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

Contractor:
Vermont Mechanical, Inc.
Chantal Bitzer

VMI PO #: Subcontract

Lead time after approval: N/A

Date items required at project:

Architect

General Contractor

Engineer

Contractor has checked this submittal 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.

Other:
Slade; David
Cosmogenic Nuclide Laboratory
Fume Hood Balance
Delehanty Hall
University Of Vermont
Burlington, Vermont
Vermont Mechanical # DLR750006201
Precision Balancing # 2774
October 2, 2015
Air Apparatus Test Report

**System/Unit:** AHU-4

### UNIT DATA

<table>
<thead>
<tr>
<th>Make</th>
<th>Clean PAK</th>
<th>Class/Discharge</th>
<th>/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model No.</td>
<td>Size 22 Fanwall</td>
<td>Tag No.</td>
<td>AHU-4</td>
</tr>
<tr>
<td>Serial No.</td>
<td>A09 AH-01</td>
<td>Location</td>
<td>Rooftop</td>
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### MOTOR DATA

<table>
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<tr>
<th>Make</th>
<th>Toshiba (Two Motors)</th>
<th>Model / Part No.</th>
<th>BO154FLF2USH02</th>
<th>RPM</th>
<th>1775</th>
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<tr>
<td>Frame</td>
<td>254T</td>
<td>Volts / Phase /Hz</td>
<td>230-460, 3, 60</td>
<td>S.F.</td>
<td>1.15</td>
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<tr>
<td>H.P.</td>
<td>15</td>
<td>Full Load Amps</td>
<td>37 - 18.5</td>
<td>Flac</td>
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<tr>
<td>Measured Volts</td>
<td>3.4 KW (Freq)</td>
<td>Measured Amps</td>
<td>15.8 (Freq)</td>
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### DRIVE DATA

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<td>Sheave Size / Make</td>
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</tr>
<tr>
<td>Bushing / Bore Size</td>
<td>Direct Drive</td>
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<tr>
<td>No. Belts / Make / Size</td>
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<tr>
<td>Fan Design RPM</td>
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<td>Motor Actual RPM</td>
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### AIR DATA

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<tr>
<td>Total CFM</td>
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<td>6,689</td>
</tr>
<tr>
<td>O.A. CFM</td>
<td>6,850</td>
<td>6,689</td>
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<tr>
<td>Ret. Air CFM</td>
<td>/</td>
<td>/</td>
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<tr>
<td>Pre-Heat S.P. Drop</td>
<td>N/A</td>
<td>Cooling Coil S.P. Drop</td>
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<tr>
<td>Pre-Filter S.P. Drop</td>
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<td>Hi Eff. Filter S.P. Drop</td>
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<tr>
<td>Vortex Damp. Pos.</td>
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<td>O.A. Damper Pos.</td>
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<td>Disch. S. P.</td>
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<td>Suc. S. P.</td>
<td>/</td>
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<tr>
<td>Pre-Heat S.P. Drop</td>
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<td>Pre-Filter S.P. Drop</td>
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### NOTES

1. Unable to drill unit for pressure readings.
2. System read with 'A' fan running.
## Diffuser, Register, & Grille Test Report

**System/Unit:** AHU-4

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<thead>
<tr>
<th>Area Served</th>
<th>Outlet Number</th>
<th>Type</th>
<th>Size</th>
<th>&quot;K&quot; Factor</th>
<th>Design FPM</th>
<th>Design CFM</th>
<th>Pre CFM</th>
<th>Final FPM</th>
<th>Final CFM</th>
<th>Final CFM</th>
<th>%Diff</th>
<th>Refer to Note</th>
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<td>1</td>
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<td>500</td>
<td>500</td>
<td>498</td>
<td>514</td>
<td>514</td>
<td>514</td>
<td>2.8%</td>
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</tr>
<tr>
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<td>1</td>
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<tr>
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<td>513</td>
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</table>

Total from Previous Page(s) Total 6850
Previous Total 6689

**NOTES**

1.) Refer to drawing for diffuser location.
2.) Flow hood used 'K' factor equals (1) one.
3.) Ceiling not accessible to make damper adjustments.
4.) Pre-Readings from 7-27-15 Report (Total = 6,528 CFM)
5.) AHU-4 static setpoint = .70"
**Diffuser, Register, & Grille Test Report**

**System/Unit:** E.F. 4 & 5

<table>
<thead>
<tr>
<th>Area Served</th>
<th>Outlet Number</th>
<th>Type</th>
<th>Size</th>
<th>&quot;K&quot; Factor</th>
<th>Design</th>
<th>Pre CFM</th>
<th>Final</th>
<th>%Diff</th>
<th>Refer to Note</th>
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<td>CFM</td>
<td>FPM</td>
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<td>1</td>
<td>SS</td>
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<td>.087</td>
<td>575</td>
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<td>1368</td>
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<td>.049</td>
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<td>29</td>
<td>570</td>
<td>28</td>
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<td>SS</td>
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<td>1005</td>
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<td>.087</td>
<td>575</td>
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**Total from Previous Page(s)**

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<td>Previous Total</td>
<td>5355</td>
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**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)
Fume Hood Components

- Supply Fan Speed Controller (Located behind front panel)
- Teflon Ulpa Filter
- Perforated Diffusion Panel
- Sash
- Sash Opening
- Hood Supply Fan
- Pre-Filter
- Air Flow Monitor
- Air Flow Sensor

Note: Supply fan set for 60 FPM "Downflow Velocity". Readings were taken and recorded 2" and 6" below the perforated 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.

| 1.5" above | 88 | 50 | 61 | 70 | 68 | 56 | 70 | 63 | 83 | 92 |
| 1" above   | 239 | 203 | 195 | 221 | 216 | 204 | 236 | 186 | 214 | 213 | 226 |
| 1.5" below | 214 | 188 | 204 | 153 | 196 | 224 | 216 | 224 | 190 | 216 | 189 |

Average 142 FPM

Air Flow Monitor Readout = 113 FPM

| 2.8" above | 8.5" above | 14.1" above | 19.7" above | 25.4" above | 34" above | 36.7" above | 42.3" above | 47.9" above | 53.6" above | 59.2" above | 62" above |
| 2.5" above | 153 | 196 | 224 | 216 | 224 | 190 | 216 | 219 |

Air Flow Monitor Readout = 283 FPM

Average 261 FPM
## Fume Hood #2

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

<table>
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<td>Average 109 FPM</td>
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## Fume Hood #3

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

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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Air Flow Monitor Readout = 156 FPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25&quot;</td>
<td>180</td>
<td>160</td>
<td>175</td>
<td>148</td>
<td>168</td>
<td>170</td>
<td>175</td>
<td>177</td>
<td>178</td>
<td>178</td>
<td>177</td>
<td>Average 224 FPM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>281</td>
<td>278</td>
<td>281</td>
<td>284</td>
<td>293</td>
<td>287</td>
<td>262</td>
<td>281</td>
<td>290</td>
<td>276</td>
<td>254</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Fume Hood #4**

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

<table>
<thead>
<tr>
<th>10&quot;</th>
<th>1.5&quot;</th>
<th>1.5&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>40</td>
<td>27</td>
</tr>
<tr>
<td>40</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>27</td>
<td>40</td>
<td>81</td>
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<td>81</td>
<td>89</td>
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<tr>
<td>40</td>
<td>89</td>
<td>80</td>
</tr>
<tr>
<td>27</td>
<td>80</td>
<td>65</td>
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<tr>
<td>40</td>
<td>65</td>
<td>61</td>
</tr>
<tr>
<td>190</td>
<td>190</td>
<td>191</td>
</tr>
<tr>
<td>190</td>
<td>191</td>
<td>191</td>
</tr>
<tr>
<td>190</td>
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<td>191</td>
<td>191</td>
</tr>
<tr>
<td>190</td>
<td>191</td>
<td>191</td>
</tr>
</tbody>
</table>

Average 133 FPM

Air Flow Monitor Readout = 120 FPM

<table>
<thead>
<tr>
<th>5&quot;</th>
<th>1.25&quot;</th>
<th>1.25&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>186</td>
<td>176</td>
<td>202</td>
</tr>
<tr>
<td>202</td>
<td>183</td>
<td>181</td>
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<tr>
<td>193</td>
<td>172</td>
<td>172</td>
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<tr>
<td>186</td>
<td>185</td>
<td>172</td>
</tr>
<tr>
<td>172</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>186</td>
<td>185</td>
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<tr>
<td>202</td>
<td>202</td>
<td>202</td>
</tr>
<tr>
<td>290</td>
<td>287</td>
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<td>296</td>
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<tr>
<td>268</td>
<td>267</td>
<td>262</td>
</tr>
<tr>
<td>262</td>
<td>251</td>
<td>252</td>
</tr>
</tbody>
</table>

Average 229 FPM

**Fume Hood #5**

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

<table>
<thead>
<tr>
<th>10&quot;</th>
<th>1.5&quot;</th>
<th>1.5&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>60</td>
<td>31</td>
</tr>
<tr>
<td>31</td>
<td>60</td>
<td>32</td>
</tr>
<tr>
<td>60</td>
<td>32</td>
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<td>32</td>
<td>0</td>
<td>53</td>
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<tr>
<td>0</td>
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<td>37</td>
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<tr>
<td>0</td>
<td>37</td>
<td>48</td>
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<tr>
<td>0</td>
<td>48</td>
<td>95</td>
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<tr>
<td>0</td>
<td>95</td>
<td>83</td>
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<td>0</td>
<td>83</td>
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<tr>
<td>0</td>
<td>103</td>
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<td>0</td>
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<tr>
<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Average 139 FPM

Air Flow Monitor Readout = 120 FPM

<table>
<thead>
<tr>
<th>5&quot;</th>
<th>1.25&quot;</th>
<th>1.25&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>266</td>
<td>213</td>
<td>250</td>
</tr>
<tr>
<td>250</td>
<td>186</td>
<td>204</td>
</tr>
<tr>
<td>186</td>
<td>178</td>
<td>198</td>
</tr>
<tr>
<td>198</td>
<td>211</td>
<td>198</td>
</tr>
<tr>
<td>198</td>
<td>256</td>
<td>291</td>
</tr>
<tr>
<td>256</td>
<td>291</td>
<td>198</td>
</tr>
<tr>
<td>291</td>
<td>198</td>
<td>178</td>
</tr>
<tr>
<td>198</td>
<td>204</td>
<td>186</td>
</tr>
<tr>
<td>204</td>
<td>250</td>
<td>230</td>
</tr>
<tr>
<td>250</td>
<td>230</td>
<td>186</td>
</tr>
<tr>
<td>230</td>
<td>250</td>
<td>268</td>
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<tr>
<td>268</td>
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<td>296</td>
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<td>296</td>
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<td>300</td>
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<tr>
<td>300</td>
<td>274</td>
<td>267</td>
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<tr>
<td>274</td>
<td>267</td>
<td>268</td>
</tr>
<tr>
<td>267</td>
<td>268</td>
<td>304</td>
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<tr>
<td>268</td>
<td>304</td>
<td>308</td>
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<tr>
<td>308</td>
<td>304</td>
<td>316</td>
</tr>
<tr>
<td>316</td>
<td>308</td>
<td>373</td>
</tr>
</tbody>
</table>

Average 260 FPM
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

<table>
<thead>
<tr>
<th>37</th>
<th>57</th>
<th>57</th>
<th>38</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>68</td>
<td>70</td>
<td>53</td>
</tr>
</tbody>
</table>

Average = 53

6" from Perforated Panel

<table>
<thead>
<tr>
<th>48</th>
<th>53</th>
<th>55</th>
<th>43</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>58</td>
<td>50</td>
<td>45</td>
</tr>
</tbody>
</table>

Average = 50

Hood #2

<table>
<thead>
<tr>
<th>47</th>
<th>50</th>
<th>63</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>72</td>
<td>69</td>
<td>39</td>
</tr>
</tbody>
</table>

Average = 55

Hood #3

<table>
<thead>
<tr>
<th>42</th>
<th>54</th>
<th>78</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>68</td>
<td>70</td>
<td>62</td>
</tr>
</tbody>
</table>

Average = 60

Hood #4

<table>
<thead>
<tr>
<th>57</th>
<th>65</th>
<th>42</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>68</td>
<td>53</td>
</tr>
</tbody>
</table>

Average = 58

Hood #5

<table>
<thead>
<tr>
<th>38</th>
<th>62</th>
<th>41</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>71</td>
<td>52</td>
<td>40</td>
</tr>
</tbody>
</table>

Average = 47

P.O. Box 5416 • Essex Junction, VT 05453-5416
Telephone 802-879-3951 / Fax 802-857-0016
Air Apparatus Test Report

**System/Unit:** EF-6

### UNIT DATA

<table>
<thead>
<tr>
<th>Make</th>
<th>Greenheck</th>
<th>Class/Discharge</th>
<th>/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model No.</td>
<td>8-BISW-41-X-10-1</td>
<td>Tag No.</td>
<td>EF</td>
</tr>
<tr>
<td>Serial No.</td>
<td>11221500 0802</td>
<td>Location</td>
<td>Rooftop</td>
</tr>
</tbody>
</table>

### MOTOR DATA

<table>
<thead>
<tr>
<th>Make</th>
<th>WEG</th>
<th>Model / Part No.</th>
<th>1UTF0GNNXX1/204E</th>
<th>RPM</th>
<th>1750</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>B56</td>
<td>Volts / Phase /Hz</td>
<td>208-230-460, 3, 60</td>
<td>S.F.</td>
<td>1.25</td>
</tr>
<tr>
<td>H.P.</td>
<td>1/2</td>
<td>Full Load Amps</td>
<td>2.21 - 2.0 - 1.0</td>
<td>Flac</td>
<td>/</td>
</tr>
<tr>
<td>Measured Volts</td>
<td>206.2 - 206.3 - 206.5</td>
<td>Measured Amps</td>
<td>1.6 - 1.6 - 1.6</td>
<td>BHP</td>
<td>/</td>
</tr>
</tbody>
</table>

### DRIVE DATA

<table>
<thead>
<tr>
<th>Fan Data</th>
<th>Motor Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheave Size / Make</td>
<td>AK34 x QT</td>
</tr>
<tr>
<td>Bushing / Bore Size</td>
<td>QT x 1&quot;</td>
</tr>
<tr>
<td>No. Belts / Make / Size</td>
<td>1 / Carlisle / 4L300R</td>
</tr>
<tr>
<td>Fan Design RPM</td>
<td>1808</td>
</tr>
<tr>
<td>Motor Actual RPM</td>
<td>/</td>
</tr>
</tbody>
</table>

### AIR DATA

<table>
<thead>
<tr>
<th>Design</th>
<th>Actual</th>
<th>Design</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total CFM</td>
<td>595</td>
<td>Total S.P.</td>
<td>1.5&quot;</td>
</tr>
<tr>
<td>O.A. CFM</td>
<td>/</td>
<td>Exh. Fan</td>
<td>/</td>
</tr>
<tr>
<td>Ret. Air CFM</td>
<td>/</td>
<td>Exh. Fan</td>
<td>/</td>
</tr>
<tr>
<td>Pre-Heat S.P. Drop</td>
<td>/</td>
<td>Cooling Coil S.P. Drop</td>
<td>/</td>
</tr>
<tr>
<td>Pre-Filter S.P. Drop</td>
<td>/</td>
<td>Hi Eff. Filter S.P. Drop</td>
<td>/</td>
</tr>
<tr>
<td>Vortex Damp. Pos.</td>
<td>/</td>
<td>O.A. Damper Pos.</td>
<td>/</td>
</tr>
</tbody>
</table>

### NOTES

1.) Exhaust set to room pressure.
# Diffuser, Register, & Grille Test Report

**System/Unit:** E.F. 6

<table>
<thead>
<tr>
<th>Area Served</th>
<th>Outlet Number</th>
<th>Type</th>
<th>Size</th>
<th>&quot;K&quot; Factor</th>
<th>Design FPM</th>
<th>Design CFM</th>
<th>Pre CFM</th>
<th>Final FPM</th>
<th>Final CFM</th>
<th>%Diff</th>
<th>Refer to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CE</td>
<td>12&quot;x12&quot;</td>
<td>1</td>
<td></td>
<td>200</td>
<td>200</td>
<td></td>
<td>85</td>
<td>85</td>
<td>-57.5%</td>
<td>2,3</td>
</tr>
<tr>
<td>2</td>
<td>CE</td>
<td>12&quot;x13&quot;</td>
<td>1</td>
<td></td>
<td>375</td>
<td>375</td>
<td></td>
<td>456</td>
<td>456</td>
<td>21.6%</td>
<td>2,3</td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Total FPM</th>
<th>Total CFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>575</td>
<td>541</td>
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</tbody>
</table>

**Notes**

1. Refer to drawing for exhaust location.
2. Take-off damper is fully open.
3. Exhaust set to room pressure.
Air Apparatus Test Report

**System/Unit:** EF-7

### UNIT DATA

<table>
<thead>
<tr>
<th>Make</th>
<th>Twin City Fan</th>
<th>Class/Discharge</th>
<th>Class 1 / Size 105</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model No.</td>
<td>Type BCJ - SW</td>
<td>Tag No.</td>
<td>EF-7</td>
</tr>
<tr>
<td>Serial No.</td>
<td>15-545098-1-1</td>
<td>Location</td>
<td>Rooftop</td>
</tr>
</tbody>
</table>

### MOTOR DATA

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

### DRIVE DATA

<table>
<thead>
<tr>
<th>Fan Data</th>
<th>Motor Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheave Size / Make</td>
<td>Sheave Size / Make</td>
</tr>
<tr>
<td>AK39H</td>
<td>1VL40</td>
</tr>
<tr>
<td>Bushing / Bore Size</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>1 / Browning / 3L260</td>
<td>8 3/4&quot;</td>
</tr>
<tr>
<td>Fan Design RPM</td>
<td>Not Given</td>
</tr>
<tr>
<td>Fan Actual RPM</td>
<td>1,654</td>
</tr>
<tr>
<td>Motor Actual RPM</td>
<td>1,694</td>
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### AIR DATA

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Actual</th>
<th>Total S.P.</th>
<th>Design</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total CFM</td>
<td>400</td>
<td>370</td>
<td>/</td>
<td>H/A</td>
<td></td>
</tr>
<tr>
<td>O.A. CFM</td>
<td>Exhaust</td>
<td>Fan</td>
<td>Disch. S. P.</td>
<td>/</td>
<td>Atmospheric</td>
</tr>
<tr>
<td>Ret. Air CFM</td>
<td>Exhaust</td>
<td>Fan</td>
<td>Suc. S. P.</td>
<td>/</td>
<td>1.1&quot; Neg.</td>
</tr>
<tr>
<td>Pre-Filter S.P. Drop</td>
<td>/</td>
<td>Hi Eff. Filter S.P. Drop</td>
<td>/</td>
<td></td>
<td>/</td>
</tr>
<tr>
<td>Vortex Damp. Pos.</td>
<td>/</td>
<td>O.A. Damper Pos.</td>
<td>/</td>
<td>Ret. Air Damp Pos.</td>
<td>/</td>
</tr>
</tbody>
</table>

### NOTES

1.) Adjustable sheave on motor set near minimum position.
**Diffuser, Register, & Grille Test Report**

**System/Unit:** E.F. 7

<table>
<thead>
<tr>
<th>Area Served</th>
<th>Outlet Number</th>
<th>Type</th>
<th>Size</th>
<th>&quot;K&quot; Factor</th>
<th>Design FPM</th>
<th>Design CFM</th>
<th>Pre CFM FPM</th>
<th>Pre CFM CFM</th>
<th>%Diff CFM</th>
<th>Refer to Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>SS</td>
<td>4&quot;</td>
<td>.087</td>
<td>2299</td>
<td>200</td>
<td>2222</td>
<td>193</td>
<td>-3.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>SS</td>
<td>4&quot;</td>
<td>.087</td>
<td>2299</td>
<td>200</td>
<td>2035</td>
<td>177</td>
<td>-11.5%</td>
<td></td>
</tr>
</tbody>
</table>

Total from Previous Page(s)

Previous Total

Total 400

Total 370

**NOTES**

1.) Refer to drawing for exhaust location.
AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION

Customer ID: 011144
Customer: PRECISION BALANCING LLC
City: ESSEX JUNCTION
State: VT
As-Received Model #: ADM-870
Converted to Model #: 
Order #: R150980
PO #: 
Customer Eqpt ID: 

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 SIF-CP02 Revision 26

Dated: 07/31/14
Calibration Technician(s): Dougherty, James

Calibration Approved by: Clark, Dan

As-Received Test performed after minor repair: Yes

Final Test
Date: 03/31/15
Rhum %
Date: 03/31/15
Ambient Temperature °F
Ambient Temperature °F
Barometric Pressure in Hg
Barometric Pressure in Hg

All within spec (YES) NO NA

ABSOLUTE PRESSURE TEST (in Hg)

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

TEST METER TOLERANCE = ± 2.0 % ± .1 in Hg

As-Received Test Within Spec (YES) NO NA See Notes

<table>
<thead>
<tr>
<th>Approx Set Pt</th>
<th>Standard</th>
<th>Test Meter</th>
<th>% Diff</th>
<th>Standard</th>
<th>Test Meter</th>
<th>% Diff</th>
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<th>% Diff</th>
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DIFFERENTIAL PRESSURE TEST (in wc)

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

TEST METER TOLERANCE = ± 2.0 % ± 0.001 in wc

As-Received Test Within Spec (YES) NO NA See Notes

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Overrange 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

ADM Recalibration Rev38/12/11/14 • 1 of 2
**AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION**

**LOW VELOCITY CONFIRMATION (FPM)**

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<th>M02009</th>
<th>As-Rcvd</th>
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<th>Test 3</th>
<th>Vel Eqv Trans Std: S/N:</th>
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<th>Test 3</th>
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<th>Test 3</th>
<th>Vel Eqv Trans Std: S/N:</th>
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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)**

<table>
<thead>
<tr>
<th>RTD Simulator: S/N</th>
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<th>As-Rcvd</th>
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<th>Test 2</th>
<th>Test 3</th>
<th>Set Point: 35.6°F</th>
<th>95°F</th>
<th>154.4°F</th>
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<td>154.4°F</td>
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<td>Test 3</td>
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<td>154.4°F</td>
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<td>Test 3</td>
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<td>154.4°F</td>
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<td>RTD Simulator: S/N</td>
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<td>Test 3</td>
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<td>154.4°F</td>
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<td>Test 3</td>
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<td>RTD Simulator: S/N</td>
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<td>Test 3</td>
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<td>154.4°F</td>
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<td>Test 2</td>
<td>Test 3</td>
<td>Set Point: 35.6°F</td>
<td>95°F</td>
<td>154.4°F</td>
</tr>
</tbody>
</table>

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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(480) 991-6744 • Fax (480) 443-1257 • www.shortridge.com
AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION

LOW VELOCITY CONFIRMATION (FPM)

<table>
<thead>
<tr>
<th>Approx Set Point</th>
<th>Standard</th>
<th>Test Meter</th>
<th>Diff</th>
<th>Standard</th>
<th>Test Meter</th>
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</table>

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)

<table>
<thead>
<tr>
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<th>As-Rcvd</th>
<th>Test 2</th>
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<td>154.4°F</td>
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</tbody>
</table>

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

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

NOTES:

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AIRDATA MULTIMETER CERTIFICATE OF RECALIBRATION

S/N: M951030

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

As-Received Model #: ADN-870
Converted to Model #: MM-870
Order #: R150980
PO #: 5479350
Customer Eqpt ID:

Calibration Due Date: 07/31/14

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. Instrument 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 Technique(s):

Calibration Approved by:

Title: Asst Cal Super

Date: 03/31/2015

As-Received Test performed after minor repair: Yes

Test by

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<th>Date</th>
<th>R H</th>
<th>%</th>
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Barometric Pressure 28.5 Hg

All within spec

ABSOLUTE PRESSURE TEST (in Hg)

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<th>Pressure Standard</th>
<th>Heise #02-R S/N: 41741/42451 As-Rcvd Test 2 Test 3</th>
<th>Pressure Standard</th>
<th>Heise #12-R S/N: 43165/44731 As-Rcvd Test 2 Test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Standard</td>
<td>Heise #04-R S/N: 41743/42453 As-Rcvd Test 2 Test 3</td>
<td>Pressure Standard</td>
<td>Heise #14-R S/N: 43412/45043 As-Rcvd Test 2 Test 3</td>
</tr>
<tr>
<td>Pressure Standard</td>
<td>Heise #06-R S/N: 41742/42452 As-Rcvd Test 2 Test 3</td>
<td>Pressure Standard</td>
<td>Heise #16-R S/N: 44313/45044 As-Rcvd Test 2 Test 3</td>
</tr>
<tr>
<td>Pressure Standard</td>
<td>Heise #08-R S/N: 42186/43328 As-Rcvd Test 2 Test 3</td>
<td>Pressure Standard</td>
<td>Heise #18-R S/N: 45581/46845 As-Rcvd Test 2 Test 3</td>
</tr>
<tr>
<td>Pressure Standard</td>
<td>Heise #10-R S/N: 42203/43352 As-Rcvd Test 2 Test 3</td>
<td>Pressure Standard</td>
<td>Heise #20-R S/N: 45582/46847 As-Rcvd Test 2 Test 3</td>
</tr>
</tbody>
</table>

Differential Pressure Test (in wc)

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

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

ADM Recalibration Rev/38/12/11/14
1 of 2 12/11/14
Certificate No: S26973  
Manufacturer: Nidec-Shimpo America Corp.  
Model: DT-315EB  
Description: Digital Stroboscope  
Serial No: 22169412  
Range: 54.0 to 33,000 FPM  
Tolerance: ±0.01% of reading  
Date Calibrated: 05/04/2015  
Next Date Due: 05/04/2016  
Calibrated by: S.BLYAKHMAN  
Conditions  
Degrees Fahrenheit: 74.4°F  
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:** B3C89039  
**Accuracy:** Certificate No. 1293116

<table>
<thead>
<tr>
<th>Check Point (STD)</th>
<th>+ Limit (FPM)</th>
<th>– Limit (FPM)</th>
<th>Unit Reads (FPM)</th>
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<tbody>
<tr>
<td>1,000.0</td>
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<td>999.9</td>
<td>1,000.1</td>
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<tr>
<td>4,999.7</td>
<td>5,000.2</td>
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<tr>
<td>10,000</td>
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<tr>
<td>32,997</td>
<td>33,000</td>
<td>32,994</td>
<td>32,999</td>
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</table>

SHIMPO INSTRUMENTS  
1701 Glenlake Avenue  
Itasca, IL 60143
NO SPACE AVAILABLE FOR MODULE IN XL500 PANEL. A SPARE ANALOG INPUT WAS RECONFIGURED AS A DIGITAL INSTEAD.

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

INCLUDE ACCESSORIES AS REQUIRED.
**DELEHANTY HALL COSMOS ALARM MATRIX**

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>ALARM Light</th>
<th>Cause</th>
<th>Manual Trip of Fan</th>
<th>Airflow</th>
<th>Reduced</th>
<th>STOP for +1 day</th>
<th>Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF RUN STATES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF PRESSURE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Supply AIR</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Pressures</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Temperature</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
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<td>LOSS OF Humidity</td>
<td>YES</td>
<td>YES</td>
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<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Differential Pressure</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Fire Alarm</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
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<td>LOSS OF Smoke Alarm</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Overflow Alarm</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Water Alarm</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Gas Alarm</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF Current Alarm</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF AIR</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF WATER</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF ELECTRICITY</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF HARD SHUTDOWN</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF COOLING</td>
<td>YES</td>
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<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF HEATING</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF DRYING</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>AHU-4</td>
<td>REDUCED</td>
<td>LOSS OF CLEANLINESS</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

**ALARM ONLY**

- RED LIGHT INDICATION AT LOCAL PANEL
- NO FAN ON-SITE
- ALARM ONLY
AS-BUILT

The HVAC system will not operate at all. The failure is caused by the failure of the HVAC system to run due to a problem in the HVAC system. The problem is due to a failure in the HVAC system, which is caused by a failure in the HVAC system's control system.

A failure in the HVAC system will cause the system to fail to run due to a problem in the HVAC system's control system. The problem is due to a failure in the HVAC system, which is caused by a failure in the HVAC system's control system.

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## Component Verification Checklist

**Project:** Delehanty Cosmogenic Nuclide Laboratory  
**Checked By:** David Slade – Slade Engineering *(DCS)*

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Specified Make /Model</th>
<th>Approved Make /Model</th>
<th>Installed Make /Model</th>
<th>Notes</th>
<th>Date</th>
<th>Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust Fan for snorkel hoods (EF-7)</td>
<td>Twin City / BCJ 400 CFM @ 1.2” w.c. 208V, 1 ph, 60 hz Motor HP: not specified Motor Type: TEFC</td>
<td>Twin City / BCJ 400 CFM @ 1.2” w.c. 208V, 1 ph, 60 hz Motor HP: ¼ HP Motor Type: TEFC</td>
<td>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</td>
<td>Fan body as specified and approved. Motor does not match submittal and is to be replaced under warranty.</td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Freezestat for AHU-4</td>
<td>Johnson Controls / A70GA-1C</td>
<td>Johnson Controls / A70GA-1C</td>
<td>Johnson Controls / A70GA-1</td>
<td>“C” suffix is a Johnson Controls sales designation that has no impact product specification.</td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Actuator for Outdoor Air Damper</td>
<td>Belimo / AFBUP-SN4</td>
<td>Belimo / AFBUP-SN4</td>
<td>Belimo / AFBUP-SN4</td>
<td>“H” suffix indicates internal heater for additional condensation protection.</td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Actuators for Supply Fan Dampers</td>
<td>Belimo / AFBUP-SN4</td>
<td>Belimo / AFBUP-SN4</td>
<td>Belimo / AFBUP-SN4</td>
<td></td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Pressure Transmitter (AHU-4 Supply)</td>
<td>Setra / 2671005 WQ11A1HD</td>
<td>Setra / 2671005 WQ11A1HD</td>
<td>Setra / 2671005 WQ11A1HD</td>
<td>Specified model # was incorrect by 1 digit. Corrected during submittal review.</td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Pressure Transmitters (EF-4&amp;5 Suction)</td>
<td>Setra / 2671005 WQ11A1HD</td>
<td>Setra / 2671005 WQ11A1HD</td>
<td>Setra / 2671005 WQ11A1HD</td>
<td>Specified model # was incorrect by 1 digit. Corrected during submittal review.</td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Variable Frequency Drives (VFDs) for EF-4&amp;5</td>
<td>Yaskawa / A1000 or ABB / ACH</td>
<td>Yaskawa / PU2A0030FAA</td>
<td>CIMR-PU2A0030FAA</td>
<td>“CIMR” is a Yaskawa standard designation that has no impact product specification.</td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Key Switch for Hibernation Mode</td>
<td>AB / 800T-E</td>
<td>NKK / CKM12AFW01</td>
<td>NKK / CKM12AFW01</td>
<td>Specified model # was incorrect for the application. Corrected during submittal review.</td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
<tr>
<td>Lab Status Illuminated Sign</td>
<td>i-Signs / Slim-line SBL824R-J533</td>
<td>Ser. No. 3951-FB12-D55A</td>
<td>Custom sign so not labeled with model #. Sign meets specification.</td>
<td></td>
<td>1/14/16</td>
<td>(DCS)</td>
</tr>
</tbody>
</table>
Job: DLR75-000
Delehanty Hal @ UVM
180 Colchester Ave
Burlington, VT 05405

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

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

VMI PO #: CM2595

Lead time after approval: 4 Weeks

Contractor: Vermont Mechanical, Inc.
Chantal Bitzer

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

REVIEW COMMENTS:
1) Provide extended grease lines as specified.
### Equipment Submittal

| project                  | UVM Delehanty Hall Lab  
<table>
<thead>
<tr>
<th></th>
<th>Burlington, Vermont</th>
</tr>
</thead>
<tbody>
<tr>
<td>architect</td>
<td>IDC Architects</td>
</tr>
<tr>
<td>engineer</td>
<td>CHZMHILL</td>
</tr>
</tbody>
</table>
| contractor              | Vermont Mechanical      
|                         | Williston, Vermont      |
| submitted by            | Michael Bronder         
|                         | R. F. Peck Co., Inc.    
|                         | Albany, New York        |
|                         | Date: July 17, 2015     |

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

**Contents:** Twin City Fans – Exhaust Fan
### FAN DETAILS

**Job Name:** UVM DELEHANTY

**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**: WA  
- **Discharge**: WA  
- **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

<table>
<thead>
<tr>
<th>Octave Bands</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>LwA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level at Inlet</td>
<td>60</td>
<td>65</td>
<td>66</td>
<td>67</td>
<td>67</td>
<td>64</td>
<td>59</td>
<td>50</td>
<td>71</td>
</tr>
</tbody>
</table>

Sound Power Levels in dB re.10⁻¹² Watts:

*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.

---

All quotations per Twin City Fan Terms and Conditions found at www.twincityfan.com/TC_TCF.pdf  
Page 1 of 2
## Pricing Detail

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

Each Weight .................................. 105 lb
Extended Weight ............................... 105 lb
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

<table>
<thead>
<tr>
<th>Description</th>
<th>Qty</th>
<th>Model</th>
<th>Size</th>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>BCJ</td>
<td>105</td>
<td>SWSI</td>
<td>105</td>
</tr>
</tbody>
</table>

Approximate weight each, includes fan, motor, and accessories.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Class</th>
<th>Rotation</th>
<th>No. of Poles</th>
<th>Motor Type</th>
<th>Base Mounting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>W/A</td>
<td>10</td>
<td>W/A</td>
<td>Irrelevant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance</th>
<th>CFM</th>
<th>SP (Max)</th>
<th>RPM</th>
<th>Occ BHP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>400</td>
<td>1,200</td>
<td>1,712</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Temperature: 70 °F  Altitude: 0 ft

<table>
<thead>
<tr>
<th>Motor Data</th>
<th>HP</th>
<th>RPM</th>
<th>Vol/Ph/Hz</th>
<th>Enclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/4</td>
<td>1,800</td>
<td>208-230V/1/60</td>
<td>TEFC</td>
</tr>
</tbody>
</table>

Efficiency: Standard

<table>
<thead>
<tr>
<th>Sound Data</th>
<th>Level/Decibel</th>
<th>Level/Decibel</th>
<th>LwA</th>
<th>dBA</th>
<th>Sones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td>65</td>
<td>66</td>
<td>67</td>
<td>67</td>
</tr>
</tbody>
</table>

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

REV. DESC: UPDATE OVERALL LENGTHS

REV. LTR: L  VERSION: 04  TDR: 000000767401
FILE: \AAA\00025\008  REVISED: 09:00:29 10/02/2012  STD HORZ MODEL 34L NEMA 48 TEF0
MTL: -  BY: ENBUCFO  SH 1 of 1
## L3403

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

- **List Price**: $344.00 USD
- **Multiplier Symbol**: K
- **Ship Weight**: 20 LB
- **UPC**: 781568100097

### Specifications

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<th>0.250 hp</th>
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<tr>
<td>Frequency</td>
<td>60 Hz</td>
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<tr>
<td>Voltage</td>
<td>230 V, 115 V</td>
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<tr>
<td>Enclosure</td>
<td>TEFC</td>
</tr>
<tr>
<td>Frame Material</td>
<td>Steel</td>
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<td>Frame</td>
<td>48</td>
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<td>XP Division</td>
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<td>Baldor-Reliance</td>
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<td>Agency Approvals</td>
<td>CSA, UR</td>
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<td>Ambient Temperature</td>
<td>40 °C</td>
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<tr>
<td>Auxiliary Box</td>
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<table>
<thead>
<tr>
<th>KVA Code</th>
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<tbody>
<tr>
<td>Lifting Lugs</td>
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<tr>
<td>Locked Bearing Indicator</td>
</tr>
<tr>
<td>Motor Lead Exit</td>
</tr>
<tr>
<td>Motor Lead Quantity/Wire Size</td>
</tr>
<tr>
<td>Motor Lead Termination</td>
</tr>
<tr>
<td>Motor Standards</td>
</tr>
<tr>
<td>Motor Type</td>
</tr>
<tr>
<td>Mounting Arrangement</td>
</tr>
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<td>Number of Poles</td>
</tr>
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<td>Overall Length</td>
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<td>Power Factor</td>
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<td>Product Family</td>
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<td>4</td>
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<tr>
<td>57</td>
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<td>General Purpose</td>
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[http://www.baldor.com/catalog/L3403](http://www.baldor.com/catalog/L3403)
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<td>Base Indicator</td>
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<td>Bearing Grease Type</td>
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<tr>
<td></td>
<td>3.0 A @ 208 V</td>
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<tr>
<td></td>
<td>2.5 A @ 230 V</td>
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<td>Duty Rating</td>
<td>CONT</td>
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<td>Electrically Isolated Bearing</td>
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<td>Feedback Device</td>
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<td>Front Face Code</td>
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<td>Heater Indicator</td>
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<tr>
<td>Shaft Diameter</td>
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</tr>
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<td>Shaft Extension Location</td>
<td>Pulley End</td>
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<td>Shaft Rotation</td>
<td>Reversible</td>
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<td>Shaft Slinger Indicator</td>
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<tr>
<td>Speed</td>
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<tr>
<td>Speed Code</td>
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<td>Starting Method</td>
<td>DOL</td>
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<tr>
<td>Thermal Device - Bearing</td>
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<tr>
<td>Thermal Device - Winding</td>
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</tr>
<tr>
<td>Vibration Sensor Indicator</td>
<td>No Vibration Sensor</td>
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</tbody>
</table>
L3403

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

Product Information Packet PDF

List Price
Multiplier Symbol
Ship Weight
UPC

344.00 USD
K
20 LB
781568100097

SPECs DRAWINGS NAMEPLATE PERFORMANCE PARTS ACCESSORIES

PERFORMANCE AT 230 V, 60 HZ, 0.25 HP

Typical performance; not guaranteed values.

General Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Load Torque</td>
<td>0 LB-FT</td>
</tr>
<tr>
<td>No-Load Current</td>
<td>0 A</td>
</tr>
<tr>
<td>Line-Line Res. @ 25° C</td>
<td>8.88 Ohms A Ph / 7.06 Ohms B Ph</td>
</tr>
<tr>
<td>Temp. Rise @ Rated Load</td>
<td>57° C</td>
</tr>
<tr>
<td>Temp. Rise @ S.F. Load</td>
<td>70° C</td>
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Load Characteristics

<table>
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<tr>
<th>Load</th>
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<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
<th>125%</th>
<th>150%</th>
<th>S.F.</th>
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</thead>
<tbody>
<tr>
<td>Power Factor</td>
<td>25.0</td>
<td>32.0</td>
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<td>49.0</td>
<td>57.0</td>
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<tr>
<td>Efficiency</td>
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<td>40.0</td>
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<table>
<thead>
<tr>
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<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Start Configuration</td>
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<tr>
<td>Break-Down Torque</td>
<td></td>
</tr>
<tr>
<td>Pull-Up Torque</td>
<td></td>
</tr>
<tr>
<td>Locked-Rotor Torque</td>
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</tr>
<tr>
<td>Starting Current</td>
<td></td>
</tr>
<tr>
<td>DOL</td>
<td></td>
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<tr>
<td></td>
<td>2.13 LB-FT</td>
</tr>
<tr>
<td></td>
<td>1.88 LB-FT</td>
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<tr>
<td></td>
<td>2.48 LB-FT</td>
</tr>
<tr>
<td></td>
<td>9.95 A</td>
</tr>
<tr>
<td>Rated Load</td>
<td>0%</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>Speed (rpm)</td>
<td>1,795</td>
</tr>
<tr>
<td>Line Amps</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Performance Curves
**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

**Other:**
Slade;David

**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.

**Lead time after approval:**  4 Weeks

**Date items required at project:**

**Architect**

**Engineer**
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.

<table>
<thead>
<tr>
<th>MESSAGE</th>
<th>LED/COLOR</th>
<th>HEIGHT</th>
<th>AMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAB OFF LINE HOOD NOT USABLE</td>
<td>Wide Angle Red Diffused</td>
<td>1.75”</td>
<td>0.096</td>
</tr>
</tbody>
</table>

NOTE: Above messages are independent.

Proudly Made in the USA
**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**  
**Contractor:** Vermont Mechanical, Inc.  
Chantal Bitzer  
**VMI PO #:** Subcontract  
**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.

**Lead time after approval:** N/A  
**Date items required at project:**

**Other:** Slade;David

**General Contractor**

**Engineer**
Model No. CKM12AFW01

Series CK

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 1.5 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/s²) acceleration for CKM; 30G (294m/s²) 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.
High Security Keylocks

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

CKM12AFW01

<table>
<thead>
<tr>
<th>Code</th>
<th>Pos. 1</th>
<th>Pos. 2</th>
<th>Pos. 3</th>
<th>Key Removes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>ON</td>
<td>NONE</td>
<td>ON</td>
<td>Positions 1 and 3</td>
</tr>
<tr>
<td>2B</td>
<td>ON</td>
<td>NONE</td>
<td>ON</td>
<td>Position 1</td>
</tr>
<tr>
<td>3E</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>Position 2</td>
</tr>
</tbody>
</table>

Circuits & Key-Removable Positions

Contact Material

- W Silver
  - Rated 3A @ 250V AC

* Wire harness & cable assemblies offered only in Americas

DESCRIPTION FOR TYPICAL ORDERING EXAMPLE

CKM12AFW01

- One key supplied with each switch
- 16mm Diameter Bushing
- Silver Contacts
  - Rated 3A @ 250V AC
- Solder Lug Terminals
- SPDT ON-NONE-ON Circuit
- Key Removable in Positions 1 and 3
- Solder Lug Terminals

Tactiles

Pushbuttons

Rotaries

Slides

Rollers

Programmable Illuminated PB

Supplement

Accessories

Indicators

Tilt

Touch

High Security Keylocks

Model No. CKM12AFW01

Series CK
### POLES, CIRCUITS & KEY-REMOVABLE POSITIONS

<table>
<thead>
<tr>
<th>Pole &amp; Throw</th>
<th>Model</th>
<th>Key Positions</th>
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</thead>
<tbody>
<tr>
<td>SMDT</td>
<td>CKM12A</td>
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<td></td>
<td>OFF</td>
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<tr>
<td></td>
<td></td>
<td>ON</td>
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**Connected Terminals**

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<tr>
<th>Key Removable</th>
<th>Not Removable</th>
<th>Maximum Arc</th>
</tr>
</thead>
<tbody>
<tr>
<td>POS 1</td>
<td>POS 2</td>
<td>POS 3</td>
</tr>
<tr>
<td>POS 1</td>
<td>POS 2</td>
<td>POS 3</td>
</tr>
<tr>
<td>POS 1</td>
<td>POS 2</td>
<td>POS 3</td>
</tr>
</tbody>
</table>

**Schematic**

- **COM-1**: Key Removable
- **COM-2**: Not Removable
- **NOM**: Maximum Arc

### KEYS

#### 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

#### Tubular Key

- **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

### CONTACT MATERIALS, RATINGS & TERMINALS

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

#### Solder Lug Terminals

- **Solder Lug Terminal for CKM**

#### Epoxy Seal

- **(0.8)**
  - 0.031
- **(5.0)**
  - 0.197
- **(2.4)**
  - 0.094
- **(2.7)**
  - 0.106

#### Pushbuttons

- **(10.0)**
  - 0.378

#### Accessory

- **(2.7)**
  - 0.106
- **(0.8)**
  - 0.031
Series CK
High Security Keylocks

TYPICAL SWITCH DIMENSIONS

16mm Bushing • Flat Key

90° Angular Throw

45° Angular Throw

16mm Bushing • Tubular Key

90° Angular Throw

45° Angular Throw

CKM12AFW01

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

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

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

Contractor: Vermont Mechanical, Inc.
Chantel Bitzer

Review Status

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

"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

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 disconnects are provided in accordance with the NEC.
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 input signal from a process controller. Independent PI 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
- Modbus RTU (built-in)
- DeviceNet
- EtherNet/IP
- Modbus TCP/IP
- PROFIBUS- DP
- PROFINET

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/F Control
- Enclosure Solutions:
  - Open Type / iP00
  - Nema Type 1 (kit required for some models)
  - Flange Type (front = Open/IP00; back = Nema Type 11)
- Three Phase Power Solutions:
  - Six Pulse (Standard)
  - 240V: 3/4 to 175 HP
  - 480V: 1 to 1000 HP
  - 600V: 2 to 250 HP
  - Twelve Pulse (Low Harmonics)
  - 480V: 40 to 1000 HP
- Ambient Operating Temperature: -20°C to 40°C (4°F to 104°F)
- Global Certification: UL, CE, C-UL, C-Tick

Standard I/O:
- (8) multi-function digital inputs (24Vdc)
- (3) multi-function analog inputs (0-10Vdc, 4-20mA)
- (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, 4-20mA)
- Sensor feedback power supply (+24Vdc @ 150 mA supply)
- 120V converter for 8 standard digital inputs (option)
## 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

<table>
<thead>
<tr>
<th>Model Number (DMR-P)</th>
<th>Rated Output Current (amps)</th>
<th>Dimensions (in.)</th>
</tr>
</thead>
<tbody>
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### 380-480V / 3-Phase

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### 500-600V / 3-Phase

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</tbody>
</table>

### 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.
<table>
<thead>
<tr>
<th>Schedule</th>
<th>Motor Data</th>
<th>Drive Data</th>
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</thead>
<tbody>
<tr>
<td>Item</td>
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<td>Tag / Equipment ID</td>
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<tr>
<td>2</td>
<td>1</td>
<td>EF-5</td>
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</tbody>
</table>

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.
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/s² (1 G) maximum at 10 to 20 Hz
5.9 m/s² (0.6 G) at 20 Hz to 55 Hz (small HP)
2.0 m/s² (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 (at 1 meter) above that resulting from across the line operation.
Available NEMA 1 (JP20) 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 resetable 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.
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
Upgradable 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
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.

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

<table>
<thead>
<tr>
<th>Product Code Number</th>
<th>Switch Action</th>
<th>Range °F (°C)</th>
<th>Differential F° (C°)</th>
<th>Bulb and Capillary</th>
<th>Maximum Bulb Temperature °F (°C)</th>
<th>Range Adjuster</th>
</tr>
</thead>
<tbody>
<tr>
<td>A70GA-1C¹</td>
<td>Open low</td>
<td>15 to 55 (-9.4 to 12.8)</td>
<td>5 (2.8)</td>
<td>20 ft of 1/8 in. O.D. tubing</td>
<td>400 (204.4)</td>
<td></td>
</tr>
<tr>
<td>A70GA-2C</td>
<td>Close low</td>
<td>35 to 80 (1.7 to 26.7)</td>
<td>3 to 30 (-16.1 to -1.1), factory set at 12 (-11.1)</td>
<td>3/8 in. x 3 in. 8 ft capillary</td>
<td>250 (121)</td>
<td>Screwdriver slot</td>
</tr>
<tr>
<td>A70HA-1C¹</td>
<td>Open low</td>
<td>15 to 55 (-9.4 to 12.8)</td>
<td>Manual reset</td>
<td>20 ft of 1/8 in. O.D. tubing</td>
<td>400 (204.4)</td>
<td></td>
</tr>
<tr>
<td>A70HA-2C</td>
<td>Close high</td>
<td>35 to 80 (1.7 to 26.7)</td>
<td></td>
<td>3/8 in. x 3 in. 6 ft capillary</td>
<td>250 (121)</td>
<td></td>
</tr>
<tr>
<td>A70HA-14C</td>
<td>Close high</td>
<td>15 to 55 (-9.4 to 12.8)</td>
<td></td>
<td>20 ft of 1/8 in. O.D. tubing</td>
<td>400 (204.4)</td>
<td></td>
</tr>
<tr>
<td>A70KA-1C</td>
<td>Open high</td>
<td>100 to 170 (37.8 to 76.7)</td>
<td>3/8 in. x 3 in. 8 ft capillary</td>
<td>240 (116)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Product Code Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVR17A-620R</td>
<td>Automatic reset cover</td>
</tr>
<tr>
<td>CVR17A-621R</td>
<td>Manual reset cover</td>
</tr>
</tbody>
</table>

Technical Specifications

Electrical Ratings

<table>
<thead>
<tr>
<th>Pole Number</th>
<th>LINE-M2 (Main)</th>
<th>LINE-M1 (Auxiliary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Ratings VAC</td>
<td>120</td>
<td>208</td>
</tr>
<tr>
<td>AC Full Load A</td>
<td>16.0</td>
<td>9.2</td>
</tr>
<tr>
<td>AC Locked Rotor A</td>
<td>96.0</td>
<td>55.2</td>
</tr>
<tr>
<td>AC Non-Inductive A</td>
<td>16.0</td>
<td>9.2</td>
</tr>
<tr>
<td>Pilot Duty – Both Poles</td>
<td>125 VA, 120 to 600 VAC and 57.5 VA, 120 to 300 VDC</td>
<td></td>
</tr>
</tbody>
</table>

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.

Model 267 Features:
- ±0.25%, 0.4%, 0.5%, 1% FS Accuracy
- Suitable for Harsh Environments
- Optional LCD Display

- 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
Model 267
Very Low Differential Pressure Transducer

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Model Range</th>
<th>Output Pressure Fitting/Elec. Termination</th>
<th>Accuracy (Full Scale)</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>267 = 267</td>
<td>11 4-20 mA</td>
<td>±1% FS</td>
<td>LCD</td>
</tr>
<tr>
<td>OR1W/1B</td>
<td>1/8” Brass Fitting</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>OR25W/2B</td>
<td>1/8” Barbed Brass Fitting</td>
<td>±0.25% FS</td>
<td>D</td>
</tr>
<tr>
<td>OR5W/5B</td>
<td>1/8” Barbed Brass Fitting</td>
<td>±0.5% FS</td>
<td>E</td>
</tr>
<tr>
<td>OR01W/1B</td>
<td>1/8” Barbed Brass Fitting</td>
<td>±1% FS</td>
<td>F</td>
</tr>
<tr>
<td>OR05W/5B</td>
<td>1/8” Barbed Brass Fitting</td>
<td>±0.5% FS</td>
<td>G</td>
</tr>
<tr>
<td>OR001W/1B</td>
<td>1/8” Barbed Brass Fitting</td>
<td>±1% FS</td>
<td>H</td>
</tr>
</tbody>
</table>

ORDERING EXAMPLE: Part No. 2671R25WD11G2CD for a 0 to 0.25 in. WC Unidirectional Range, 4-20 mA Output, 1/8” Brass Fitting, PG-9 Electrical Termination, ±1% Accuracy with LCD Display

DIMENSIONS

GENERAL SPECIFICATIONS

Performance Data Physical Description

<table>
<thead>
<tr>
<th>Standard</th>
<th>Optional</th>
<th>Case</th>
<th>Electrical Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy RSS</td>
<td>±1.0% FS</td>
<td>±0.4% FS</td>
<td>±0.25% FS</td>
</tr>
<tr>
<td>Non-Linearity, BFSL</td>
<td>±0.98% FS</td>
<td>±0.38% FS</td>
<td>±0.22% FS</td>
</tr>
<tr>
<td>Hysteresis</td>
<td>±0.10% FS</td>
<td>±0.10% FS</td>
<td>±0.10% FS</td>
</tr>
<tr>
<td>Non-Repeatability</td>
<td>±0.05% FS</td>
<td>±0.05% FS</td>
<td>±0.05% FS</td>
</tr>
<tr>
<td>Zero/Span Shift</td>
<td>±0.033% FS</td>
<td>±0.06% FS</td>
<td>±0.033% FS</td>
</tr>
</tbody>
</table>

Pressure Media

<table>
<thead>
<tr>
<th>Circuit</th>
<th>2-Wire, Protected from Misting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Effects</td>
<td>4 to 20 mA</td>
</tr>
</tbody>
</table>

Compensated Range "F (°C) | ±40 to +150 (+5 to +65) |

Environmental Data

<table>
<thead>
<tr>
<th>Excitation (for 0-5 VDC Output)</th>
<th>9 to 30 VAC /12 to 40 VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excitation (for 0-10 VDC Output)</td>
<td>110 to 380V /13 to 40 VDC</td>
</tr>
</tbody>
</table>

Excitation (for 0-5 VDC Output) | 4 to 20 mA |

Electrical Data (Voltage)

| Maximum Loop Voltage VDC | 30.0 ± 0.04 x (Resistance of Receiver plus line) |

Operating Temperature "F (°C) | ±65 to +180 (+54 to +82) |

Weight (approx.) 9.0 Ounces (255 grams)

Electronic Board

Static Duct Probe

PG-9 Strain Relief

9 Pin D-Sub Conn.

1/2” Conduit Opening

Phone: 800-257-3872 • Fax: 978-264-0292 • setra.com © Setra Systems, Inc. All rights reserved. The Setra Systems name and logo are registered trademarks of Setra Systems, Inc.
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 actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches.

The AFBUP-S N4, AFUXUP-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

<table>
<thead>
<tr>
<th>AFBUP N4, AFBUP-S N4, AFXUP N4, AFXUP-S N4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
</tr>
<tr>
<td>Power consumption</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Transformer sizing</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Electrical connection</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Overload protection</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>Torque</td>
</tr>
<tr>
<td>Direction of rotation</td>
</tr>
<tr>
<td>Mechanical angle of rotation</td>
</tr>
<tr>
<td>Running time</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Position indication</td>
</tr>
<tr>
<td>Manual override</td>
</tr>
<tr>
<td>Humidity</td>
</tr>
<tr>
<td>Ambient temperature</td>
</tr>
<tr>
<td>Storage temperature</td>
</tr>
<tr>
<td>Housing</td>
</tr>
<tr>
<td>Housing material</td>
</tr>
<tr>
<td>Agency listings †</td>
</tr>
<tr>
<td>Noise level</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Servicing</td>
</tr>
<tr>
<td>Quality standard</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Auxiliary switches</td>
</tr>
</tbody>
</table>

Dimensions (inches [mm])

<table>
<thead>
<tr>
<th>Clamp Configurations</th>
<th>1/2” Field Selectable</th>
<th>3/4” Centered (Default)</th>
<th>1.05” Centered (Field Selectable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D312_Diagram</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† Rated Impulse Voltage 4kV, Type of action 1 AA (1 AA.B for -S version), Control Pollution Degree 4.
**Accessories**

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>06</td>
<td>8mm and 10 mm wrench</td>
</tr>
<tr>
<td>00001</td>
<td>Gland (needed for additional wires)</td>
</tr>
<tr>
<td>0001</td>
<td>Gasket for Gland (needed for additional wires)</td>
</tr>
</tbody>
</table>

**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.

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

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

**Wiring Diagrams**

1. **AFBUP N4, AFBUP-S N4, AFXUP N4, AFXUP-S N4**
2. **Wiring Diagrams**
3. **On/Off wiring**
4. **Auxiliary Switches**
5. **WARNING Live Electrical Components!**
6. **APPLICATION NOTES**
7. **INSTALLATION NOTES**
8. **CAUTION Equipment Damage!**
9. **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.
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.


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 wear 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


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.
   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.
# SUBMITTAL SCHEDULE

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>SUBMITTAL REQUIREMENT</th>
<th>WITH BID</th>
<th>AS INDICATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 05 93-01</td>
<td>Upon completion of balancing Work, submit complete report consisting of data sheets covering phases of Work specified herein.</td>
<td>Before date of Substantial Completion</td>
<td></td>
</tr>
<tr>
<td>23 05 93-02</td>
<td>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”.</td>
<td>With record documents</td>
<td></td>
</tr>
<tr>
<td>23 05 93-03</td>
<td>Sign reports by person in charge of on-site Work.</td>
<td>With record documents</td>
<td></td>
</tr>
<tr>
<td>23 05 93-04</td>
<td>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.</td>
<td>Before date of Substantial Completion</td>
<td></td>
</tr>
<tr>
<td>ITEM NO.</td>
<td>SUBMITTAL REQUIREMENT</td>
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<td>--------------------------------</td>
</tr>
</tbody>
</table>
| 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 |

Before date of Substantial Completion
<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>SUBMITTAL REQUIREMENT</th>
<th>WITH BID</th>
<th>AS INDICATED</th>
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</thead>
</table>
| 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:  
                                      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                            |                                  |
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 L10) 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.
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:
2. Howden.
4. Industrial Air Products.
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

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>SUBMITTAL REQUIREMENT</th>
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<tbody>
<tr>
<td>23 34 16-01</td>
<td>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 &amp; operating), configuration, and duct connection sizes and locations. C. Materials of construction for housing and major components.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>23 34 16-04</td>
<td>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.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ITEM NO.</td>
<td>SUBMITTAL REQUIREMENT</td>
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</tbody>
</table>
| 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        |              |
<table>
<thead>
<tr>
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<th>AS INDICATED</th>
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</thead>
</table>
| 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 |
| **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 | 0.075 lb/ft³ | |
| 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 |
## EQUIPMENT DATA SHEET

### Centrifugal Fan

<table>
<thead>
<tr>
<th>Inlet Sound Power</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Octave</td>
<td>60</td>
</tr>
<tr>
<td>2nd Octave</td>
<td>65</td>
</tr>
<tr>
<td>3rd Octave</td>
<td>66</td>
</tr>
<tr>
<td>4th Octave</td>
<td>67</td>
</tr>
<tr>
<td>5th Octave</td>
<td>67</td>
</tr>
<tr>
<td>6th Octave</td>
<td>64</td>
</tr>
<tr>
<td>7th Octave</td>
<td>59</td>
</tr>
<tr>
<td>8th Octave</td>
<td>50</td>
</tr>
</tbody>
</table>

### MAXIMUM DIMENSIONS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Length</td>
<td>27”</td>
</tr>
<tr>
<td>Width</td>
<td>20”</td>
</tr>
<tr>
<td>Height</td>
<td>27”</td>
</tr>
<tr>
<td>Operating Weight</td>
<td>90 lbs</td>
</tr>
</tbody>
</table>

### 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
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.
  10. Electrical identification.
  11. Disconnect switches.
  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.


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:
At the completion of electrical system installation and at such time as CH2M HILL may indicate, conduct an operating test for acceptance.

Demonstrate that equipment operates in accordance with the Contract Documents.

Perform test in presence of CH2M HILL.

Furnish instruments and personnel required for the test.

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.

Test References:
3. Association of Edison Illuminating Companies (AEIC).
4. Institute of Electrical and Electronics Engineers (IEEE).
5. Insulated Power Cable Engineers Association (IPCEA).
7. National Electrical Manufacturer's Association (NEMA).
10. State and local codes and ordinances.

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.

Responsibilities:
1. 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.

2. The Owner's electrical engineer will furnish settings of protective devices unless a power system study has been required elsewhere in these Specifications.

Implementation:
1. 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.

2. 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.

3. 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.
      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:

<table>
<thead>
<tr>
<th>System Voltage</th>
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</table>

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MAY 28, 2015– Rev.0

Basic Electrical Construction Materials and Methods

26 05 02 - 14
<table>
<thead>
<tr>
<th>Conductor</th>
<th>480Y/277V</th>
<th>208Y/120V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Brown</td>
<td>Black</td>
</tr>
<tr>
<td>Phase B</td>
<td>Orange</td>
<td>Red</td>
</tr>
<tr>
<td>Phase C</td>
<td>Yellow</td>
<td>Blue</td>
</tr>
<tr>
<td>Neutral</td>
<td>White with orange stripe</td>
<td>White</td>
</tr>
<tr>
<td>Grounding</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Switchleg (lighting)</td>
<td>Purple</td>
<td>Pink</td>
</tr>
</tbody>
</table>

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.
   3. 480-Volt, Three-Phase System: Blue.
   5. Grounding: Green.
   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

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

END OF SECTION
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.
   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.
### SUBMITTAL SCHEDULE

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>SUBMITTAL REQUIREMENT</th>
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<tr>
<td>26 29 23-01</td>
<td>Catalog cut-sheets, other descriptive literature</td>
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<tr>
<td>26 29 23-02</td>
<td>Enclosure external and internal layout drawings with bill of material, dimensions and openings</td>
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<td>Weights</td>
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<td>Speed range and output frequency range in Hertz</td>
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<td>Maximum continuous output horsepower operating capability</td>
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<tr>
<td>26 29 23-08</td>
<td>Maximum short-term (60-second duration) horsepower without shutdown or damage to AFD</td>
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<tr>
<td>26 29 23-09</td>
<td>Maximum input current under rated load and in speed range for conductor sizing</td>
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<td>26 29 23-10</td>
<td>Recommended sizes for line overcurrent protection</td>
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<td>Fault duty withstand capability in symmetrical amperes</td>
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<td>Efficiency under rated load at 60, 45, 30, and 15 Hz</td>
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<td>Mounting, including seismic</td>
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<td>Data sheets</td>
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<td>Instruction and technical manuals</td>
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<td>Spare parts list and pricing</td>
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END OF SECTION
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:
   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
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.
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. 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.

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

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<tr>
<th>ITEM NO.</th>
<th>SUBMITTAL REQUIREMENT</th>
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<td>Continuity tests</td>
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<td>Operational Acceptance Test (OAT)</td>
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<td></td>
<td>Functional Acceptance test (FAT)</td>
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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. 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.
   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.

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.


10. Instrument specifications.

11. Instrument check out sheet w/signatures.

12. Factory calibration sheets.

END OF SECTION