processed, to produce an output waveform in a series of variable-width pulses. Unique firmware algorithms optimize motor magnetization through control of voltage, current and frequency applied to generate a nearly sinusoidal output waveform.

STANDARDS

UL 508C (Power Conversion)

CSA 22.2 No. 14-10 (Industrial Control Equipment)

UL 1995 (Plenum)

CE mark 2006/95/EC LVD

CE mark 2004/108/EC

IEC 61800-5-1 (LVD)

EN 61800-3

IEC 60529

IEEE C62.41

BTL Listed (BACnet)

UL, cUL listed; CE marked

RoHS Compliant

ENVIRONMENTAL & SERVICE CONDITIONS

Ambient service temperature: -10°C to 40°C (14°F to 104°F)

Ambient storage temperature: -20°C to 60°C (-4°F to 140°F)

Humidity: 95% RH or less, non-condensing

Altitude: Up to 1000 meters (3300 feet), higher by derating

Service factor: 1.0

Vibration: 9.81m/s^2 (1 G) maximum at 10 to 20 Hz
5.9 m/s^2 (0.6 G) at 20 Hz to 55 Hz (small HP)
2.0 m/s^2 (0.2 G) at 20 Hz to 55 Hz (large HP)

Plenum mounting capable (IP20)

QUALITY ASSURANCE

In circuit testing of all printed circuit boards is conducted to ensure proper manufacturing

Final printed circuit board assemblies are functionally tested via computerized test equipment

All fully assembled controls are tested with induction motor loads to assure unit specifications are met

The average MTBF (Mean Time Between Failure) is 28 years

CONSTRUCTION

Input Section- The drive power input stage converts three-phase AC line power into a fixed DC voltage via a solid-state full wave diode rectifier with MOV (Metal Oxide Varistor) surge protection. An internal 3% DC bus reactor at ratings of greater than 30HP reduces harmonics for cleaner power (optional at smaller ratings).

Intermediate Section- The DC bus maintains a fixed, filtered DC voltage with short circuit protection as a DC supply for the drive output section. The DC bus is monitored by drive diagnostic logic circuits to continuously protect and monitor the power components.

Output Section- Insulated Gate Bipolar Transistors (IGBTs) convert DC bus voltage to a variable frequency, variable voltage PWM sine-coded AC output to the motor. Use of IGBT devices allow motor noise at 60 Hz to measure less than 2 dB (@ 1 meter) above that resulting from across the line operation.

Available NEMA 1 (IP20) wall-mounted enclosure ratings:

240VAC: 1 thru 75 HP (optional thru 150 HP)
480VAC: 1 thru 125 HP (optional thru 1000 HP)
600VAC: 1 thru 100 HP (optional thru 250 HP)

Microprocessor based control circuit uses non-volatile memory (NVRAM) so all programming data is saved when the drive is disconnected from power

Current transformers detect the output current for motor control and protective functions

Multi-language 5-line 16-character LCD operator keypad with real time clock. Provides local programming, run/stop control, monitoring, speed reference and reset commands.

Customizable display of readouts including output frequency, output voltage, output current, output power, DC bus voltage, PI feedback and fault status. Includes parameter settings copy backup function.

Built-In real time clock for time/date stamping of fault events along with timer functions for starting, stopping and speed changes without the need for external controls

Removable I/O terminal board has backup memory. All parameter changes are automatically saved to both the main control board and the I/O board. Leave I/O wiring connected when replacing a drive

Easy to remove DC voltage heat sink cooling fans with programmable on/off control

Zero side clearance mounting capability for space savings

Drive mounting with heatsink out the back of the enclosure

USB Type B port for quick and easy PC Connection

PROTECTION

Output current overload rating: 120% of drive's continuous current rating for 60 seconds

Output short circuit protection

Current limited stall prevention (overload trip prevention) during acceleration, deceleration, and run conditions

Optically isolated operator keypad controls

Fault display with time stamp storage of last 10 faults

Motor hunting prevention function

Electronic ground fault protection

Electronic thermal motor overload protection (UL approved)

DC bus charge indication

Heat sink over temperature protection

Cooling fan operation hours monitor

Input/output phase loss protection

Reverse prohibit function

Short circuit withstand rating of 100K amps RMS

OPERATION

Over 100 programmable functions with resettable factory fan and pump presets

User parameter settings initialization for re-establishing project specific parameter settings

Output frequency and speed display can be programmed for speed-related and control indications including: Hz, RPM, % or custom units

Power loss ride-thru (2 seconds capable)

Time delay on start, peak avoidance

Drive accepts either a direct acting or a reverse acting speed command signal

Bi-directional speed search capability allows starting into a rotating load. Two types: current detection and residual voltage detection

DC injection braking prevents fan wind milling at motor start

Ramp-to-stop or coast-to-stop selection

Auto restart capability: 0 to 10 attempts with adjustable delay time between attempts

One custom selectable Volts/Hertz pattern and multiple preset Volts/Hertz patterns

Analog speed reference signals have adjustable bias and gain

Automatic energy savings, reduced voltage operation

While the drive is running, operational changes in control and display functions are possible including:

Frequency reference command
Start/stop commands
Acceleration time (0 to 6000 seconds)
Deceleration time (0 to 6000 seconds)
Monitor displays
Remove the operator keypad

PRODUCT FEATURES

Displacement power factor: 0.98 throughout the motor speed range

Drive efficiency: 96% at half-speed; 98% at full-speed

Starting torque capability: 150% from 3 Hz

Speed control range: 40:1

Carrier frequency: adjustable from 1 kHz to 15 kHz

Input phase insensitive; sequencing of the three phase input is unnecessary

Voltmeter, ammeter, kilowatt meter, elapsed run time meter and heatsink temperature monitoring functions

Two internal (PI) Controls

1. Drive internal PI closed loop control with selectable engineering units
2. Independent PI control of external devices

Differential PI feedback feature

Sleep function in both closed loop and open loop control

Feedback signal low pass filter

Feedback signal loss detection with selectable response

Feedback signal inverse capability

Feedback transmitter power supply: 24 VDC, 150 mA

Input and output terminal status monitors

Diagnostic fault/alarm indicators with dedicated contacts

S-curve soft start / soft stop capability

Network communication loss detection with selectable response

Up/down motor operated pot (MOP) floating point control

17 preset speeds

Critical frequency rejection capability: 3 selectable, adjustable bandwidths

Dynamic noise control function for quiet motor operation

Programmable security code for operator keypad lockout

Run/stop command methods:

- Terminal strip (2-wire or 3-wire)
- Network communication
- Operator keypad

Speed reference (speed command) methods:

- 0 to 10 VDC or -10 to 10 VDC (20 kΩ)
- 4 to 20 mA or 0 to 20 mA (250 Ω)
- 0 to 32 kHz pulse train
- Network communication
- Operator keypad

Eight programmable multi-function digital input terminals (24 VDC, sinking or sourcing, internal/external power supply) providing 60+ programmable functions including:

- Multi-step speed references
- Jog commands
- PID control enable/disable

Three programmable multi-function digital output terminals (2 Form-A and 1 Form-C relays, 1 A @ 250 VAC / 30 VDC) providing 50+ functions including:

- During run
- Drive ready
- Speed agree
- No load detection (broken belt/shaft alert)

One fixed Fault output relay (Form-C, 1 A @ 250 VAC / 30 VDC)

Three programmable multi-function analog input terminals (individually selectable for 0 to 10 VDC, -10 to 10 VDC, 4 to 20 mA, or 0 to 20 mA) providing 15+ functions including:

- Frequency reference
- PID setpoint
- PID feedback

Two programmable multi-function analog output terminals (individually selectable for 0 to 10 VDC, -10 to 10 VDC, or 4 to 20 mA) providing 20+ functions including:

Output Frequency
Output Current
Output Power

One programmable multi-function pulse train input terminal (0 to 32 kHz) providing several functions including:

Frequency reference
PID setpoint
PID feedback

1 fixed Fault output relay (Form-C, 1 A @ 250 VDC / 30 VDC)

1 built-in RS-422/485 115.2 kbps Modbus/Memobus network communication port

Stationary and rotational motor auto-tuning

Overexcitation braking function stops the motor in up to half the normal time

Motor preheat function

Upgradeable Drive firmware via PC program

Customizable operator keypad monitor display

Heat sink over temperature speed fold-back feature

Bumpless transfer between local and remote modes

Fan failure detection and selectable response

OPTIONS

Analog output option card provides 3 additional outputs

Network communication option cards include: DeviceNet, EtherNet/IP, Modbus TCP/IP, PROFIBUS-DP, PROFINET, EtherCAT, BACnet, LonWorks, Metasys (N2), Apogee FLN (P1) and MECHATROLINK-II

Auxiliary control power module

120 VAC digital input interface card

Remote operator mounting kit (UL Type 1, 4, 4X, 12)

DriveWizard PC software for programming and monitoring

Energy savings and harmonic prediction software

Integrated 12-pulse version (480 V, 40 HP and larger) provides a cost-effective solution for low harmonics

Code No. LIT-1927140
Issued November 13, 2015

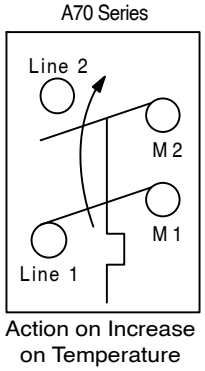
A70 Series Four-Wire, Two-Circuit Temperature Control

Description

The A70 Series Temperature Control incorporates a vapor-charged sensing element. The A70G, A70H, and A70K have a four-wire, two-circuit contact block that contains two isolated sets of contacts.

The contacts are designed so that when the main contact opens, the auxiliary contact closes.

Refer to the *A70, A72 Series Temperature Controls for Refrigeration and Heating Product Bulletin (LIT-125155)* for important product application information.



A70 Series Action Diagram

A70GA-1 Temperature Control

Features

- long-life, snap-acting contacts
- automatic or manual reset models

Applications

Typical applications include energizing an indicator light after a low temperature cutout on a ventilating system.

Selection Charts

A70 Series Four-Wire, Two-Circuit Temperature Control

Product Code Number	Switch Action		Range °F (°C)	Differential F° (C°)	Bulb and Capillary	Maximum Bulb Temperature °F (°C)	Range Adjuster
	Main Contacts	Auxiliary Contacts					
A70GA-1C[1]	Open low	Close low	15 to 55 (-9.4 to 12.8)	5 (2.8)	20 ft of 1/8 in. O.D. tubing	400 (204.4)	Screwdriver slot
A70GA-2C			35 to 80 (1.7 to 26.7)	3 to 30 (-16.1 to -1.1), factory set at 12 (-11.1)	3/8 in. x 3 in. 6 ft capillary	250 (121)	
A70HA-1C[1]			15 to 55 (-9.4 to 12.8)	Manual reset	20 ft of 1/8 in. O.D. tubing	400 (204.4)	
A70HA-2C			35 to 80 (1.7 to 26.7)		3/8 in. x 3 in. 6 ft capillary	250 (121)	
A70HA-14C			15 to 55 (-9.4 to 12.8)		20 ft of 1/8 in. O.D. tubing	400 (204.4)	
A70KA-1C	Open high	Close high	100 to 170 (37.8 to 76.7)		3/8 in. x 3 in. 6 ft capillary	240 (116)	

1. On these models, the low cutout stop is set and sealed at 35°F (1.6°C). It cannot be set lower. The control responds only to the lowest temperature along any 14 to 16 in. section of the entire 20 ft element.

Replacement Covers

Product Code Number	Description
CVR17A-620R	Automatic reset cover
CVR17A-621R	Manual reset cover

Technical Specifications

Electrical Ratings

Pole Number	LINE-M2 (Main)						LINE-M1 (Auxiliary)			
Motor Ratings VAC	**120**	**208**	**240**	**277**	**480**[1]	**600**[1]	**120**	**208**	**240**	**277**
AC Full Load A	16.0	9.2	8.0	—	5.0	4.8	6.0	3.4	3.0	—
AC Locked Rotor A	96.0	55.2	48.0	—	30.0	28.8	36.0	20.4	18.0	—
AC Non-Inductive A	16.0	9.2	8.0	7.2	—	—	6.0	6.0	6.0	6.0
Pilot Duty – Both Poles	125 VA, 120 to 600 VAC and 57.5 VA, 120 to 300 VDC									

1. Not compressor motor loads.

Model 267

Very Low Differential Pressure Transducer

Setra's Model 267 is the most rugged high accuracy, low differential pressure transducer on the market. It delivers accuracies of ±0.25%, 0.4%, 0.5% and ±1% FS and pressure ranges from 0.1" W.C. up to 100" W.C. The 267 is housed in a robust, NEMA 4 rated enclosure and has an optional static pressure probe reducing installation and material costs. The 267 is offered with an optional LCD display and a standard accuracy of ±0.5% making it ideal for high accuracy Pharmaceutical applications.

Customization is Standard

The 267, unlike most competitors, offers many mechanical and electrical options that can be integrated into existing designs. The optional 0.25" diameter pressure probe is made of sturdy extruded aluminum and is designed with baffles to prevent velocity pressure errors which saves money and reduces time on the job site.

Robust Enclosure for Difficult Applications

The 267 is housed in a NEMA 4 rated housing and is built to withstand harsh environments. The 267 is available in both wall and duct mount providing the installer with flexible mounting options. The wall mount allows the sensor to be installed anywhere, whereas the duct probe configuration is designed to maximize space efficiency in difficult applications.

The Setra Sensor

The core technology of the 267 is the all stainless steel capacitive sensing element. Setra designs and manufactures all of their sensing elements resulting in full control over the process and quality of every single sensor. The welded dead-ended capacitive sensors requires minimal amplification and delivers excellent accuracy and longterm stability. Setra's technology has been used in over 8 million installations and has the highest field acceptance rate in the industry.

- **±0.25%, 0.4%, 0.5%, 1% FS Accuracy**
- **Suitable for Harsh Environments**
- **Optional LCD Display**

Model 267 Features:

- 0.1" W.C. up to 100" W.C. Pressure Ranges
- Optional 3.5 Digit LCD Display w/ 0.5% FS Accuracy
- NEMA 4 Rated Housing
- PG-9, PG-13 or Conduit Electrical Termination
- Integral Static Pressure Probe
- 24 VAC or 24 VDC Excitation
- Meets CE Conformance Standards

Applications:

- HVAC Systems
- Energy Management Systems
- Static Duct Pressure
- Cleanroom Pressure
- Oven Pressurization & Furnace Draft Controls

Phone: 800-257-3872 • Fax: 978-264-0292 • setra.com

Model 267

Very Low Differential Pressure Transducer

ORDERING INFORMATION

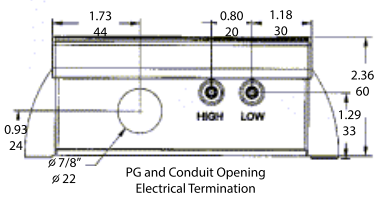
2 6 7 1 – ☐☐☐☐☐ – ☐☐ – ☐☐ – ☐ – ☐

Model	Range								Output		Pressure Fitting/Elec. Termination		Accuracy (Full Scale)		Display	
2671 = 267	Unidirectional		Bidirectional		Unidirectional		Bidirectional		11	4-20 mA	3/16" Barbed Brass Fitting		C	±1% FS	D	LCD
	0R1WD	0 to 0.1 "W.C.	0R1WB	±0.1"W.C.	025LD	0 to 25 Pa	025LB	±25 Pa	2D	0-5 VDC	G1	PG-13.5 Strain Relief	E	±0.4% FS*	N	None
	R25WD	0 to 0.25"W.C.	R25WB	±0.25"W.C.	050LD	0 to 50 Pa	050LB	±50 Pa	2E	0-10 VDC	G2	PG9 Strain Relief	F	±0.25% FS*		
	0R5WD	0 to 0.5"W.C.	0R5WB	±0.5"W.C.	100LD	0 to 100 Pa	100LB	±100 Pa			D9[1]	9 pin D-Sub Conn.	G	±1% FS*		
	001WD	0 to 1"W.C.	001WB	±1.0"W.C.	250LD	0 to 250 Pa	250LB	±250 Pa			A1	1/2" Conduit Opening	H	±0.5% FS*		
	1RSWD	0 to 1.5"W.C.	1RSWB	±1.5"W.C.	500LD	0 to 500 Pa	500LB	±500 Pa			1/4"NPTF Brass Fitting					
	2R5WD	0 to 2.5"W.C.	2R5WB	±2.5"W.C.	10CLD	0 to 1000 Pa	10CLB	±1000 Pa			1K	PG-9 Strain Relief				
	005WD	0 to 5.0"W.C.	005WB	±5.0"W.C.	25CLD	0 to 2500 Pa	25CLB	±2500 Pa			2K	PG-13.5 Strain Relief				
	010WD	0 to 10"W.C.	010WB	±10"W.C.	40CLD	0 to 4000 Pa	40CLB	±4000 Pa			9K	9 Pin D-Sub Conn.				
	025WD	0 to 25"W.C.	025WB	±25"W.C.	70CLD	0 to 7000 Pa	70CLB	±7000 Pa			AK	1/2" Conduit Opening				
	050WD	0 to 50"W.C	050WB	±50"W.C.							Static Duct Probe					
	100WD	0 to 100"W.C.	100WB	±100"W.C.							1P	PG-9 Strain Relief				
											2P	PG-13.5 Strain Relief				
											9P	9 Pin D-Sub Conn..				
											AP	1/2" Conduit Opening				

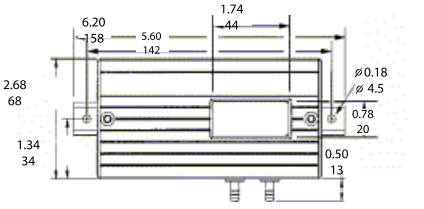
*includes Cal Cert.

Ordering Example: Part No. 2671R25WD11G2CD for a 0 to .25 in. WC Unidirectional Range, 4-20 mA Output, 3/16" Barbed Brass Fitting, PG-9 Electrical Termination, 1% Accuracy with LCD Display

DIMENSIONS

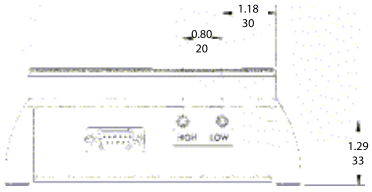


PG and Conduit Opening
Electrical Termination

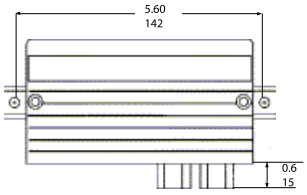


LCD available as an Option
on Model 267 only.

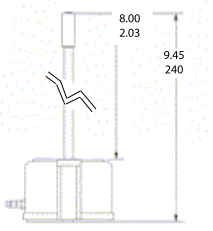
3/16" O.D. PRESSURE FITTING FOR
1/4" PUSH-ON TUBING



9 pin D-sub Connector
Electrical Termination



1/4" NPT Brass Fitting



Static Duct Probe

GENERAL SPECIFICATIONS

Performance Data				Physical Description	
	Standard	Optional		Case	IP65/NEMA 4 Plastic Glass-Filled Polycarbonate UL94V-0 Case
Accuracy RSS[1] (at constant temp)	±1.0% FS	±0.4% FS	±0.25% FS	Electrical Connection	Screw Terminal Strip Inside of Case
Non-Linearity, BFSL	±0.98% FS	±0.38% FS	±0.22% FS	Electrical Terminations	PG-9/PG13.5 Strain Relief, 1/2" Conduit Opening, or 9 Pin D-Sub Connector*
Hysteresis	±0.10% FS	±0.10% FS	±0.10% FS	Zero and Span Adjustments	Accessible Inside of Case
Non-Repeatability	±0.05% FS	±0.05% FS	±0.05% FS	Weight (approx.)	9.0 Ounces (255 grams) 9.5 Ounces (Duct Probe Assembly)
Position Effect: Consult factory				**Electrical Data (Current)**	
Pressure Media				Circuit	2-Wire, Protected from Miswiring
Thermal Effects[2,3]				Output[7]	4 to 20 mA[4]
Compensated Range °F (°C)	+40 to +150 (+5 to +65)			Bidirectional Output at Zero	12 mA
Zero/Span Shift %FS/°F (°C)	±0.033 (±0.06)			Min. Loop Supply Voltage (VDC)	9 + 0.02 x (Resistance of Receiver plus line)
Maximum Line Pressure	10 PSI			Max. Loop Supply Voltage (VDC)	30 + 0.004 x (Resistance of Receiver plus line)
Overpressure	Up to 10 PSI (Range Dependant)			**Electrical Data (Voltage)**	
Long-Term Stability	0.1% FS Total			Circuit	3-Wire (Exc, Gnd, Sig), Protected from Miswiring
Environmental Data				Excitation (for 0-5 VDC Output)	9 to 30 VAC /12 to 40 VDC
Operating[6] Temperature °F (°C)	0 to +150 (-18 to +65)			Excitation (for 0-10 VDC Output)	11 to 30 VAC /13 to 40 VDC
Storage Temperature °F (°C)	-65 to +180 (-54 to +82)			Output[3]	0 to 5 VDC[5] / 0 to 10 VDC[5]

[1] RSS of Non-Linearity, Hysteresis, and Non-Repeatability.
[2] Units calibrated at nominal 70°F. Maximum thermal error computed from this datum.
[3] Calibrated into a 50K ohm load, operable into a 5000 ohm load or greater.
[4] Zero output factory set to within ±0.16 mA (±0.08 mA for optional accuracies). Span (Full Scale) output factory set to within ±0.16 mA (±0.08mA for optional accuracy).
[5] Zero output factory set to within ±50mV (±25 mV for optional accuracies). Span (Full Scale) output factory set to within ±50mV (±25 mV for optional accuracies)
[6] Operating temperature limits of the electronics only. Pressure media temperatures may be considerably higher.
[7] Calibrated at factory with a 24 VDC loop supply voltage and a 250 ohm load.

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AFBUP N4, AFBUP-S N4, AFXUP N4, AFXUP-S N4

NEMA 4, On/Off, Spring Return, 24 to 240 VAC

Torque min. 180 in-lb, for control of air dampers

Application

For On/Off, fail-safe control of dampers in HVAC systems. Actuator sizing should be done in accordance with the damper manufacturer's specifications. Control is On/Off from an auxiliary contact, or a manual switch.

The actuator is mounted directly to a damper shaft up to 1.05" in diameter by means of its universal clamp. A crank arm and several mounting brackets are available for applications where the actuator cannot be direct coupled to the damper shaft.

Operation

The AFB N4 and AFX N4 series actuators provide true spring return operation for reliable fail-safe application and positive close off on air tight dampers. The spring return system provides constant torque to the damper with, and without, power applied to the actuator.

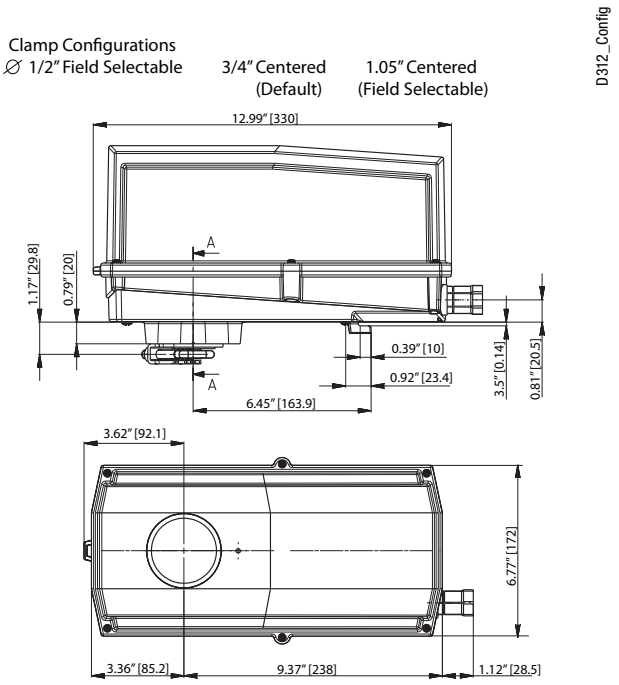
The AFB N4 and AFX N4 series provides 95° of rotation and is provided with a graduated position indicator showing 0° to 95°.

The actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches.

The AFBUP-S N4, AFXUP-S N4 versions are provided with two built-in auxiliary switches. These SPDT switches provide safety interfacing or signaling, for example, for fan start-up. The switching function at the fail-safe position is fixed at +10°, the other switch function is adjustable between +10° to +90°.

Technical Data	AFBUP N4, AFBUP-S N4, AFXUP N4, AFXUP-S N4
Power supply	24...240 VAC -20% / +10%, 50/60 Hz 24...125 VDC ±10%
Power consumption running	7 W
holding	3.5 W
Transformer sizing	7 VA @ 24 VAC (class 2 power source) 8.5 VA @ 120 VAC 18 VA @ 240 VAC
Electrical connection AFBUP... N4	3 ft, 18 GA appliance cable, 1/2" conduit connector **-S models:** Two 3 ft, 18 gauge appliance cables with 1/2" conduit connectors
AFXUP... N4	3 ft [1m], 10 ft [3m] or 16 ft [5m] 18 GA appliance cable, with or without 1/2" conduit connector **-S models:** Two 3 ft [1m], 10 ft [3m] or 16 ft [5m] appliance cables with or without 1/2" conduit connectors
Overload protection	Electronic throughout 0 to 95° rotation
Control	On/Off
Torque	180 in-lb [20 Nm] minimum
Direction of rotation spring	reversible with CW/CCW mounting inside housing
Mechanical angle of rotation	95° (adjustable with mechanical end stop, 35° to 95°)
Running time motor	< 75 sec
spring	20 sec @ -4°F to 122°F [-20°C to 50°C]; < 60 sec @ -22°F [-30°C]
Position indication	visual indicator, 0° to 95° (0° is full spring return position)
Manual override	5 mm hex crank (3/16" Allen), supplied
Humidity	max. 95% RH non-condensing
Ambient temperature	-22°F to 122°F [-30°C to 50°C]
Storage temperature	-40°F to 176°F [-40°C to 80°C]
Housing	UL Type 4, NEMA 4, IP66
Housing material	polycarbonate
Agency listings †	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2004/108/EC & 2006/95/EC
Noise level	<50dB(A) motor @ 75 seconds ≤62dB(A) spring return
Servicing	maintenance free
Quality standard	ISO 9001
Weight	9.7 lbs (4.4 kg), 10 lbs (4.5 kg) with switches
† Rated Impulse Voltage 4kV, Type of action 1.AA (1.AA.B for -S version), Control Pollution Degree 4.	
AFBUP-S N4, AFXUP-S N4	
Auxiliary switches	2 x SPDT 3A (0.5A) @ 250 VAC, UL Approved one set at +10°, one adjustable 10° to 90°

Dimensions (inches [mm])



AFBUP N4, AFBUP-S N4, AFXUP N4, AFXUP-S N4

NEMA 4, On/Off, Spring Return, 24 to 240 VAC

Accessories

Tool-06	8mm and 10 mm wrench
43442-00001	Gland (needed for additional wires)
11097-00001	Gasket for Gland (needed for additional wires)

NOTE: When using AFBUP N4, AFBUP-S N4, AFXUP N4, AFXUP-S N4 actuators, only use accessories listed on this page.
For actuator wiring information and diagrams, refer to Belimo Wiring Guide.

Typical Specification

On/Off spring return damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a jackshaft up to a 1.05" diameter. The actuators must be designed so that they may be used for either clockwise or counterclockwise fail-safe operation. Actuators shall be protected from overload at all angles of rotation. If required, two SPDT auxiliary switch shall be provided having the capability of one being adjustable. Actuators with auxiliary switches must be constructed to meet the requirements for Double Insulation so an electrical ground is not required to meet agency listings. Actuators shall be cULus Approved and have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards. Actuators shall be as manufactured by Belimo.

Wiring Diagrams

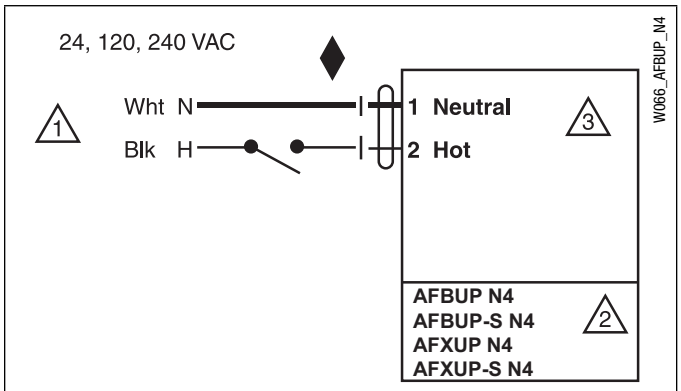
INSTALLATION NOTES

1. Provide overload protection and disconnect as required.
2. ***CAUTION** Equipment Damage!*
   Actuators may be connected in parallel.
   Power consumption and input impedance must be observed.
3. No ground connection is required.
4. For end position indication, interlock control, fan startup, etc.,
   AFBUP-S N4, AFXUP-S N4 incorporates two built-in auxiliary switches: 2 x SPDT, 3A (0.5A) @250 VAC, UL Approved, one switch is fixed at +10°, one is adjustable 10° to 90°.

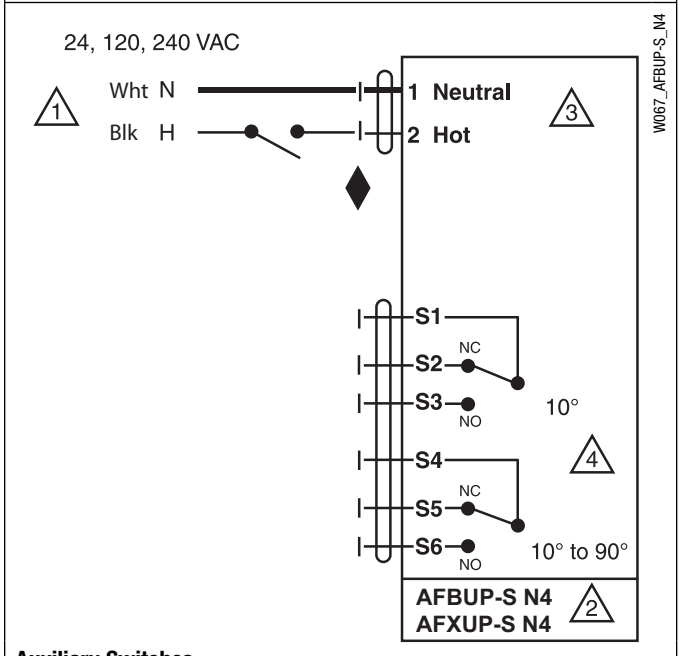
APPLICATION NOTES

- Meets cULus requirements without the need of an electrical ground connection.

***WARNING** Live Electrical Components!*
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



On/Off wiring



Auxiliary Switches

SECTION 23 05 93

AIR SYSTEMS TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.1 SUMMARY

A. Section includes performing balancing and adjusting of heating, ventilating, and air conditioning equipment and associated appurtenances.
   1. Adjust and balance complete system as specified herein.
   2. Record test data on drawings made from latest available revised set of Drawings.
   3. At completion of Work, instruct operating personnel in proper operation and maintenance of equipment.

1.2 REFERENCES

A. Industry Standard: Perform testing and balancing in accordance with AABC National Standards for Field Measurement and Instrumentation, form number 81266, Volume One.

B. Perform testing of the performance of laboratory fume hoods in accordance with ANSI/ASHRAE Standard 110 – Method of Testing Performance of Laboratory Fume Hoods.

1.3 SYSTEM DESCRIPTION

A. General extent of systems to be balanced is shown on Drawings. Work includes:
   1. Baseline readings of Lab supply air and exhaust air systems including air handling unit, exhaust fans, terminal units, and pressure relationships between the lab spaces as indicated on the drawings prior to any system modifications.
   2. Following system modifications, perform testing, adjusting and balancing of supply and exhaust air systems to achieve airflows, velocities, and pressure relationships to match the baseline readings with the exception of one fume hood. The fume hood in the high level lab must be adjusted in accordance with manufacturer's specifications.
   3. Performance testing of Lab fume hoods in accordance with ANSI/ASHRAE Standard 110.
   4. Provide assistance during commissioning of control system modifications to help determine control system setpoints for various modes of operation including system responses to failure scenarios and a reduced flow "hibernation" mode for the Lab.

1.4 SUBMITTALS

A. Refer to the Submittal Schedule at the end of Part 3 for a list of Submittal requirements for this Section.

1.5 QUALITY ASSURANCE

A. Perform Work to obtain optimum performance from systems.

1.6 QUALIFICATIONS

A. Qualifications of Balancing Specialist:
   1. Organization whose sole activity is testing, adjusting, and balancing environmental systems.
   2. Organization utilizing only employees experienced and trained specifically in complete balancing of environmental systems.
   3. Organization that has satisfactorily balanced minimum of three systems of comparable type and size.
   4. Organization certified by AABC or NEBB.

1.7 WARRANTY

A. Upon completion of Work and prior to requesting payment, guarantee systems have been balanced to:
   1. Tolerances as described in this Section.
   2. Lowest sound and vibration levels possible.
   3. Lowest energy consumption level possible.

B. Rebalancing: Rebalance environmental systems found outside of criteria specified at no additional cost. This shall include the Lab Hoods if they fail to pass the ANSI/ASHRAE Standard 110 testing.

PART 2 PRODUCTS

2.1 MATERIALS

A. Provided materials, supplies, tools, equipment, labor, and services necessary for balancing, testing, and adjusting Work.

B. Ensure test equipment used in balancing Work has been calibrated within previous 3 months.

PART 3 EXECUTION

3.1 ASSOCIATED WORK

A. System changes required prior to final balance, as determined by initial system check, performed by entity responsible for furnishing and installing that particular system.

3.2 AIR SYSTEM TESTING AND BALANCING TOLERANCES

A. Supply and Exhaust Fans: Plus 10 to minus 5 percent of design flow as shown on Drawings.

B. Air Outlets and Inlets: Plus 10 to minus 5 percent of design flow as shown on Drawings.

3.3 GENERAL PROCEDURES

A. Coordinate any work required within the Lab spaces with the Owner. Balancing personnel working within the Lab must be escorted at all times by the Owner and follow protocol as directed by the Owner.
   1. Personnel working in the Lab areas must where clean overalls and boot covers.
   2. Ceiling tiles cannot be removed in any lab space with the exception of the Vestibule.
   3. The owner must be present for movement of any ceiling tiles.

B. Minimize insulation cuts for installation of test probes. Upon completion of testing, adjusting, and balancing, patch insulation with new materials matching existing. Restore vapor retarder and finish to match existing.

C. Seal ductwork test holes with metal or plastic snap-in plugs.

D. Mark equipment settings with paint or other suitable permanent identification material to indicate final settings.

3.4 SYSTEM PREPARATION

A. Determine optimum locations in main and branch ductwork for accurate air flow measurement.

B. Locate start and stop switches, variable frequency drives, disconnect switches, electrical interlocks, and motor starters.

C. Verify that motor starters and variable frequency drives are equipped with properly sized thermal protection.

D. Check dampers for proper position to achieve desired air flow path.

E. Check ductwork for air flow blockages.

F. Check air handling unit condensate drains for proper connection and function.

G. Check for proper sealing of air handling components.

3.5 LABORATORY FUME HOOD PERFORMANCE TESTING PROCEDURE

A. Provide performance testing of each of the five laboratory fume hoods in accordance with ANSI/ASHRAE Standard 110 – Method of Testing Performance of Laboratory Fume Hoods.

B. Tests shall include:
   1. Flow visualization
   2. Face velocity measurements
   3. Tracer gas containment “as used” (AU) test

C. Testing criteria:
   1. Design sash position = 10 inch (verify maximum safe working sash opening)
   2. Provide test results at 5 inch also.
   3. Minimum face velocity at design sash position = 100 fpm.

3.6 CONSTANT VOLUME AIR SYSTEM BALANCING PROCEDURE

A. Examine fan drives and set proper belt tension and alignment.

B. Adjust fans to deliver total design air flow within maximum allowable rpm listed by manufacturer.

C. Determine fan static pressure as follows:
   1. Measure outlet static pressure as far downstream as practicable and upstream from restrictions, elbows, branches, and transitions.
   2. Measure outlet static pressure directly at fan outlet or through flexible connection.
   3. Measure inlet static pressure for single inlet fans in inlet duct as near fan as possible, upstream from flexible connection and downstream from duct restrictions.

D. Measure static pressure differential across each air handling unit component and each component in ductwork system.

E. Artificially load air filters during balancing to produce air pressure differential midway between initial clean pressure drop and recommended final pressure drop. Submit method and material used for artificial loading to Owner and Engineer for approval prior to testing.

F. Determine variations between design static pressures and actual static pressures. Compare actual system effect factors with design system effect factors. Make corrective changes to align design and actual conditions.

G. Measure system air volume delivery rates by means of duct traverse method.

H. Adjust fans speeds to achieve design air flow rates. Ensure that fan speed adjustments do not overload motors.

I. Adjust volume dampers for main ductwork, submains, and major branches to design air flows within specified tolerances.

J. Where sufficient space for pitot tube traverse is not available, measure air flow at terminal devices to calculate air flow for that branch.

K. Measure terminal outlets using direct reading hood or outlet manufacturer's written instruction and calculating factors.

L. Adjust terminal outlets and inlets for each space to design air flows within specified tolerances of design values.

M. Adjust patterns of adjustable outlets for proper distribution without drafts.

N. Ensure that total flow from outlets equals total flow in branch ducts which in turn equal total flow from fan.

O. Ensure that automatic operated devices pertinent to adjustment of air system are set and adjusted to deliver required quantities of air at temperatures specified and shown on Drawings. Coordinate adjustment of automatic control devices with controls specialist.

3.7 MOTORS

A. Test at final balanced condition and record following data:
   1. Manufacturer.
   2. Model.
   3. Serial number.
   4. Motor rpm.
   5. Efficiency rating.
   6. Nameplate and measured voltage for each phase.
   7. Nameplate and measured amperage for each phase.
   8. Starter thermal protection element rating.

B. Provide following additional tests for motors driven by variable frequency drives:
   1. Test for proper operation at speeds varying from minimum to maximum.
   2. Test manual bypass (if applicable) for controller to prove proper operation.
   3. Record following Variable Frequency Motor Controller information:
      a. Manufacturer.
      b. Model.
      c. Serial number.
      d. Nameplate data.

3.8 TEMPERATURE AND HUMIDITY CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between setpoints and actual measurements.

D. Verify operation of limiting controllers.

E. Verify free travel and proper operation of control devices.

F. Verify sequence of operation of control devices.

3.9 SUBMITTAL SCHEDULE

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
23 05 93-01	Upon completion of balancing Work, submit complete report consisting of data sheets covering phases of Work specified herein.		Before date of Substantial Completion
23 05 93-02	Provide single line drawings to same scale as design drawings on same size sheets, depicting significant deviations from original design, designated as "Corrected Balancing and Adjusting Drawings".		With record documents
23 05 93-03	Sign reports by person in charge of on-site Work.		With record documents
23 05 93-04	Provide 8-1/2" x 11" forms for loose-leaf binding, with blanks for listing of required test ratings and for certification of report. The complete final report shall also be provided in electronic PDF format.		Before date of Substantial Completion

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
23 05 93-05	System Report Data: 1. Fans: a. Manufacturer, model, and nameplate horsepower. 2. Amperage: a. Nameplate. b. Corrected full load. 3. Operating Voltage: a. Design. b. Operating. c. Motor current characteristics. 4. Speed: a. Design. b. Operating. 5. Brake horsepower: a. Design. b. Operating. 6. Air flow (cfm): a. Design. b. Operating. 7. Suction and discharge static pressures (inches w.c.): a. Design. b. Operating. c. Test methods for determining air flow rates.		Before date of Substantial Completion
23 05 93-06	System Report Data: Systems External to Fans: 1. Grille, register, or diffuser reference number and location. 2. Design velocity and cfm. 3. “K” factor.		Before date of Substantial Completion

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
23 05 93-07	System Report Data: Chilled Water Cooling Coils: 1. Coil face area, rows, and fins/inch. 2. Entering and leaving air condition (Fdb/Fwb). 3. Air velocity through coil (fpm). 4. Coil static pressure drop (inches w.g.).		Before date of Substantial Completion
23 05 93-08	System Report Data: Hot Water Heating Coils: 1. Coil face area, rows, and fins/inch. 2. Entering and leaving air condition (Fdb). 3. Air velocity through coil (fpm). 4. Coil static pressure drop (inches w.g.).		Before date of Substantial Completion
23 05 93-09	System Report Data: Lab Fume Hoods: 1. Report documenting results of Lab Fume Hood testing per ANSI/ASHRAE Standard 110. 2. Results of flow visualization tests. 3. Fume Hood face velocity measurements including grid point velocity readings and the average of the integrated readings for each fume hood for both 5” and 10” sash positions. 4. Results of tracer gas tests including the “as used” (AU) performance rating for each hood for both 5” and 10” sash positions. w.g.).		Before date of Substantial Completion
23 05 93-10	Test Equipment: Submit complete list of test equipment used in performing balancing Work complete with serial numbers and verification of latest calibration date.		Prior to delivery

END OF SECTION

SECTION 23 34 16

CENTRIFUGAL FANS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes requirements necessary to furnish and install the following fans:
   1. Centrifugal Fans.

B. Related Sections:
   1. Section 40 05 15 – Basic Mechanical Requirements.

1.2 PERFORMANCE REQUIREMENTS

A. Provide equipment as indicated on the Equipment Data sheet.

1.3 SUBMITTALS

A. Refer to the Submittal Schedule at the end of Part 3 for a list of submittal requirements for this section.

1.4 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210.

B. Sound Ratings: AMCA 301, tested to AMCA 300.

C. Balance Quality: Conform to AMCA 204.

1.5 WARRANTY

A. Warrant that materials, equipment, and components supplied will meet specified performance requirements and be free of improper workmanship, faults, leaks, or defects for not less than 1 year after acceptance of equipment by Owner or 18 months after shipment, whichever occurs first. Extend warranty for a period of 1 year for specific repairs made or parts replaced during the initial warranty period.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive and inspect fans for damage and shortage at Project Site.

B. Unload fans carefully to avoid damage.

C. Use padded or strap slings.

D. Lift fans only at points recommended by manufacturer.

E. Store fans in safe, dry location.

PART 2 PRODUCTS

2.1 GENERAL

A. The following criteria apply to fans specified in this Section:
   1. Belt and Shaft Guards: Provide OSHA approved guards where required for compliance.
   2. Motors:
      a. Selection: Provide fan motors rated for at least 110 percent greater horsepower than the required brake horsepower.
      b. Provide motor type as indicated on the Equipment Data Sheet.
   3. Bearings: Oversized, heavy-duty, grease-lubricated, pillow block ball bearings, selected for average life (ABMA 9 L_{10}) of not less than 100,000 hours, with extended lube lines.
   4. Belt Drives:
      a. Belt Drive Package: V-belt type, cast iron or steel sheaves, statically and dynamically balanced, keyed, rated for 120 percent of motor nameplate horsepower. Variable and adjustable pitch sheaves for motors 15 hp and under, selected so required rpm is obtained with sheaves set at mid-position, matched belts.
      b. Acceptable Manufacturers:
         1) Woods.
         2) Browning.
      c. Belt and Shaft Guard: Easily removable, OSHA approved with bright yellow finish.
      d. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.
      e. Provide speed test openings at shaft locations.
   5. Vibration Isolation: Provide rubber-in-shear vibration isolation.
   6. Access Doors: Provide access doors on the fan housings for inspection of internal components.

B. Fan Bearings:
   1. Select bearings in accordance with standards set forth by the American Bearing Manufacturer’s Association (ABMA) published rating data.
   2. Mount bearings out of the airstream on structural steel supports and/or bases. Provide either grease-lubricated bearings with external grease fittings and vent lines.
   3. Provide self-aligning bearings designed for average life based on ABMA rating designations.

2.2 CENTRIFUGAL FANS – CLASS I THROUGH IV

A. Acceptable Manufacturers:
   1. Barry Blower.
   2. Howden.

3. Greenheck.
4. Industrial Air Products.
5. New York Blower.
6. Twin City.

B. Centrifugal Fans, General:
1. Centrifugal spiral-shaped fan scroll welded to straight and parallel sides with welded inlet and outlet flanges. Include a single spun inlet bell ground smooth and treated or coated as specified for the intended service.
2. Bearings: Provide bearing support constructed of structural channels or heavy-formed angles. Mount the bearing out of airstream.
3. Shaft Seals: Install shaft seals to fill the shaft hole in the fan housing. Provide seal materials suitable for intended service.
4. Shafts: Construct shafts with AISI C-1018, 1040, or 1045 hot-rolled steel, ground, polished, and ring gauged. Size shafts so that its first critical speed will be at least 1.35 times the maximum operating speed. Provide 0.0003 inch or less per foot of shaft length for lateral static deflection.
5. Drain: Provide low-point drain in fan scroll, constructed from a threaded pipe coupling welded to the housing scroll, and fitted with a PVC plug.
6. Fan Housing: Constructed of steel of suitable thickness and reinforcement required by the fan class rating and service environment.
7. Finish and coating: Thoroughly degrease and deburr the entire fan assembly and apply a rust-preventative primer. Following fan assembly apply a finish coat of paint to the entire assembly. Coat fan shaft with a rust protectant.

PART 3 EXECUTION

3.1 ISOLATION

A. Isolate sheet metal duct connection from fan using flexible connection to match existing.

B. Install fan mounts using rubber-in-shear isolators as specified in data sheets at the end of this Section.

3.2 INSTALLATION

A. Locate units where shown on the Drawings and provide access space for motor, drive, bearing service, and fan shaft removal.

B. Perform lubrication, drive belt setup, and additional manufacturer’s installation requirements prior to startup.

3.3 FIELD QUALITY CONTROL

A. Startup Services:
1. Provide a manufacturer’s factory-trained technician to assist the Contractor during installation and to provide written certification that the equipment has been installed as specified and in accordance with the manufacturer’s directions.

2. Log and record startup performance data from field tests and adjust as necessary to meet specified performance.
3. After the fan is operating normally, conduct instructional sessions with the Owner's service personnel to:
   a. Review the maintenance manuals.
   b. Perform each step necessary for startup, shutdown, troubleshooting, and routine maintenance.
   c. Schedule this service orientation through the Owner.
4. Upon completion of the inspections, startup, testing, and checkout procedures, submit a written notice to the Owner that the units are ready for beneficial use.

3.4 ATTACHMENTS

A. The following attachments (attached after End of Section) are part of this Section:
   1. Equipment Data Sheet.

3.5 SUBMITTAL SCHEDULE

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
23 34 16-01	Provide the following detailed information on the equipment proposed. Itemize deviations from the specified requirements. If not so indicated, unit manufacturer will be required to furnish at no cost to the owner: A. Information requested in the RFQ, including equipment data sheets, schedules and sketches. B. Equipment drawings showing dimensions, weights (shipping & operating), configuration, and duct connection sizes and locations. C. Materials of construction for housing and major components.	X	
23 34 16-04	Product Data: Include: A. Unit designation number. B. Type of unit. C. Manufacturer's name and model number. D. Dimensions of unit, mounting attachments, and specified accessories. E. Description of fabrication materials for unit.	X	

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
23 34 16-05	Description of unit motor including: A. Manufacturer's name and model number. B. Nameplate horsepower. C. Efficiency (%). D. Service factor. E. Type enclosure. F. Speed (rpm). G. Electrical characteristics (V/Ph/Hz).	X	
23 34 16-06	Description of unit drive package including: A. Manufacturer's name and model number for sheaves and belts. B. Horsepower rating. C. Sheave diameters. D. Bushing sizes. E. Belt sizes and numbers. F. Percent adjustment above and below design setpoint.	X	
23 34 16-07	Shipping and operating weights of unit with weight distribution at support points.	X	
23 34 16-08	Fan performance curves indicating: A. Air quantity. B. Static pressure. C. Bhp. D. Efficiency. E. Tip speed. F. Rpm. G. Sound power level (dB re10-12 watts) for each octave band.	X	

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
23 34 16-09	Shop Drawings: Include: A. Overall equipment layout, indicating available service areas and clearance requirements. B. Elevations and sections to show clearances, methods of support, and details of installation. C. Locations and sizes of openings. D. Description of construction materials of unit. E. Power and control wiring diagrams indicating factory and field wiring requirements. F. Detailed unit test plan prior to conducting factory tests. G. Factory test results.	X	
23 34 16-10	Operating and Maintenance Manual: A. Submittal Data: 1. Product Data. 2. Shop Drawings. B. Spare Parts List: 1. Part description. 2. Part number. 3. Price.		Before date of Substantial Completion

		By:
Owner: University of Vermont		Date:
		Equipment No.: EF-7
	EQUIPMENT DATA SHEET	
	Centrifugal Fan	

GENERAL	
Manufacturer	Twin City (Basis of Design)
Model	BCJ (Basis of Design)
Location	Roof
Quantity	1
FAN DATA	
Fan Type	Centrifugal
Wheel Type	Backward inclined
Class	1
Arrangement	10
Size	By vendor
Air Density	.075 lb/ft^3
Air Flow Capacity	400 CFM
Static Pressure	1.2 inches w.c.
Fan Efficiency (%):	56.8
Fan RPM	By vendor
Drive	Adjustable pitch V-belt
Motor Brake horsepower	By vendor
Fan Tip Speed	By vendor
Outlet Velocity	By vendor
FAN MOTOR DATA	
Horsepower (hp):	By vendor
Motor RPM	1800
Voltage/Ph/Hz:	208/1/60
Motor Enclosure Type	TEFC
Motor Efficiency	Standard
SOUND DATA	
Sound (Sones)	8.8

		By:
Owner: University of Vermont		Date:
		Equipment No.: EF-7
	EQUIPMENT DATA SHEET	
	Centrifugal Fan	

Inlet Sound Power	
1st Octave	60
2nd Octave	65
3rd Octave	66
4th Octave	67
5th Octave	67
6th Octave	64
7th Octave	59
8th Octave	50
MAXIMUM DIMENSIONS	
Length	27”
Width	20”
Height	27”
Operating Weight	90 lbs
ACCESSORIES	
Bolted access door	
Housing drain and plug	
Inlet and companion flanges	
Companion flange and sleeve	
Rubber-in-shear vibration isolators	
Weather Cover	
REMARKS	

END OF SECTION

SECTION 26 05 02

BASIC ELECTRICAL CONSTRUCTION MATERIALS AND METHODS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes requirements specifically applicable to Division 26.

B. Section Includes:
1. Vibration isolation.
2. Demolition.
3. Conduit.
4. Wire and cable.
5. Boxes.
6. Cabinets and enclosures.
7. Terminal blocks and accessories.
8. Wiring devices.
9. Supporting devices.
10. Electrical identification.
11. Disconnect switches.
12. Grounding.
13. Equipment and systems to meet project seismic requirements.

C. Work Excluded:
1. Power company metering facilities.
2. Incoming communication service.
3. Interior communication system.

D. The Contractor shall be responsible for furnishing and installing incidental items not actually shown or specified but which are required by good practice to provide complete functional systems.

E. Intent of Drawings:
1. Electrical plan drawings show only general locations of equipment and devices unless specifically dimensioned.
2. The Contractor shall be responsible for the proper routing of conduit and cable for power and controls.

1.2 DESIGN REQUIREMENTS

A. For materials specified in this Section, minimum standard of quality shall be in accordance with applicable industry standards, including, but not limited to, NEMA, ANSI, IEEE, UL, and federal standards publications.

B. Electrical components shall be UL listed and labeled and meet applicable requirements of Factory Mutual.

C. Compliance by the Contractor with the provisions of this Specification does not relieve him of the responsibilities of furnishing equipment and materials of proper design, mechanically and electrically suited to meet operating guarantees at the specified service conditions.

D. Equipment and devices to be installed outdoors or in unheated enclosures shall be capable of continuous operation within an ambient temperature of -20 to 120 degrees F, and a relative humidity of zero to 100 percent.

E. Where applicable, equipment and installation shall meet requirements for corrosive and hazardous locations.

F. Conform to the latest codes and legal requirements, obtain permits, and arrange for inspections.

1.3 SUBMITTALS

A. Refer to the Submittal Schedule at the end of Part 3 for a list of submittal requirements for this Section.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and Equipment: Labeled and/or listed as acceptable to the authority having jurisdiction as suitable for the use intended.

B. Where two or more units of the same class of material are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

C. Provide manufacturer's standard finish color except where specific color is indicated.

2.2 VIBRATION ISOLATION

A. Unit Double Neoprene Pad (DNP): Formed by two layers of 1/4-inch- to 3/8-inch-thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate with layers permanently adhered together; 40- to 50-durometer neoprene; pads sized so that they will be loaded within manufacturer's recommended range. Provide steel top plate equal to the size of the pad to transfer weight of supported unit to pads and to distribute load evenly over surface of pads.

B. Unit DNP isolators shall be formed from one of the following products:
1. Type NR: Amber/Booth.
2. Type Korpad: Korfund Dynamics.
3. Type WSW: Mason Industries.
4. Type NPS: Peabody Noise Control.
5. Series Shear Flex: Vibration Mountings & Control.

C. Unit Hanger Neoprene or Glass Fiber (HN): Neoprene-in-shear or glass fiber element contained in a steel housing. Provide neoprene neck bushing (or other element) where hanger rod passes through hanger housing to prevent rod from contacting hanger housing; diameter of hole in housing sufficient to permit hanger rod to swing through a 30 degree arc before contacting hanger housing.

D. Unit HN isolators shall be one of the following products:
1. Type BRD-A: Amber/Booth.
2. Type H: Korfund Dynamics.
3. Type HD: Mason Industries.
4. Type RH or FH: Peabody Noise Control.
5. Type RHD or RFD: Vibration Mountings & Control.

E. Structural Isolation Breaks (SIB):
1. Utilize pad isolators for busway, cable tray, wireway, and 4-inch and larger conduit at SIBs.
2. Support one end on 1-inch isolators for 25-feet on one side of SIB.

F. Flexible Electrical Connections:
1. Type A: Field fabricated using a minimum 24-inch length of flexible conduit or cable.
2. Type B: Field fabricated using a minimum 48-inch length of flexible conduit or cable.

2.3 METAL CONDUIT AND FITTINGS

A. Rigid Steel Conduit: Rigid galvanized steel.

B. Intermediate Metal Conduit (IMC): Galvanized steel.

C. PVC Externally Coated Conduit: Rigid steel conduit with external 20-mil PVC coating and internal phenolic coating over a galvanized surface.

D. Electrical Metallic Tubing (EMT): Galvanized tubing.

E. Flexible Metal Conduit: Steel.

F. Liquidtight Flexible Conduit: Flexible metal conduit with PVC jacket.

G. Fittings and Conduit Bodies: Threaded type or [compression type for EMT; material to match conduit.

2.4 NONMETALLIC CONDUIT AND FITTINGS

A. Rigid Nonmetallic Conduit: Schedule 40 PVC.

B. Electrical Plastic Tubing (EPT): PVC.

C. Liquidtight Nonmetallic Flexible Conduit: Flexible plastic conduit.

D. Fittings and Conduit Bodies: PVC.

2.5 CONDUIT SUPPORTS

A. Conduit Clamps, Straps, and Supports: Galvanized steel, cadmium plated, or malleable iron for metallic conduit, nonmetallic for nonmetallic conduit.

2.6 BUILDING WIRE

A. Power and Lighting Systems 600V or Less:
   1. Conductor: Stranded copper, 600-volt insulation. Minimum size 12 AWG.
   2. Insulation Type: THHN/THWN.
   3. Use XHHW where temperature may be 45 degrees F or less.

B. Control Circuits: Copper, stranded conductor, 600-volt insulation. Minimum size 14 AWG.

C. Signal Circuits:
   1. Special cables shall be as specified on the Drawings.
   2. Conductors for General Use: Stranded copper conductor, 16 AWG minimum with insulation.

2.7 OUTLET BOXES

A. Sheet Metal Outlet Boxes: Galvanized steel with 1/2-inch male fixture studs where required. Minimum depth of 2 inches.

B. Nonmetallic Outlet Boxes: Minimum depth of 2 inches. Provide gasketed, watertight cover.

C. Cast Boxes: Copper-free aluminum or cast Feraloy, deep-type, gasketed cover, threaded hubs. Minimum depth of 2 inches. For hazardous locations, provide boxes approved for applicable atmosphere classification.

2.8 PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: Galvanized steel.

B. Sheet Metal Boxes Larger Than 12 Inches in Any Dimension: Hinged enclosure in accordance with paragraph 2.12, Hinged Cover Enclosures.

C. Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast Feraloy or cast aluminum box and cover with ground flange, neoprene gasket, and stainless steel cover screws. For hazardous locations, provide boxes approved for applicable atmosphere classification.

2.9 HINGED COVER ENCLOSURES

A. Construction: NEMA 250; Type 1 for indoor dry locations where enclosed equipment is required to be ventilated, Type 4 for indoor or outdoor wet locations, 4X for indoor or outdoor wet corrosive locations, or 12 for indoor dry locations; steel, except corrosive to be FRP.

B. Finish: Manufacturer's standard enamel finish.

C. Covers: Gasketed with continuous hinge, held closed by flush latch operable by screwdriver.

D. Interior Panel for Mounting Terminal Blocks or Electrical Components: 14-gauge steel, white enamel finish.

2.10 TERMINAL BLOCKS AND ACCESSORIES

A. Power Terminals: Unit construction, closed-back type, with tubular pressure screw connectors, rated 600 volts. Provide 25 percent spare terminals.

B. Signal and Control Terminals: Modular construction type, DIN 46 277/3 channel mounted; screw clamp compression connectors, rated 300 volts. Minimum terminal width of 0.24 inch, capable of holding two 12 AWG or two 14 AWG conductors in each connector. Terminal identification numbers shall be thermoset characters (black) on a white background. Provide 25 percent spare terminals.

2.11 SUPPORTING DEVICES

A. Support Channel or Angle: Galvanized steel in general, stainless galvanized steel in corrosive areas.

B. Hardware: Cadmium- or zinc-plated in general, corrosion resistant in corrosive areas.

C. For individual conduit runs not directly fastened to the structure, use rod hangers manufactured by Unistrut.

D. For multiple conduit runs, use galvanized steel or angle trapeze-type conduit support designed for maximum deflection not greater than 1/8 inch.

2.12 ELECTRICAL IDENTIFICATION

A. Nameplates: Engraved three-layer laminated plastic, minimum 3/16-inch-high white letters on a black background. Emergency Equipment Nameplates: White letters on a red background.

B. Tape Labels: Embossed adhesive tape with minimum 3/16-inch white letters on black background or 3/16-inch Kroy black letters on a white background.

C. Wire and Cable Markers: Clear, heat-shrink tubing type Brady LS2000; cloth or wraparound-adhesive types not approved.

D. Conductor-Color Tape: Colored vinyl electrical tape.

2.13 DISCONNECT SWITCHES

A. Fusible Switch Assemblies: Quick-make, quick-break, load-interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in on position. Handle lockable in off position. Fuse Clips: Designed to accommodate Class R fuses.

B. Nonfusible Switch Assemblies: Type HD; quick-make, quick-break, load-interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in on position. Handle lockable in off position.

C. Enclosures: as indicated on the Drawings.

2.14 GROUNDING

A. Ground Connections: Exothermic welded-type connectors as manufactured by Cadweld or Thermoweld or compression type of connectors designed for this special purpose as manufactured by Burndy or Thomas and Betts.

PART 3 EXECUTION

3.1 BASIC ELECTRICAL INSTALLATION REQUIREMENTS

A. Workmanship:
1. Install work using procedures defined in NECA Standard of Installation.
2. Install material and equipment in accordance with manufacturer's instructions. Provide calibrated torque wrenches and screwdrivers as required.
3. Utilize booties for work within AHU.

B. Service Continuity:
1. Maintain continuity of electric service to functioning portions of process or buildings during the hours of normal use.
2. Arrange temporary outages for cutover work with the Owner. Keep the outages to a minimum number and minimum length of time.
3. Lab downtime is a critical project issue. Minimize lab HVAC downtime during switchover and reprogramming. This will minimize the possibility of lab contamination and cleaning.

C. Startup Testing and Inspection of Electrical Equipment:
1. Provide tests specified hereinafter and as indicated under individual items of materials and equipment specified in other sections.
2. Performance Test:

a. At the completion of electrical system installation and at such time as CH2M HILL may indicate, conduct an operating test for acceptance.
b. Demonstrate that equipment operates in accordance with the Contract Documents.
c. Perform test in presence of CH2M HILL.
d. Furnish instruments and personnel required for the test.

3. Voltage: At completion of project, check voltage at point of termination of power supply system to project. Check voltage amplitude and balance between phases for loaded and unloaded conditions. Adjust taps of transformers such that the no-load voltage is approximately equal to or up to 3 percent above normal.
4. Test References:
   a. The testing and inspection to comply with applicable sections of the following codes and standards:
      1) American National Standards Institute (ANSI).
      2) American Society for Testing and Materials (ASTM).
      3) Association of Edison Illuminating Companies (AEIC).
      4) Institute of Electrical and Electronics Engineers (IEEE).
      5) Insulated Power Cable Engineers Association (IPCEA).
      6) National Electrical Code (NEC).
      7) National Electrical Manufacturer's Association (NEMA).
      8) International Electrical Testing Association (NETA).
      9) National Fire Protection Association (NFPA).
      10) State and local codes and ordinances.
   b. The inspection and testing to comply with the project plans and specifications, as well as with the manufacturer's drawings, instruction manuals, and other applicable data for the apparatus tested.
5. Responsibilities:
   a. Clean the equipment and torque down accessible bolts, perform routine insulation resistance tests on branch and feeder circuits, continuity checks on branch and control wiring, and rotation tests for distribution and utilization equipment. At each test site, provide test control power necessary to perform the tests specified. After review by CH2M HILL, correct deficiencies noted.
   b. The Owner's electrical engineer will furnish settings of protective devices unless a power system study has been required elsewhere in these Specifications.
6. Implementation:
   a. Safety practices to comply with applicable state and local safety orders, as well as with the Occupational Safety and Health Act (OSHA). Compliance with NFPA Standard 70E and the Accident Prevention Manual for Industrial Operations of the National Safety Council to be observed.
   b. Tests to be performed on apparatus which is de-energized. Do not proceed with the work until it has been determined that it is safe to do so.
   c. Power circuits to have conductors shorted to ground by a hotline-grounded device approved for the purpose. Warning signs and protective barriers to be provided as necessary to conduct the tests safely.

d. In general utilize methods outlined in acceptance testing specifications for electrical power distribution equipment and systems from the International Electrical Testing Association (NETA), but do not exceed manufacturer's limitations.

7. Reports:
   a. The test report to include the following sections:
      1) Scope of testing.
      2) Equipment tested.
      3) Description of test.
      4) Test results.
      5) Conclusions and recommendations.
      6) Appendix, including test forms.
   b. Each piece of equipment to be recorded on a data sheet listing the condition of the equipment as found and as left. Include recommendations for necessary repair and/or replacement parts. The data sheets to indicate the name of the engineer who tested the equipment and the date of the test completion.

3.2 INSTALLATION OF VIBRATION ISOLATION

A. Isolated electrical equipment to be positioned so that it is freestanding and does not contact the building structure or other systems.

B. Mechanical Equipment: Electrical connections to vibration-isolated mechanical equipment to be made using flexible electrical connections. Connections made with conduit less than 1 inch to be Type A or Type B; for conduit sized 1 inch and larger, use Type B.

C. Isolation Mounts:
   1. Mounts to be aligned squarely above or below mounting points for the supported equipment.
   2. If a housekeeping pad is provided, the isolators to bear on the housekeeping pad and the isolator baseplate to rest entirely on the pad.
   3. Hanger rods for vibration-isolated support to be connected to structural beams or joists, not from the floor slab between beams and joists. Provide intermediate support members as necessary.
   4. Vibration-isolation hanger elements to be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting objects.

D. Flexible Electrical Connections:
   1. Type B connections to be installed in a grossly slack U shape or a 360 degree loop.
   2. The flexible coupling or conduit not be tied to the building structure or other rigid material beyond the point where it takes off from the rigid conduit.

3.3 DEMOLITION

A. Verify that field measurements and circuiting arrangements.

B. Verify that abandoned wiring and equipment serve only abandoned equipment.

C. Demolition based on field walkthrough with Owner.

D. Beginning of demolition means Contractor accepts existing conditions.

E. Remove, relocate, and extend existing installations to accommodate new construction.

F. Remove abandoned conductors to source of supply.

G. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut embedded or concealed conduit flush with walls and floors and patch surfaces.

H. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

I. Repair adjacent construction and finishes damaged during demolition and extension work.

J. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

K. Extend existing installations using materials and methods compatible with existing electrical installations or as specified.

L. Clean and repair existing materials and equipment which remain or are to be reused.

3.4 INSTALLATION OF CONDUIT

A. Route exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.

B. Maintain minimum 6-inch clearance between conduit and piping. Maintain 12-inch clearance between conduit and heat sources such as flues, steam pipes, and heating appliances. Maintain minimum 18-inch clearance above ceiling grid.

C. Arrange conduit supports to prevent distortion of alignment by wire-pulling operations. Fasten conduit using galvanized straps, lay-in adjustable hangers, clevis hangers, or bolted split stamped galvanized hangers.

D. Do not fasten conduit with wire or perforated pipe straps. Remove wire used for temporary conduit support during construction before conductors are pulled.

E. Cut conduit square using a saw or pipecutter; deburr cut ends.

F. Bring conduit to the shoulder of fittings and couplings and fasten securely.

G. Use conduit hubs for fastening conduit to cast boxes and for fastening conduit to sheet metal boxes in damp or wet locations.

H. Except for communications conduits, use conduit bodies to make sharp changes in direction as around beams. Conduit bodies to be readily accessible.

I. Avoid moisture traps where possible; where unavoidable, provide junction box with drain fitting at conduit low point.

J. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture. Provide a permanent cap over each end of each empty conduit.

K. Provide a pull rope or pull tape in each empty conduit. Tie pull rope securely to duct plug or wall racking at each end. Provide conduit identification at each end.

L. Install expansion-deflection joints where conduit crosses building expansion or structural isolation break (SIB) joints; Expansion fittings to have copper bonding jumper.

M. Where conduit penetrates fire-rated walls and floors, seal opening around conduit with UL-listed foamed silicone elastomer compound with rating equal to or greater than the wall/floor penetrated.

N. Use PVC-coated rigid steel factory elbows for bends in plastic conduit runs longer than 100 feet or in plastic conduit runs which have more than two bends regardless of length.

O. Wipe plastic conduit clean and dry before joining. Apply full, even coat of cement to entire area that will be inserted into fitting. Let joint cure for 20 minutes minimum.

P. Concealed, embedded, and buried conduit to emerge at right angles to the surface and have none of the curved portion of the bend exposed.

Q. Provide warning tapes above underground conduits.

R. For conduits penetrating other interior areas with at least a 20 degree F delta in temperature, provide seal-offs on each side of the wall, fill both with sealant, and seal the conduit-to-wall interface on both sides.

3.5 CONDUIT INSTALLATION SCHEDULE

A. Exposed Outdoor Locations: Rigid steel conduit.

B. Wet Interior Locations: Rigid steel conduit.

C. Concealed Dry Interior Locations: Electrical metallic tubing.

D. Exposed Dry Interior Locations: Electrical metallic tubing.

E. Corrosive Interior Locations: Schedule 40 PVC conduit.

F. Hazardous (Classified) Locations: Rigid steel conduit.

3.6 INSTALLATION OF BUILDING WIRE

A. Place an equal number of conductors for each phase of a circuit in same raceway or cable.

B. Splice only in junction or outlet boxes. Control cables to be spliced on terminal blocks and only with the written permission of CH2M HILL.

C. Neatly train and lace wiring inside boxes, equipment, and panelboards.

D. Make conductor lengths for parallel circuits equal.

E. Where connection of cables installed under this Section is to be made by others, provide pigtails of adequate length for neat, trained, and bundled connections.

F. Pull all conductors into a raceway at the same time. Use UL-listed wire-pulling lubricate for pulling 4 AWG and larger wires.

G. Install wire in raceway after interior of building has been physically protected from the weather and mechanical work likely to injure conductors has been completed.

H. Completely and thoroughly swab raceway system before installing conductors.

I. Use solderless pressure connectors with insulating covers for copper wire splices and taps 8 AWG and smaller. For 10 AWG and smaller, use insulated-spring wire connectors with plastic caps on lighting and receptacle circuits.

J. Control circuit conductors to be terminated at terminal blocks only.

K. Use split-bolt connectors for copper wire splices and taps 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.

L. Thoroughly clean wires before installing lugs and connectors.

M. Make splices, taps, and terminations to carry full ampacity of conductors without perceptible temperature rise.

N. Terminate spare conductors with electrical tape.

O. Inspect wire and cable for physical damage and proper connection.

P. Torque test conductor connections and terminations to manufacturer's recommended values.

Q. Perform continuity and insulation tests on power and equipment branch circuit conductors. Verify proper phasing connections.

3.7 INSTALLATION OF BOXES

A. Types to be Provided, Steel Raceway System:
   1. Exterior Locations: Cast Feraloy with neoprene gaskets.
   2. Interior Locations With:
      a. Rigid Steel Conduit: Cast Feraloy.
      b. Intermediate Metallic Conduit: Cast Feraloy.
      c. Electrical Metallic Tubing: Sheet steel.
      d. Communications Wireway: Same material as wireway.
   3. Interior Wet Locations with Exposed and Concealed Raceways: Cast Feraloy with neoprene gaskets.

B. Types to be Provided – Plastic Raceway System: Nonmetallic.

C. Single In-Line Communications Conduit Runs:
   1. 2-inch Conduit and Smaller: Type C conduit bodies of cast Feraloy or nonmetallic construction as required for the location. Gaskets outdoors and in wet locations.
   2. Conduit Larger Than 2-Inch: Straight-through communications wireway as specified for the location.

D. Do not install outlet boxes back to back in walls.

E. Locate outlet boxes in masonry walls to require cutting of masonry unit corner only.

F. Provide knockout closures for unused openings.

G. Support outlet boxes independently of conduit.

H. Use multiple-gang outlet boxes where multiple devices are mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

I. Install outlet boxes in walls without damaging wall insulation.

J. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.

K. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches of recessed luminaire to be accessible through luminaire ceiling opening.

L. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall and adjustable steel channel fasteners for flush ceiling outlet boxes.

M. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

N. Support pull and junction boxes independent of conduit.

O. Provide pull boxes to limit conduit runs to 150 feet and contain no more than three 90 degree, right-angle bends unless accepted by CH2M HILL. For communications raceways limit runs to 100 feet and no more than two 90 degree bends.

P. Provide communications pull boxes of sufficient size and place raceway connections in a manner that ensures the minimum inside cable bend radius is more than 10 times the inside diameter of the conduit. Do not install boxes, bends, elbows, tees, conduit, outlet bodies, and other conduit fittings which do not provide for this minimum inside cable bend radius.

Q. Outlet, pull, and junction boxes to be accessible.

R. Install terminal boxes as indicated.

S. Close openings in boxes, condulets, raceways, and equipment.

3.8 INSTALLATION OF CABINETS AND ENCLOSURES

A. Install cabinets and enclosures plumb; anchor securely to wall and structural supports at each corner, minimum.

B. Provide accessory feet for freestanding equipment enclosures.

C. Install trim plumb.

D. Install terminal blocks as indicated.

3.9 INSTALLATION OF SUPPORTING DEVICES

A. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using precast insert system, expansion anchors, preset inserts, beam clamps, or spring steel clips.

B. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchor on concrete surfaces; sheet metal screws in sheet metal studs; and wood screws in wood construction.

C. Do not fasten supports to piping, ductwork, mechanical equipment, or conduit.

D. Do not use powder-actuated anchors without written permission from CH2M HILL.

E. Do not drill structural steel members without written permission from CH2M HILL.

F. Fabricate supports from structural steel or steel channel rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring-lock washers under nuts.

G. In wet locations, install freestanding electrical equipment on concrete pads or raised channel sills.

H. Install surface-mounted cabinets and panelboards with minimum of four anchors.

I. Bridge studs top and bottom with channels to support recessed mounted cabinets and panelboards in stud walls.

J. Use galvanized supports in areas subject to corrosives.

K. Support systems in compliance with project seismic requirements.

3.10 INSTALLATION OF ELECTRICAL IDENTIFICATION

A. Degrease and clean surfaces to receive nameplates or tape labels.

B. Install nameplates and/or tape labels parallel to equipment lines.

C. Secure nameplates to equipment fronts using screws or rivets. Utilize noncorrosive screws for engraved nameplates. Secure nameplate to outside face of flush-mounted panelboard doors in finished locations.

D. Use tape labels for identification of individual wall switches, receptacles, boxes, and control device stations.

E. Provide wire markers on each phase, neutral, or ground conductor in panelboard gutters, pull boxes, outlet and junction boxes, and at load connection. Identify with branch circuit or feeder number for power and lighting circuits and with control wire number as indicated on schematic and interconnection diagrams or equipment manufacturer's shop drawings for control wiring.

F. Utilize permanent black markers to identify circuits, destinations, and spares on junction and pull box lids. Clarify detail inside larger boxes.

G. Post neutral and phase color codes at each panelboard.

H. Place signs at service equipment noting the location of generator and uninterruptible power supply systems.

I. Place signs at each building disconnect noting where other building disconnects are located.

J. Intrinsically safe conductors to be light blue.

K. Conductors for power circuits shall be identified per the following schedule unless Owner has site standard that needs to be followed:

	System Voltage

Conductor	480Y/277V	208Y/120V
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Neutral	White with orange stripe	White
Grounding	Green	Green
Switchleg (lighting)	Purple	Pink

L. Provide nameplates to identify electrical distribution and control equipment and loads served. Letter Height: 1/8 inch for individual switches and loads served, 1/4 inch for distribution and control equipment identification.

M. Life Safety and Security System Device Identification:
1. Label devices with self-adhesive labels, 1/8-inch characters, white letters on a red background.

N. Conduit color coding schedule to be as follows unless Owner has site standard that needs to be followed:
1. Use colored tape.to identify conduit by system.
2. Primary Distribution System: Purple.
3. 480-Volt, Three-Phase System: Blue.
4. 208-Volt, Single- and Three-Phase System: Black.
5. Grounding: Green.
6. General Control Systems (non-FMS line voltage): Brown and white.
7. FMS (Facility Management System) and FMS Controlled Circuitry (Low Voltage): Blue and black.

3.11 INSTALLATION OF INDIVIDUALLY MOUNTED CIRCUIT BREAKERS AND DISCONNECT SWITCHES

A. Install disconnect switches where indicated on the Drawings.

B. Install circuit breakers plumb.

C. Maximum Height: Top of enclosure at 78 inches AFF.

D. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check for proper installation and tightness of connections for circuit breakers.

3.12 INSTALLATION OF GROUNDING

A. Install grounding system in accordance with NEC Article 250 unless specifically instructed otherwise in these Contract Documents.

B. Provide separate isolated equipment grounding conductor bonded to system at service or separately derived source where required for reduction of electrical noise.

C. Grounding conductors not to be spliced, except in junction or outlet boxes.

D. Provide a separate, insulated equipment grounding conductor in feeder and branch circuits.

E. Grounding Connections:
   1. Connect grounding conductors to ground rods at the upper end of the rod with the end of the rod and the connection point below finished grade.

F. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

3.13 SUBMITTAL SCHEDULE

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
26 05 02-01	Provide product data for wire and cable.		2 weeks after award of contract
26 05 02-02	Provide product data for disconnect switches		2 weeks after award of contract
26 05 02-03	Provide product data for conduit		2 weeks after award of contract
26 05 02-04	Provide test reports.		Before final acceptance
26 05 02-05	Provide inspection and permit certificates, certificates of final inspection and acceptance from the authority having jurisdiction, and operation and maintenance manuals.		

END OF SECTION

SECTION 26 29 23

VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes the requirements necessary to furnish and install pulse-width modulated (PWM) variable frequency motor controllers for controlling speed of ac squirrel-cage induction motors.

B. Variable frequency motor controllers are described as the following:
   1. Variable frequency drive (VFD).
   2. Adjustable frequency drive (AFD).

C. Manufacturer's Responsibilities:
   1. Coordinate application engineering and startup support to ensure drives are properly selected.
   2. Drive problems before and after installation during warranty period at project site.
   3. Provide technical assistance during testing along with shipping and coordination costs.

1.2 SUBMITTALS

A. Refer to the Submittal Schedule at the end of Part 3 for a list of submittal requirements for this Section.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Asea Brown Boveri (ABB) ACH series.

B. Yaskawa A1000 series.

2.2 GENERAL

A. Input Voltage: 208 Vac plus or minus 10 percent, three phase, 60 Hz plus or minus 2 percent.

B. Main Disconnect: Circuit breaker interlocked with enclosure door, breaker rated for 65,000A fault duty symmetrical withstand.

C. Minimum 93 percent drive efficiency.

D. Overload Capability: 120 percent for 1 minute.

E. Overload Protection: Thermal overload relays in all three phases.

F. Overcurrent Protection: Current-limiting fuses.

G. Surge Protection: On input terminals, able to withstand 510V line-to-ground.

H. Operating Frequency Range: 3 to 67 Hz.

I. Active current limit to provide 110 percent torque for 1 minute.

J. AFD capable of operating when powered from normal power, engine generator power, solidly grounded power system, or resistance grounded power system.

K. AFD capable of starting and operating without motor connected.

L. Rate AFD for altitude where installed.

M. Provide terminal blocks for control and power interfaces.

N. Enclosure: NEMA 12 unless indicated otherwise.

2.3 COMMUNICATIONS AND CONTROLS

A. Full digital control of frequency and voltage with 7-segment LCD built-in key pad with programming, monitoring, alarms, adjustment, and control features including:
   1. Manual/Off/Auto selector with bumpless transfer.
   2. Local manual speed, start, stop, reset controls.
   3. Local or remote speed reference selector for bumpless transfer via programmable acceleration/deceleration rates.
   4. Adjustment of speed, rate of change, dc boost, current limit, frequency skip.
   5. Run pilot light.
   6. Remote start-stop control capability via contact.
   7. Monitoring of current, frequency, voltage, and speed.
   8. Drive diagnostics.

B. Interfaces and Cards:
   1. RS232/RS485 and 4-20 mA interfaces.
   2. Troubleshooting and diagnostic card.
   3. Interfaces and interposing relays per AFD interface drawings.
   4. Three programmable contacts for remote indication of events and alarms.
   5. Failsafe dry contacts for fail and run indications.

C. Programming and Software:
   1. Programming port for laptop running drive vendor configuration software.
   2. If control signal is lost, keep speed at previous setting.
   3. Flying restart after momentary 0.5 to 20 second power failure.

2.4 POWER QUALITY

A. Provide AFD with 5% input line reactors.

2.5 DRIVEN LOAD CHARACTERISTICS

A. Motor Voltage Rating: 208 three phase.

B. Motor Service Factor: 1.0 for inverter rated and 1.15 for others.

C. Motor Temperature Rise: Class B, based on 40 degrees C ambient.

D. Motor Insulation: Class F.

E. Motor Torque Characteristic: NEMA Design B.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 TESTING AND ADJUSTING

A. Test in accordance with manufacturer's recommendations.

B. Make and record settings in coordination with operating requirements from CH2M HILL.

C. For AFDs sent to driven equipment OEM facilities, provide testing, adjustment, and technical assistance for operation of overall system.

3.3 MANUFACTURERS SERVICES

A. Furnish manufacturer's representative for the following services at job site or classroom as designated by Owner for minimum workdays listed below, travel time excluded:
   1. 1 workday for programming.
   2. 2 workdays for functional and performance testing.
   3. 1 workday for instruction of personnel.

3.4 FIELD QUALITY CONTROL

A. Retest units failing to meet Specifications to satisfaction of CH2M HILL.

B. Furnish units that perform as specified if AFDs fail second test.

3.5 SUBMITTAL SCHEDULE

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
26 29 23-01	Catalog cut-sheets, other descriptive literature		
26 29 23-02	Enclosure external and internal layout drawings with bill of material, dimensions and openings		
26 29 23-03	Weights		
26 29 23-04	Capacities and ratings		
26 29 23-05	AFD single-line diagram		
26 29 23-06	Speed range and output frequency range in Hertz		
26 29 23-07	Maximum continuous output horsepower operating capability		
26 29 23-08	Maximum short-term (60-second duration) horsepower without shutdown or damage to AFD		
26 29 23-09	Maximum input current under rated load and in speed range for conductor sizing		
26 29 23-10	Recommended sizes for line overcurrent protection		
26 29 23-11	Fault duty withstand capability in symmetrical amperes		
26 29 23-12	Efficiency under rated load at 60, 45, 30, and 15 Hz		
26 29 23-13	Mounting, including seismic		
26 29 23-14	Performance characteristics		
26 29 23-15	Model numbers		
26 29 23-16	Data sheets		
26 29 23-17	Electrical input and output voltage ratings, load, and interface		
26 29 23-18	Wiring, interconnection, and schematic diagrams		
26 29 23-19	Control interface		
26 29 23-20	Instruction and technical manuals		
26 29 23-21	Spare parts list and pricing		

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
26 29 23-22	Software, files, databases		
26 29 23-23	Factory testing results		
26 29 23-24	Field test results		
26 29 23-25	Operation and maintenance manuals		
26 29 23-26	Training		
26 29 23-27	AFD settings		

END OF SECTION

SECTION 40 80 01

COMMISSIONING OF INSTRUMENTATION AND CONTROL SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. This Section specifies the requirements for adjusting, testing, and calibrating the complete instrumentation and control (I&C) system.
2. Provide startup, commissioning, Operational Acceptance Testing (OAT), Functional Acceptance Testing (FAT), and documentation for the turnover of the instrumentation and control system to the Owner.
3. The instrumentation and controls system includes field instrumentation, control panels, DCS, supervisory control equipment, control networks, and associated software programming.
4. Instrumentation and control system is an existing control system being revised. System revision includes new instrumentation, new I/O, new I/O Modules and software upgrades. Software upgrades include revised programming of the DCS and associated graphics and alarms.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. The startup/commissioning team will include the commissioning agent, contractors and the Owner. Testing, startup and commissioning work will be coordinated with the Owner.
2. A member of the startup/ commissioning team is to attend system turnover coordination meetings as requested by the Owner. The intent of these meetings is to provide a report of previous testing, open issues, punch list items, additional work required to turn over systems as well as scheduling testing of upcoming testing.
3. Coordinate the final calibration, balancing and recertification of the lab and acid fume hoods. Coordinate calibration of new and existing control devices including control valves, dampers, etc. supplied by other contractors (e.g., mechanical).
4. Coordinate startup, commissioning and testing with the other contractors to avoid conflicts, errors, delays, and unnecessary interferences with the operation of the lab.
5. Identify anticipated shutdowns to the Owner. Testing or commissioning that requires a shutdown to a system that is operational/turned over cannot be performed until parties agree to a shutdown schedule (duration, testing required, etc.).
6. Identify requirements of other trades to the Owner for installation of missing equipment or the rewiring and reinstallation of instrumentation provided for this project.

7. Site lockout /tag out procedures to be followed during startup/commissioning tests. A copy of the procedure is to be included in system turnover documentation and startup/commissioning procedures

B. Pre-installation Meetings:
   1. Coordinate with the owner and Contractor on overall schedule for installation and testing.

C. Sequencing:
   1. The control system testing will not commence until Lab rebalancing and fume hood recertification is complete.

D. Scheduling:
   1. Testing schedule requires approval of the Owner. Subsequent changes to testing schedule is to be approved by the Owner.
   2. Lab downtime is critical to schedule. Minimize time HVAC system is not providing some ventilation to lab to minimize lab contamination. Possible work arounds and temporary running of HVAC system in non finalized state shall be approved by Owner.

1.3 SUBMITTALS

A. Refer to the Submittal Schedule at the end of Part 3 for a list of submittal requirements for this Section.

B. Submittals should also be provided in .pdf form so information can be uploaded to university website.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance:
   1. System acceptance and turnover to the Owner is to be defined as that point in time when the following requirements have been fulfilled:
      a. Submittals and documentation have been submitted, reviewed, and approved.
      b. The complete system of instrumentation and controls has successfully completed testing requirements cited herein.
      c. Owner’s staff training programs have been completed.
      d. System punch list items have been resolved and accepted by the Owner and CH2M HILL.

1.5 WARRANTY

A. Provide manufacturer’s one year extended warranty in writing, with Owner named as beneficiary. Warranty is to provide for correction, or at the option of the Owner, removal and replacement of the control system and its components found defective during stated warranty period after the date of Substantial Completion.

1.6 PROJECT RECORD DOCUMENTATION

A. Project record documentation is to be submitted with the system turnover package. The Owner is the sole judge of the adequacy of the submitted documentation. The following provides detailed information required in the system turnover packages:
   1. Instruments Data Sheets: required for each field device. Data sheet is to have pertinent information on the instrument, including tag, model, span, and set point, and is to be provided in both hard and soft copy.
   2. Factory and Field Instrument Calibration Sheets: required for each active I&C element (excluding simple hand switches and push buttons). Each sheet is to include instrument tag number, serial number, description, manufacturer, model number, data sheet number, calibration range, input range, output range, and error at 10, 50, and 90 percent of span. For discrete elements, the calibration sheet will include switch setting, contact action, and deadband setting. Sheets are to include space for comments and signoff by calibrator and Owner, and the date. A field calibration sheet is required for instrument that did not have a factory calibration sheet or an instrument that was re-ranged/ recalibrated due to field conditions.
   3. Operational Acceptance Test (OAT) Completion Sheet: required for each device. The completion sheet is to include the device tag, project number, date, loop number, and initials of tester. It is also include places to check adjustment complete, calibration complete, installation complete, functional test complete, and a place for comments.
   4. Functional Acceptance Test (FAT) Completion sheet: The functional acceptance test is to include as a minimum set points, tuning parameters, VFD settings, Network addresses etc.
   5. Continuity tests for control wiring.

B. Provide marked up copies of following documentation. These redlines will be turned over to the Owner during the project closeout. Incorporation of markups is by the Contractor
   1. One set of record drawings accurately depicting the final installed system devices wiring and software is required. Record drawings are to include P&IDs, I/O wiring diagrams, panel drawings, loop diagrams, and network architecture and control riser diagrams.
   2. Warranty documentation from the original vendor is to be provided for equipment installed as part of the I&C system.

C. Provide latest copy of software programming in both hard and electronic format. Software programming includes DCS programs and VFD programs.

1.7 ONSITE SUPERVISION

A. Provide an onsite resident engineer to supervise and coordinate installation, calibration, adjustment testing, and startup of the I&C system. The resident engineer is to be present during the total period required to effect a complete and operating system.

B. Provide onsite staff to perform operational and functional testing and startup of system.

PART 2 PRODUCTS

2.1 TEST INSTRUMENTS

A. General Requirements:
1. Use test equipment with at least twice the accuracy of the instrumentation being tested or be certified.
2. Use certification indicating test equipment that has been tested within 90 days of use by a Metrology Lab.
3. Use ISO-9000 certified test equipment where specified.

B. Recommended Test Equipment:
1. Digital V.O.M.: Fluke 45-01 or approved equal.
2. Low Range Inclined Manometer: Dwyer 251-AF or approved equal.
3. Precision 12-Inch Diameter Gauge, 0 to 100 psig: Heise Precision or approved equal.
4. Portable Low Pressure Test Kit: Ametek/U.S. Gauge C-102 or approved equal.
5. Process Calibrator: Biddle 720390 or approved equal.
6. Time domain reflectometer for testing network and communication cables.

C. Software Turnover: Upon completion of the project, prior to Owner acceptance, turn over programming and troubleshooting software to the Owner.

D. Upon completion of the project, schedules developed for routine calibration of equipment is to be turned over to the client.

2.2 GENERAL INSTRUMENTATION

A. Identify accessories that are not installed and are required to complete the functional testing of the system.

B. Coordinate purchase and installation of these missing items with the Owner. Redline as-built documentation to include additional instrumentation purchased to support system turnover.

PART 3 EXECUTION

3.1 GENERAL

A. Provide acceptance testing for the various building systems organized into four steps.
1. Visual inspection and documentation check.
2. Point to point verification of field devices.
3. Operational Acceptance Test (OAT).
4. Functional Acceptance Test of entire system(s) (FAT).

B. Step 1: This step includes a visual inspection of the instrumentation for proper installation and documentation. Installation is to be per the manufacturer’s installation details and recommended practices and the contract drawings. Documentation is to

include proper instrument tags, and testing provided by the instrument installer including wiring continuity and field calibrations. Documentation is to include factory tests and calibration sheets provided by the instrument manufacturer. Provide comprehensive turnover book with separate tabbed sections. Provide detailed forms for each device and the manufacturer's recommended calibration and test procedure as part of a system binder tab section.

C. Step 2 – Perform the following for point to point verification:
   1. Field device to I/O point.
   2. I/O point to DCS address.
   3. DCS address to correct SCADA database point.
   4. Reverse these operations when checking SCADA to field device.

D. Step 3 – Operational Acceptance Test (OAT): The objective of this test is to demonstrate that the I&C system and its components are operational and are ready for final operation. These tests are done on a component by component basis and do not include functional interlocks required for system operation.

E. Step 4 – Functional Acceptance Test (FAT): These tests are for entire systems and may involve other dependent systems. For instance, central plant utilities are to be operational prior to building systems testing. Typical systems in this category are air handlers, heating water, recirculating units and process cooling water. Verify each system operates in accordance with the design sequence of operation in the presence of the Owner's representative.

F. The Owner will define critical systems to be tested prior to on site installations in a simulated manner. Testing is to meet Owner approval. There are to be no exceptions.

G. .Refer to contract drawings that include Sequence of Operation (SOOs) and Alarm Matrix for this project.

H. Testing includes verification of control function and alarms locally at the lab and at the front end control system across the BACNET interface.

3.2 INSTRUMENTATION CALBRATION

A. Control Valves:
   1. Verify correct instrument. Verify correctness of installation. Continue correct path. Calibrate and adjust positioners and IP transducers. Verify proper control action (i.e., air to open factory calibration/air to close). Verify proper failure position on loss of air and loss of power. Adjust limit switch settings. Adjust opening and closing speeds and travel stops. Perform five-point calibration check.
   2. Stroke control valves by means of associated controller.

B. Control Dampers:
   1. Verify correctness of installation. Calibrate and adjust positioners and IP transducers. Verify proper control action (i.e., air to open/air to close). Verify

proper failure position on loss of air/loss of power. Adjust limit switch settings. Adjust opening and closing speeds and travel stops.

2. Stroke control dampers by means of associated control output.

C. Adjustable Frequency Drives:

1. Verify control-wiring installation to the adjustable frequency drive. Calibrate and adjust the remote speed control loop and feedback loop. Verify control actions and interlocks. Adjust minimum and maximum speed settings.
2. Ramp adjustable frequency drive by simulation of associated controller output.
3. Verify programming of each VFD.

D. Single Loop Controllers:

1. Verify control wiring for correctness. Verify power wiring.
2. Calibrate and adjust manual and auto control actions of controllers. Set controller parameters.
3. Stroke associated final element through controller output.
4. Verify set points and alarm functions.

E. Pressure and Differential Pressure Instruments:

1. Perform five-point calibration test in percent of input versus output.
2. Verify zero point under pressure and re-zero if necessary.

F. Temperature Transmitters:

1. Verify element is in correct position and sufficient length to insure accurate measurement of variable.
2. Verify correct five-point input versus output using decade precision resistance box or potentiometer.

G. Dewpoint Transmitters: Since this transmitter uses a primary measurement technique, it is more accurate than portable testing means. Follow manufacturer’s directions for pre-startup.

H. Pressure Switches:

1. Verify correct switch operation at set point (make on increasing pressure, break on increasing pressure, make on decreasing pressure, and break on decreasing pressure).
2. Verify reset (automatic or manual) and deadband if applicable.

I.

3.3 EXAMINATION

A. Verification of Conditions:

1. Conduit installation will be verified and approved before pulling control wiring.

B. Testing:

1. Operational Acceptance Tests:
    a. Operational Acceptance Tests:

1) The objective of these tests is to demonstrate that the I&C system is ready for final operation.
2) The I&C system is to be checked for proper installation, adjusted, and calibrated on a loop-by-loop basis to verify that it is ready to function as specified.
3) System elements are to be checked to verify that they have been installed properly and that terminations have been made correctly.
4) Discrete elements and systems are to have their set points adjusted and are to be checked for proper operation (e.g., interlock functions, contact closure on rising/falling, process variables, etc.).
5) Continuous elements and systems are to have three-point calibrations performed. Controller tuning constants are to be adjusted to preliminary settings.
6) The operational acceptance tests are to be completed prior to starting functional acceptance tests. The actual testing program is to be conducted in accordance with prior reviewed procedures and are to be documented as required.

2. Functional Acceptance Tests:
   a. Functional Acceptance Tests:
      1) The objective of these tests is to demonstrate that the I&C system is operating and complying with the specified performance requirements.
      2) A witnessed functional acceptance test shall be performed on the complete I&C system. Each function is to be demonstrated and verified by CH2M HILL on a paragraph-by-paragraph and loop-by-loop basis.
      3) Each test is to be witnessed and signed off by the Contractor and CH2M HILL upon satisfactory completion.
      4) The actual testing program is to be conducted in accordance with procedures developed by CH2MHILL and is to be documented as required herein.
      5) Notify CH2M HILL at least 2 weeks prior to the date of the functional acceptance test.
      6) Functional acceptance test schedule is to be coordinated with the Owner.
      7) If testing requires rework or modifications to DDC code, upon completion of modification, retest the points in question. In addition, retest a percentage of additional points from the DDC code modified to determine if the modifications altered the functionality of points previously tested.

3.4 FIELD QUALITY CONTROL

A. Field Tests:
   1. Control wiring and power wiring require continuity tests.
   2. Provide balancing test reports for Lab.

3. Provide ASHRAE Certification reports for Fume Hoods.

B. Field Inspections:
1. Control conduits shall be inspected in field before pulling control wiring.

3.5 SYSTEM STARTUP

A. Startup is not limited to the LAB DCS system. Startup also included testing and verification of information received at the front end control system across the BACNET interface.

3.6 ADJUSTING

A. Control sequence will require identifying final system settings during testing. Some test and control functions will be performed multiple time to determine optimum operating conditions for the different modes of operation...

3.7 CLOSEOUT ACTIVITIES

A. Training:
1. Prior to onsite demonstration tests, provide at the jobsite 16 hours of training for the Owner's personnel in the operation and maintenance of devices requiring calibration. As a minimum, training is to include demonstration of calibration for different instruments, including control devices purchased under previous referenced sections. Training will be coordinated with the Owner so that personnel from all shifts can attend.

3.8 SUBMITTAL SCHEDULE

ITEM NO.	SUBMITTAL REQUIREMENT	WITH BID	AS INDICATED
	Continuity tests		After completion
	Operational Acceptance Test (OAT)		After completion
	Functional Acceptance test (FAT)		After completion

SPECIAL SUBMITTAL CONSIDERATIONS
1. Before startup, testing, and commissioning commences verify that construction is complete to ensure that there are no false starts.
2. Before startup, testing, and commissioning commences provide the Owner with sample documentation of the turnover package. Package is to define which party is responsible for different documents that makeup the completed turnover package.

3. Before startup, testing, and commissioning commences provide the Owner with sample documentation of final testing procedures and documentation that will be used to verify functionality of the control system from the field device up to the supervisory network devices.
4.

B. Reference Submittals:
1. The following is a list of submittals furnished by the various contractors that will be utilized during the startup and commissioning effort. Submittals used for reference are to be returned to the Owner prior to final system turnover.
2. For each device:
   a. Catalog cut sheet.
   b. Instrument data sheet/control valve data sheet.
   c. Instrument calibration sheet/certificate (manufacturers).
3. For each control panel:
   a. Catalog cut sheets for devices in panels.
   b. Shop drawings of panel, including wiring details and schematics.
   c.
4. Project record documentation.
   a. O&M manuals.
5. Project record drawings.
6. Data sheets and calibration sheets.
7. DCS program with annotated documentation such as ladder logic diagrams.
8. Supervisory software program documentation, including detailed description of customized implementation requirements.
9. Instrument loop sheets.
10. Instrument specifications.
11. Instrument check out sheet w/signatures.
12. Factory calibration sheets.

END OF SECTION