TETRA TECH

MEMORANDUM

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From: John P. Toomey, P.E., Tetra Tech
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Date: **November 2, 2012**

Re: **Altamonte Springs RWRF Blower Evaluation**

Tt #: **200-71229-12002**

Background, Purpose, & Scope

The City of Altamonte Springs Regional Water Reclamation Facility (RWRF) has a permitted design capacity of 12.5 million gallons per day (MGD) on an average annual daily flow (AADF) basis. The current AADF is approximately half of the permitted value and the facility maintains consistent compliance with regulatory agency permit requirements related to effluent quality.

The aeration facilities at the plant include six multistage centrifugal blowers, a fine pore diffused aeration system for the treatment process, and a coarse bubble diffused aeration system for the aerated sludge holding tanks. Four of the blowers discharge to a common manifold that serves the process basin and the two remaining blower have a separate manifold that provides air to the sludge holding facilities, however, for reliability purposes, the two manifolds are interconnected The blowers have been in operation for over 20 years and the City is considering replacement of one or two of the units that serve the process basins with newer more efficient machinery that is appropriately sized for current and near-term air demands. Also, the City intends to install dedicated blowers adjacent to the sludge holding tanks to simplify process operation and avoid some rather expensive piping replacement that would necessary if the current piping configuration were to remain intact.

In view of the above considerations the City retained Tetra Tech to develop and evaluate various blower replacement options. This memorandum presents findings, conclusions, and recommendations resulting from the evaluation of several equipment options; however, it should be noted that this assignment does not address diffused aeration system replacements for the process basin or the aerated sludge holding tanks.

Wastewater Flows & Characteristics

In order to properly estimate oxygen demands and air requirements, it is necessary to examine to plant's operating data. This examination must first address average flow and influent concentrations of 5-day carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids (TSS), and total Kjeldahl nitrogen (TKN). Further, maximum monthly flow (MMF) and maximum daily flow (MDF) must be considered along with average, maximum monthly, and maximum daily mass loadings. In view of need for a comprehensive data analysis, Tables 1, 2, and 3 have been prepared to present detailed data pertaining to flows, influent characteristics, mass loadings, and peaking ratios for each of the past three calendar years. Table 4 presents a condensed summary of the data provided in the first three tables.

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TABLE 1
FLOWS, INFLUENT CHARACTERISTICS & PEAKING FACTORS FOR 2009

Month	Influent Flows (MGD)		Influent Concentrations (mg/L)			Mass Loadings (lbs/day) CBOD$_5$		Mass Loadings (lbs/day) TSS		Mass Loadings (lbs/day) TKN	
	Average	Maximum Day	Average CBOD$_5$	Average TSS	Average TKN	Average Day	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day
January 2009	5.6	6.0	226	264	51	10,451	12,591	12,250	19,708	2,362	2,943
February 2009	5.5	5.8	249	294	51	11,538	25,315	13,648	46,621	2,366	3,335
March 2009	5.6	6.3	195	235	46	9,156	12,498	11,005	14,306	2,146	2,399
April 2009	5.6	6.3	194	269	44	8,910	10,890	12,368	20,403	2,057	2,340
May 2009	6.0	7.0	205	263	37	10,177	13,954	13,205	23,245	1,826	2,200
June 2009	6.4	7.2	165	219	35	8,833	14,051	11,711	19,483	1,840	2,067
July 2009	6.2	6.9	210	287	46	10,846	39,694	14,913	71,726	2,402	2,971
August 2009	6.1	6.5	187	272	46	9,446	21,581	13,724	35,724	2,296	2,643
September 2009	5.9	6.4	231	320	39	11,392	17,971	15,761	29,157	1,894	2,355
October 2009	5.7	6.7	261	347	46	11,461	27,760	16,704	38,086	2,243	2,627
November 2009	5.6	5.7	264	375	57	12,356	20,298	17,551	31,787	2,675	3,211
December 2009	5.8	6.3	275	402	59	13,357	23,089	19,513	40,835	2,880	3,332
Annual Average	5.8		222	296	46	10,660		14,363		2,249	
Maximum Month	6.4					13,357		19,513		2,880	
Maximum Day		7.2					39,694		71,726		3,335
Peaking Factors											
MMF/AADF	1.11		MM Mass Loading/AA Mass Loading			1.25		1.36		1.28	
MDF/AADF	1.24		MD Mass Loading/AA Mass Loading			3.72		4.99		1.48	

Abbreviations

AADF	Annual Average
AADF	Annual Average Daily Flow
MDF	Maximum Daily Flow
MDF	Maximum Daily
MDF	Maximum Daily Flow
MM	Maximum Monthly
MMF	Maximum Monthly Flow

TABLE 2
FLOWS, INFLUENT CHARACTERISTICS & PEAKING FACTORS FOR 2010

Month	Influent Flows (MGD)		Influent Concentrations (mg/L)			Mass Loadings (lbs/day)					
						$CBOD_5$		TSS		TKN	
	Average	Maximum Day	Average $CBOD_5$	Average TSS	Average TKN	Average Day	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day
January 2010	5.8	6.5	247	346	57	11,923	17,994	16,657	31,539	2,732	3,033
February 2010	5.9	6.3	242	412	42	11,798	22,193	20,125	42,180	2,065	2,454
March 2010	6.1	6.9	240	336	43	12,278	23,309	17,145	56,639	2,186	3,225
April 2010	6.1	6.9	233	347	42	11,801	22,916	17,648	45,190	2,127	2,388
May 2010	6.2	6.9	224	329	42	11,491	18,711	16,237	36,186	2,052	2,966
June 2010	5.7	6.2	194	248	53	9,205	17,126	11,840	27,178	2,536	2,940
July 2010	6.1	6.8	194	295	44	9,969	17,396	15,206	43,024	2,261	2,645
August 2010	6.3	6.7	166	291	47	8,724	13,322	15,243	27,775	2,487	3,891
September 2010	6.1	6.7	215	318	39	10,911	18,603	16,092	37,530	1,996	2,373
October 2010	6.1	6.7	194	300	49	9,774	13,669	14,352	25,592	2,322	2,755
November 2010	5.5	5.9	192	269	44	8,864	12,866	12,436	17,765	1,932	2,449
December 2010	5.5	6.0	208	243	40	9,538	12,311	11,138	19,370	1,829	2,119
Annual Average	5.9		212	311	45	10,523		15,343		2,210	
Maximum Month	6.3					12,278		20,125		2,732	
Maximum Day		6.9					23,309		56,639		3,891
Peaking Factors											
MMF/AADF	1.05		MM Mass Loading/AA Mass Loading			1.17		1.31		1.24	
MDF/AADF	1.16		MD Mass Loading/AA Mass Loading			2.22		3.69		1.76	

Abbreviations

AADF	Annual Average
AADF	Annual Average Daily Flow
MDF	Maximum Daily Flow
MDF	Maximum Daily
MDF	Maximum Daily Flow
MM	Maximum Monthly
MMF	Maximum Monthly Flow

TABLE 3
FLOWS, INFLUENT CHARACTERISTICS & PEAKING FACTORS FOR 2011

Month	Influent Flows (MGD)		Influent Concentrations (mg/L)			Mass Loadings (lbs/day)					
						$CBOD_5$		TSS		TKN	
	Average	Maximum Day	Average $CBOD_5$	Average TSS	Average TKN	Average Day	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day
January 2011	5.5	6.0	224	270	44	10,301	14,680	12,449	28,201	2,022	2,428
February 2011	5.5	5.8	197	302	44	9,019	10,983	13,857	20,399	2,009	2,609
March 2011	5.4	6.9	210	270	48	9,525	13,522	12,311	20,391	2,180	3,128
April 2011	6.0	6.3	200	254	55	9,979	13,547	12,616	20,356	2,733	3,547
May 2011	5.8	6.9	195	263	64	9,447	14,962	12,728	24,737	3,071	3,830
June 2011	5.7	6.4	193	259	61	9,010	12,612	12,163	20,088	2,833	4,306
July 2011	6.0	6.5	206	312	39	10,265	17,582	15,421	21,808	1,899	2,443
August 2011	6.1	6.9	198	278	50	9,999	18,587	14,015	29,120	2,505	3,121
September 2011	6.0	6.7	209	283	43	10,521	19,630	14,372	36,976	2,117	2,718
October 2011	6.6	8.0	204	270	50	11,026	15,918	14,618	22,763	2,727	3,081
November 2011	5.3	5.8	230	272	73	10,105	12,639	12,845	19,242	3,416	4,732
December 2011	5.5	6.4	251	327	78	11,455	15,653	14,969	32,410	3,558	4,315
Annual Average	5.78		210	280	54	10,054		13,530		2,589	
Maximum Month	6.55					11,455		15,421		3,558	
Maximum Day		7.98					19,630		36,976		4,732
Peaking Factors											
MMF/AADF	1.13		MM Mass/AA Mass			1.14		1.14		1.37	
MDF/AADF	1.38		MD Mass/AA Mass			1.95		2.73		1.83	

Abbreviations

AADF	Annual Average
AADF	Annual Average Daily Flow
MDF	Maximum Daily Flow
MDF	Maximum Daily
MDF	Maximum Daily Flow
MM	Maximum Monthly
MMF	Maximum Monthly Flow

TABLE 4
SUMMARY OF FLOWS, INFLUENT CHARACTERISTICS & PEAKING FACTOR DATA

Parameter	Year		
	2009	2010	2011
AADF	5.8 MGD	6.0 MGD	5.8 MGD
MMF • Flow Value • MMF/AADF Ratio	 6.5 MGD 1.11	 6.3 MGD 1.05	 6.6 MGD 1.13
MDF • Flow Value • MDF/AADF Ratio	 7.2 MGD 1.24	 6.9 MGD 1.16	 8.0 MGD 1.38
Influent $CBOD_5$ • Average Concentration • MM/AA Mass Ratio • MD/AA Mass Ratio	 222 mg/L 1.25 3.72	 212 mg/L 1.17 2.22	 210 mg/L 1.14 1.95
Influent TSS • Average Concentration • MM/AA Mass Ratio • MD/AA Mass Ratio	 296 mg/L 1.36 4.99	 311 mg/L 1.31 3.69	 280 mg/L 1.14 2.73
Influent TKN • Average Concentration • MM/AA Mass Ratio • MD/AA Mass Ratio	 46 mg/L 1.28 1.48	 45 mg/L 1.24 1.76	 54 mg/L 1.37 1.83

The flow data shows the AADF ranging from 5.8 to 6.0 MGD; therefore, the existing AADF for the various analyses can be safely assumed to equal 6.0 MGD. The City has indicated that growth rates will be very modest for the near-term and that a gradual increase of 2.0 MGD over the next 10 years should be assumed. This results in an AADF of 8.0 MGD in 10 years.

Over the past three years the influent $CBOD_5$, TSS, and TKN concentrations averaged 215, 296, and 48 mg/L, respectively. The data showed very little annual variation; therefore, influent $CBOD_5$, TSS, and TKN concentrations of 220, 300, and 50 mg/L, respectively, appear to be reasonable values for use in estimating oxygen demands and sludge production rates for the analyses covered in this assignment.

The MMF:AADF peaking factors for the last three years ranged from 1.05 to 1.13 and averaged 1.10. The MM:AA mass loading factors for this time period ranged from 1.14 to 1.37 depending upon the parameter under consideration and the average MM/AA mass loading factor considering all of the parameters equaled 1.25. The peaking factor for MMF appears to be somewhat low when compared to values found in other systems; however, the mass loading factors are considered to be typical. For the purposes of this study a MMF/AADF peaking factor of 1.30 is considered to be a reasonable value that will yield conservative results. It should be noted that this value should simply be applied to the AADF to determine the estimated MMF, which, in turn, can be used to calculate estimated maximum monthly mass loadings based on annual average influent concentrations for the various parameters. It is not necessary to apply this peaking factor to flow and concentration values simultaneously as this would result in unreasonably high mass loadings.

The MDF:AADF peaking factors for the last three years ranged from 1.16 to 1.38 and averaged 1.26. The MD:AA mass loading factors for $CBOD_5$ and TSS showed some extremely high values as well as significant variability. This is somewhat expected due to daily sampling variations and the nature of the $CBOD_5$ and TSS tests. In contrast, the MD/AA peaking factor for TKN ranged from 1.48 to 1.83 and averaged 1.69. The TKN concentrations result from a standardized chemical analysis and they do not show unexpectedly high peaking ratios; therefore, the TKN mass loading values could be considered more representative of the "true maximum day peaking factor". In view of the flow and TKN peaking data an MDF:AADF peaking factor of 1.70 is considered reasonable for use in this study. As is the case with the MMF:AADF ratio, it is not necessary to apply this peaking factor to flow and concentration values simultaneously as this would result in unreasonable high mass loadings.

When evaluating aeration systems is not usually necessary to consider short term peak events, such as the peak hourly flow (PHF). This is because the process tanks are relatively large in comparison to the influent flow and they act as a "buffer" with respect to mass loadings. Further, the quasi-complete mix regimes that are often found in treatment systems result in dispersion of any "slugs" so that they do not result in significant variations in effluent quality. In view of these factors, PHFs have not been considered. A summary of the projected flows, influent characteristics and peaking factors resulting from the various analyses described above are presented in Table 5.

TABLE 5
SUMMARY OF PROJECTED FLOWS, INFLUENT CHARACTERISTICS & MASS LOADINGS

Parameter	Time	
	Current (2013)	10 Years (2022)
Flows • AADF • MMF • MDF	6.0 MGD 7.8 MGD 10.2 MGD	8.0 MGD 10.4 MGD 13.6 MGD
Influent $CBOD_5$ • Average Concentration • Average Annual Loading • Maximum Monthly Loading • Maximum Daily Loading	220 mg/L 11,009 lbs/day 14,311 lbs/day 18,715 lbs/day	220 mg/L 14,678 lbs/day 19,082 lbs/day 11,009 lbs/day
Influent TSS • Average Concentration • Average Annual Loading • Maximum Monthly Loading • Maximum Daily Loading	300 mg/L 15,012 lbs/day 19,516 lbs/day 25,520 lbs/day	300 mg/L 20,016 lbs/day 26,021 lbs/day 34,027 lbs/day
Influent TKN • Average Concentration • Average Annual Loading • Maximum Monthly Loading • Maximum Daily Loading	50 mg/L 2,502 lbs/day 3,253 lbs/day 4,253 lbs/day	50 mg/L 3,336 lbs/day 4,337 lbs/day 5,671 lbs/day
Notes: 1. MMF:AADF Peaking Factor = 1.30. 2. MDF:AADF Peaking Factor = 1.70. 3. Flows and loadings for intermediate years may be found by linear interpolation.		

Process Aeration Requirements

Air is required for the biological treatment process for $CBOD_5$ removal and nitrification. The Modified Ludzack-Ettinger (MLE) process provides some level of nitrogen removal and the reactions involved in the process result in an "oxygen credit" that mitigates the overall oxygen demand to a modest degree. In order to properly evaluate aeration alternatives, it is first necessary to estimate oxygen demands under current, near-term, and "permitted capacity" conditions. Water Environment Federation Manual of Practice No. 8 (WEF MOP-8) presents relatively straight-forward methodologies to estimate oxygen requirements which are applicable to the MLE process. Table 6, below presents the estimated oxygen requires for current, near-term, and permitted flows using the WEF MOP-8 methodology.

TABLE 6
SUMMARY OF PROJECTED OXYGEN REQUIREMENTS

Parameter	Time/Condition		
	Current (2013)	10 Years (2022)	Permitted Capacity
Flows • AADF • MMF • MDF	6.0 MGD 7.8 MGD 10.2 MGD	8.0 MGD 10.4 MGD 13.6 MGD	12.5 MGD 10.4 MGD 13.6 MGD
Oxygen Requirements • AADF • MMF • MDF	16,653 lbs/day 21,445 lbs/day 27,595 lbs/day	22,116 lbs/day 28,387 lbs/day 36,422 lbs/day	34,013 lbs/day 43,355 lbs/day 55,145 lbs/day

Notes:
1. MMF:AADF Peaking Factor = 1.30.
2. MDF:AADF Peaking Factor = 1.70.
3. Flows and loadings for intermediate years may be found by linear interpolation.

In order to develop and assess blower options the values presented above must be used to calculate volumetric air requirements. WEF MOP-8 includes specific methodology that facilitates the estimation such air requirements based on several factors such as temperature, tank depth, clean water oxygen transfer efficiency, barometric pressure, and operating dissolved oxygen (DO) concentration. Table 7, below summarizes the estimated air flows needed to provide the oxygen transfer rates presented in Table 6 using the WEF MOP methodology.

TABLE 7
SUMMARY OF PROJECTED AIR REQUIREMENTS

Parameter	Time/Condition		
	Current (2013)	10 Years (2022)	Permitted Capacity
Air Requirements			
• AADF	5,206 SCFM	6,928 SCFM	10,633 SCFM
• MMF	6,730 SCFM	8,925 SCFM	13,606 SCFM
• MDF	7,737 SCFM	10,288 SCFM	15,461 SCFM

Notes:
1. Air requirements are based on the follow conditions and constants:
   - α = 0.55
   - β = 0.95
   - Barometric Pressure = 14.7 psi
   - Tank Liquid Depth = 15.9 feet
   - Temperature = 20° C
   - Standard Oxygen Transfer Efficiency = 30%
   - Operating DO @ AADF & MMF = 2.0 mg/L
   - Operating DO @ MDF = 1.0 mg/L
2. Air requirements for intermediate years may be found by linear interpolation.

As previously stated the existing aeration system includes six multi-stage centrifugal blowers that serve both the biological treatment process and the sludge holding basins. Curves provided by the manufacturer (Hoffman/Gardner-Denver) indicate that each machine is capable of delivering 4,800 SCFM at a discharge pressure of 8.0 psi. Figure 1 presents a copy of the performance curve for the existing blowers.

In order to achieve more economical aeration, the City would like to replace some of the existing blowers with new, more efficient machinery that has the ability to meet wide variations in air demands. Further, the City desires to maintain the current permitted capacity of 12.5 MGD; therefore, the system must be capable of delivering approximately 15,500 SCFM with the largest unit out of service. To meet these goals it is suggested that the City consider replacing two of the existing multistage centrifugal units with blowers rated for 3,500 SCFM each. Under this concept the smaller more efficient machines would provide sufficient air for AADFs for the next 10 years and a "firm capacity" of 21,400 SCFM will be provided, which is more than adequate to address the process aeration needs at the plant's permitted capacity. In fact the firm capacity provided under this scenario is such that only one new dedicated blower would need to be installed at the aerated sludge holding basin if the interconnecting piping between the two systems remains intact.

<u>**Process Aeration Blower Options**</u>

There appear to be three basic equipment options that merit consideration for the new process aeration blowers. Each option is described below.

Multistage Centrifugal Blowers: Replacing two of the existing 300 horsepower blowers with smaller more efficient multi-stage units would provide energy savings by providing a greater range of efficient

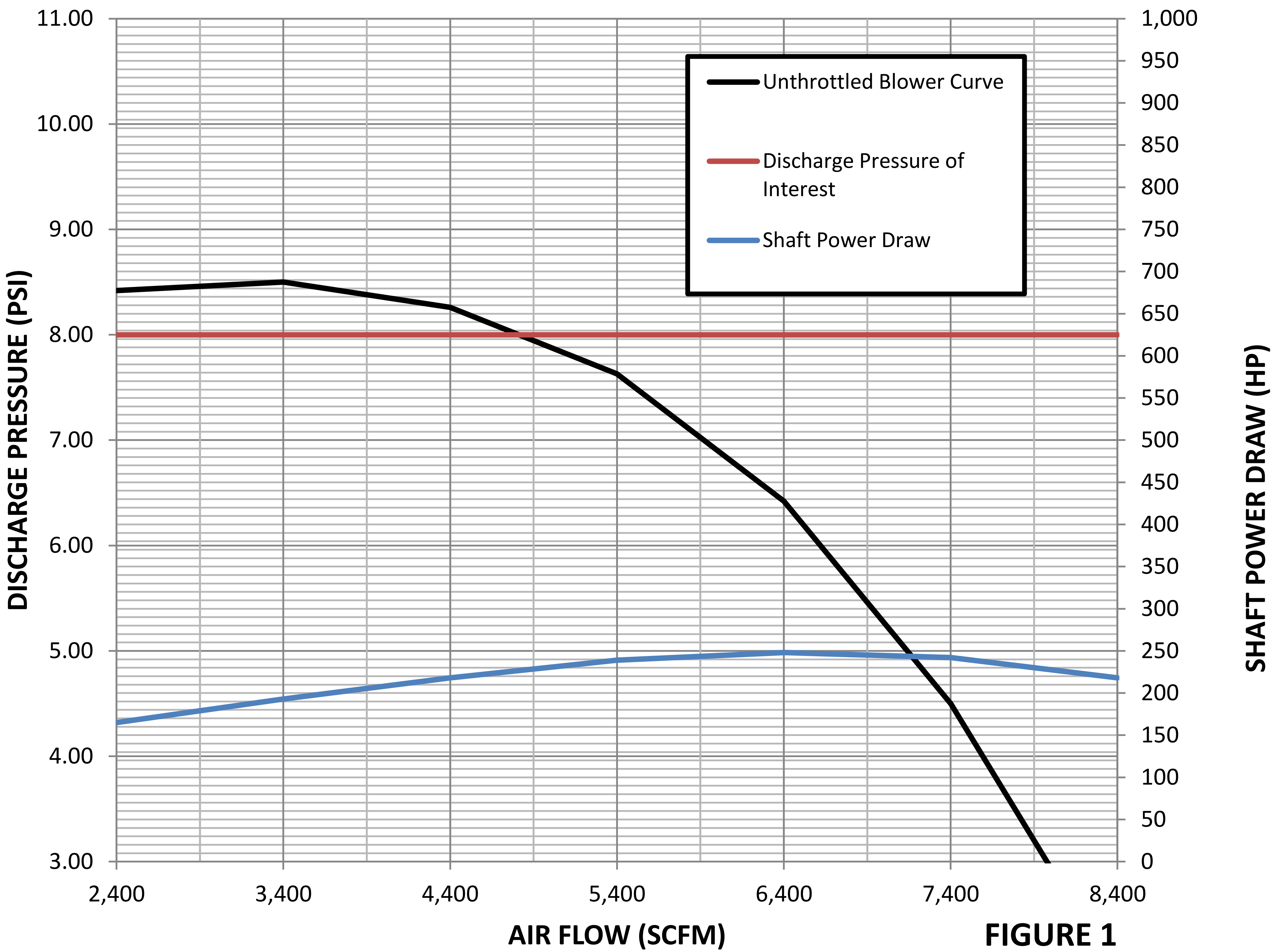


FIGURE 1

EXISTING BLOWER PERFORMANCE CURVE

operation or better “turndown” and improved compression efficiency. The units supplied under this option would be very similar to the existing units; however, they would be smaller and have 200 horsepower drive motors. Attachment A presents manufacturer’s cut sheets and performance curves for this option.

High-Efficiency Turbo Blowers: The latest high efficiency blower technology involves high-speed blowers with air bearings that accommodate rotational speeds of 20,000 to 30,000 RPM. These machines are very small in physical size when compared to multi-stage centrifugal or rotary positive displacement units and they feature a unitized package that includes the blower, variable frequency drives, and controls. As is the case with smaller multistage units, replacing two of the existing 300 horsepower blowers with smaller more efficient turbo units would provide energy savings by providing a better turndown and improved compression efficiency. Attachment B presents manufacturer’s cuts sheet and performance curves for this option.

Rotary Positive Displacement Blowers: The third option for provision of smaller more efficient blowers involves the installation of two rotary positive displacement blowers. This type of blower feature pairs of rotating lobes that provide air delivery in direct proportion to blower speed at efficiencies that are slightly less than those published for multi-stage centrifugal or turbo blowers. The lobes are usually straight; however, an axially twisted configuration is available that improves compression efficiency and lowers noise emissions. These blowers are usually furnished in a unitized package that includes the blower, variable frequency drive, and controls. Once again, replacing two of the existing 300 horsepower blowers with smaller more efficient units would provide energy savings by providing a better turndown and improved compression efficiency. Attachment C presents manufacturer’s cuts sheet and performance curves for this option.

Plotting the power requirements and allowable range of air delivery for the existing machinery and potential blower options provides a useful “initial comparison” of alternatives. Accordingly, Figure 2 presents the total power draw and operating range for the existing blowers as well as the smaller multistage, turbo, and rotary positive displacement machines.

Review of Figure 2 yields three clear conclusions:

1. All of the replacement blower options are considerably more efficient than the existing blowers when air flow is in the range of approximately 2,500 to 3,500 SCFM.
2. All three blower replacement options have similar efficiencies when air deliveries are in range of 2,500 to 3,500 SCFM.
3. The rotary positive displacement blower option has better turndown than the other two replacement options.

In the absence of hourly flow, loading, and air flow data it is typical to consider air requirements at AADF conditions when comparing annual operating and present worth costs. It is understood that air demands will vary throughout the day, but considering the AADF condition provides a useful “baseline comparison” that reflects the relative compression efficiency of the options under consideration. Accordingly, Table 8 presents the estimated capital, annual operating and present worth costs for each of the blower options.

Table 8 shows present worth values ranging from approximately $1,681,000 to $1,847,000 and the turbo blower option as the most economical selection. The rotary positive displacement blowers carry a higher present worth cost, but the premium is only about 10%.

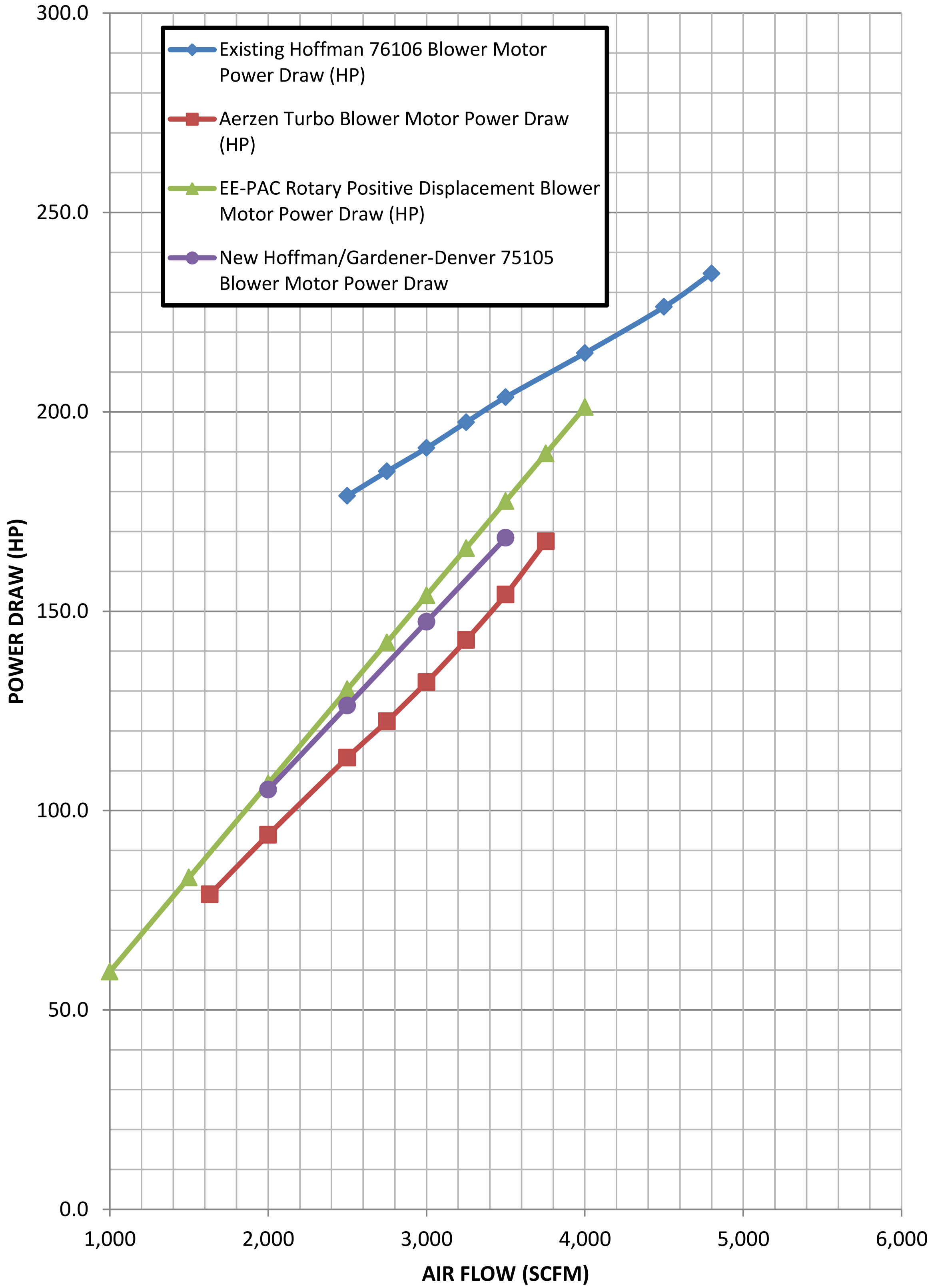


FIGURE 2
GRAPHICAL COMPARISON OF BLOWER PERFORMANCE & TURNDOWN

TABLE 8
ESTIMATED CAPITAL, OPERATING, & PRESENT WORTH COSTS FOR PROCESS BLOWERS

		New Multi-Stage Centrifugal Blowers			High Efficiency Turbo Blowers			Rotary Positive Displacement Blowers		
CAPITAL COSTS										
Blower Equipment				$164,000			$240,000			$200,000
Piping Modifications				$31,000			$31,000			$31,000
Tax, Overhead, Profit, & Installation				$65,600			$96,000			$80,000
Sub-Total				$260,600			$367,000			$311,000
Engineering & Contingency				$52,120			$73,400			$62,200
Total Capital Cost				**$312,720**			**$440,400**			**$373,200**
POWER COSTS										
Year	**Air Required @ AADF (SCFM)**	**Total Operating Power (HP)**	**Annual Power Cost, $/year**	**Present Worth of Power Cost**	**Total Operating Power (HP)**	**Annual Power Cost ($/year)**	**Present Worth of Power Cost**	**Total Operating Power (HP)**	**Annual Power Cost, $/year**	**Present Worth of Power Cost**
1	5,210	257	167,845	157,601	234	$152,774	$143,450	273	$178,597	$167,697
2	5,401	274	178,852	157,686	241	$157,473	$138,838	279	$182,480	$160,885
3	5,592	284	185,730	153,757	248	$162,350	$134,401	294	$192,186	$159,101
4	5,783	291	189,858	147,581	255	$166,949	$129,773	300	$196,069	$152,409
5	5,974	291	189,858	138,574	264	$172,220	$125,700	342	$223,247	$162,943
6	6,166	295	192,609	132,002	272	$177,506	$121,651	321	$209,658	$143,686
7	6,357	305	199,488	128,372	280	$182,747	$117,599	330	$215,481	$138,664
8	6,548	326	213,246	128,850	288	$187,975	$113,580	339	$221,305	$133,720
9	6,739	337	220,125	124,889	296	$193,458	$109,759	351	$229,070	$129,964
10	6,930	341	222,877	118,732	305	$199,220	$106,130	359	$234,894	$125,134
10-Year PW of Power Costs				**$1,388,043**			**$1,240,880**			**$1,474,202**
TOTAL PRESENT WORTH				**$1,700,763**			**$1,681,280**			**$1,847,402**

Notes:
1. Two blowers are operating at all time; however, air deliver is matched to demand. Inlet throttling is assumed for muti-stage centrifugal blowers while speed adjustment is assumed for turbo and rotary positive displacement blowers.
2. The total operating horsepower values presented reflect total power draw and include applicable allowances to address motor and VFD efficiencies.
3. Power costs are based on a unit cost for energy of $0.10/kWh.
4. Present worth costs are based on a discount rate of 6.5%.

When evaluating blower options it is important to carefully consider turndown in the overall analysis. In the case of the Altamonte Springs WRF, it is assumed that a low flow condition occurs from about midnight to 6:00 am which results in a fairly steady flow of about 3 MGD. During this period the air demand for treatment is about 2,600 SCFM; however, properly mixing the basin necessitates an air flow of approximately 3,000 SCFM. If one of the existing multistage blowers is used to deliver 3,000 SCFM the resulting power draw equals approximately 191 horsepower if inlet throttling is practiced. In contrast, the smaller replacement blowers would draw between 130 and 150 horsepower during the 6-hour low-flow period depending upon which type of equipment is selected. On an annual basis, the replacement blowers could result in a savings ranging from about $7,000 to $10,000/year. Without inlet throttling, an existing multistage blower will draw about 240 horsepower and annual cost savings associated with the replacement machinery would range from $15,000 to $18,000/year. Based on these values, it is clear that provision of smaller more efficient blowers can result in significant savings once the process and sludge holding basin air requirements are segregated.

Based on the present worth cost evaluation and the values presented above with regard to aeration during low-flow periods, it is apparent that the high-efficiency turbo blowers offer a modest economic advantage. The multistage centrifugal blowers have economic characteristics similar to the turbo blower; however, to achieve turndown via inlet throttling a modulating valve would be necessary and concerns related to control complexity and surging make this option less desirable. The rotary positive displacement blower option carries the highest present worth cost, but as previously stated, it is comparable in cost to the other alternatives. Precise air flow control, the use of well-proven technology, a wide turndown range, and the provision of a programmable logic controller that only requires an input DO signal compensates for a slightly higher cost of the rotary positive displacement blower packages; therefore, they are considered to be equal to the turbo units in terms of desirability. To facilitate a final selection, it is suggested that City Staff visit local installations featuring both types of equipment and make a decision based on operator preference.

Supplemental Aeration Basin Mixing

Each existing aeration basin is comprised on three "zones" that include separate diffuser grids. Zone 1 is located at the west end of the basin and it receives mixed liquor from the anoxic basin. This zone has the highest oxygen demand since the flow exiting the anoxic basin is basically a mixture of raw wastewater and return activated sludge. Zone 2 is immediately downstream of Zone 1 and it can be generally described as the middle one-third of the aeration basin. The oxygen demand in Zone 2 is usually fairly small, particularly when two aeration basins are being operated in parallel. Zone 3 is the final section of the aeration basin and it has a very low oxygen demand in comparison to the two upstream zones. The plant operations staff keeps data regarding the measured DO concentrations in each zone. Figure 3 presents a graphical summary of this data.

As shown in Figure 3, the DO levels in Zone 1 are fairly low and rise in downstream zones as oxygen demands are satisfied. The data shows that the average DO concentration in Zone 1 is 1.0 mg/L while DO levels in Zones 2 and 3 equal 2.4 mg/L and 4.1 mg/L, respectively.

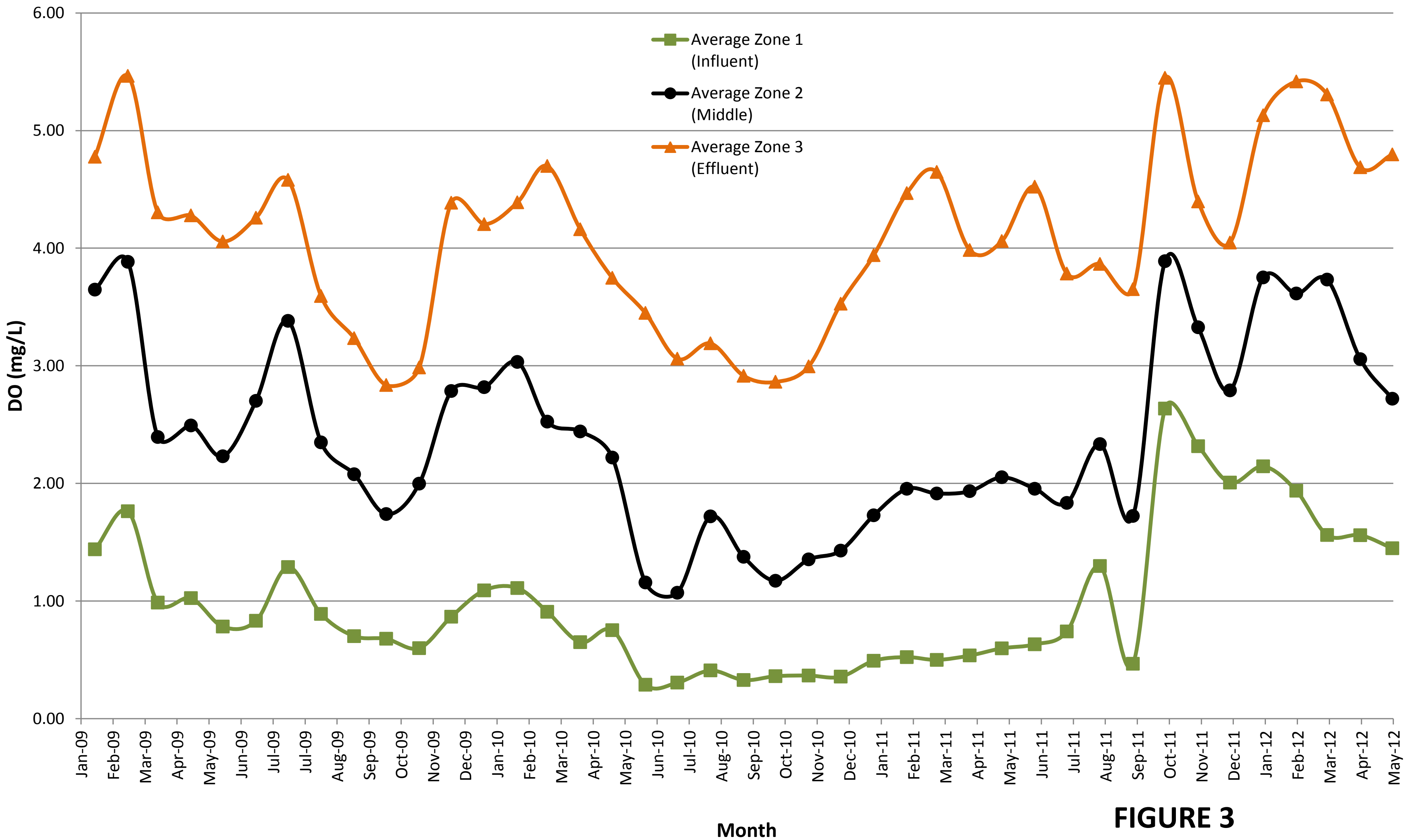


FIGURE 3

AERATION BASIN DO CONCENTRATIONS

The DO values in the first two zones are within a reasonable range while the DO in Zone 3 is quite high. The plant operations staff has attempted to obtain the lower DO concentration in Zone 3 by adjusting the butterfly valves in the droplegs for Zone 3. Unfortunately, decreasing the air delivery to this zone results in mixing problems and settling within the aeration basin.

The high DO levels in Zone 3 are not particularly problematic; however, if lower DO concentrations were obtained by decreasing air supply, lower power costs could be realized. Also, lowering the DO level in Zone 3 would enhance dentrification in the anoxic portion of the treatment process.

The situation described above is not uncommon and it occurs frequently in facilities when they are operating below their rated capacity. The most common corrective measure involves installing dedicated mixing equipment in the zones where DO is found to be high. This results in efficient mixing and minimal air requirements. In the case of the City's plant, one 7.4 horsepower submersible mixer could be installed in Zone 3 for each process train to provide mixing and very little air would need to be provided to maintain acceptable process conditions. Installation of these mixers would necessitate a capital investment of approximately $135,000 and annual power costs for the mixers would be in the range of $9,700/year. Fortunately, the air supplied to Zone 1 could be decreased by about 1,200 SCFM, which would decrease the overall blower operating power needs by 51 horsepower. This would result in a net annual cost savings of approximately $23,600/year. At this level of savings, the payback period for the mixers will be about 6 years. Typically, a payback of less than 10 years is considered desirable; therefore, installing the mixers can be considered a reasonable investment.

Sludge Holding Basin Aeration Requirements

Currently, mixed liquor is wasted from the aeration basins to gravity thickeners to maintain solids inventory within the activated sludge treatment process. The thickeners concentrate the mixed liquor to produce waste activated sludge (WAS) which has a solids content of about 1.2 percent solids by weight (1.2% DS). The thickened WAS is transferred to three 0.400 million gallon (MG) aerated holding tanks and is subsequently pumped to belt filter presses for dewatering.

At current flows WAS is transferred to the holding tanks at a rate of approximately 70,000 gallons per day (GPD) which results in an average detention time of about 17 days. Operating data indicates that the temperature of the sludge averages nearly 28° C annually. The volatile suspended solids (VSS) destruction curve published by the EPA indicates that under the current operating conditions VSS reduction within the holding tanks should be in the range of 35%. Unfortunately, detailed plant operation data shows no significant VSS destruction. The lack of biological activity within the holding tanks does not appear to be a result of insufficient aeration although the average operating DO values within the tanks are somewhat lower than those typically found in aerobic digesters.

Based on the above, it is apparent that sizing blowers for the sludge holding system based on oxygen requirements resulting from the current data will not yield reasonable results. Prior to the implementation of stringent VSS reduction requirements, it was common practice to base blower sizing for aerobic digesters and aerated holding tanks on a mixing intensity value that ranged from 20 to 40 SCFM per 1,000 cubic feet of tank volume (20 – 40 SCFM/1,000 CF). The current edition of the generally accepted design guidance publication known as “10 State Standards” sets forth an aeration rate of 30 SCFM/1,000 CF, which is probably the most common value used to design sludge holding tank aeration systems. In view of these factors, a design aeration rate of 30 SCFM/1,000 CF is considered appropriate for comparison of blower equipment. This criterion results in a total air flow rate of 4,800 SCFM for the three 0.400 MG holding basins. It should be noted that it would not be surprising to observe adequate mixing and DO levels at lower aeration intensities in the range of 15 to 20 SCFM/1,000 CF; therefore, once again, turndown in air delivery is an important consideration

Aerated Sludge Holding Tank Blower Options

Multi-stage centrifugal blowers have very “flat” delivery curves which make them somewhat undesirable in applications that involve varying water depths. Since the levels in the holding tanks vary, centrifugal blowers do not appears to merit consideration as an option for the dedicated holding tank blower. In view of this factor, the following options appear feasible.

High-Efficiency Turbo Blowers: A single high-efficiency turbo blower similar to the units considered for process aeration could be installed adjacent to the sludge holding basins to act as the primary source of air for the basins. The existing multi-stage centrifugal blowers located in the blower building would act as a back-up source air in the event that the new turbo blower becomes inoperable. Attachment D presents manufacturer’s cuts sheet and performance curves for this option.

Rotary Positive Displacement Blowers: This type of blower is similar to the rotary positive displacement machinery considered for process aeration; however, it would have straight lobes rather than helical lobes. As in the case with the turbo blower, a single unit could be installed adjacent to the sludge holding basins to act as the primary source of air for the basins while existing multi-stage centrifugal blowers located in the blower building would act as a back-up source air. Attachment E presents manufacturer’s cuts sheet and performance curves.

When comparing annual operating and present worth costs as part of a blower evaluation, it is typical to consider the design air flow of resulting from an aeration intensity of 30 SCFM/1,000 CF. It is understood that lower air demands may provide acceptable mixing and DO levels, however, using the typical design aeration intensity provides a useful “baseline comparison” that reflects the relative compression efficiency of the options under consideration. Accordingly, Table 9 presents the estimated equipment, annual operating and present worth costs for each of the blower options at an air flow of 4,800 SCFM.

As shown in Table 9 the turbo blower is considerably more expensive than the rotary positive displacement unit from a capital cost standpoint; however, the increased compression efficiency of the turbo machine more than compensates for the additional capital cost when present worth is calculated. This finding is useful, but there are two operating options that merit consideration which might alter the present worth analysis. First, since the aerated sludge holding tanks do not provide significant VSS reduction, the detention time does not appear to be critical; therefore, the operating volume can be decreased without significantly affecting operation. To accomplish liquid levels in the holding tanks could be reduced, which would lower the discharge pressure for the blowers and decrease the volume that needs to be aerobically mixed. Second, it is likely that an aeration intensity of 20 SCFM/1,000 CF will be adequate to mix the reduced basin volume and maintain aerobic conditions, which reduces the needed air delivery. Implementing both of these operational modifications would result in an air flow of approximately 2,100 SCFM and a blower discharge pressure of 5.0 psi. In practical terms, the 4,800 SCFM machinery previously described would be installed, but operated at much more favorable conditions that would lead to decreased power consumption. Table 10 presents an economic comparison of the two blower options under the reduced air flow and discharge pressure scenario.

TABLE 9
ESTIMATED CAPITAL, OPERATING, & PRESENT WORTH COSTS FOR SLUDGE HOLDING TANK BLOWER

		High Efficiency Turbo Blower			Rotary Positive Displacement Blower		
CAPITAL COSTS							
Blower Equipment				$180,000			$125,000
Piping Modifications				$17,000			$17,000
Tax, Overhead, Profit, & Installation				$102,000			$80,000
Sub-Total				$299,000			$222,000
Engineering & Contingency				$59,800			$44,400
Total Capital Cost				**$358,800**			**$266,400**
POWER COSTS							
Year	**Air Required @ AADF (SCFM)**	**Total Operating Power (HP)**	**Annual Power Cost ($/year)**	**Present Worth of Power Cost**	**Total Operating Power (HP)**	**Annual Power Cost, $/year**	**Present Worth of Power Cost**
1	4,800	216	$140,953	$132,350	258	$168,714	$158,417
2	4,800	216	$140,953	$124,273	258	$168,714	$148,748
3	4,800	216	$140,953	$116,688	258	$168,714	$139,670
4	4,800	216	$140,953	$109,566	258	$168,714	$131,145
5	4,800	216	$140,953	$102,879	258	$168,714	$123,141
6	4,800	216	$140,953	$96,600	258	$168,714	$115,626
7	4,800	216	$140,953	$90,704	258	$168,714	$108,569
8	4,800	216	$140,953	$85,168	258	$168,714	$101,942
9	4,800	216	$140,953	$79,970	258	$168,714	$95,721
10	4,800	216	$140,953	$75,089	258	$168,714	$89,878
10-Year PW of Power Costs				**$1,013,287**			**$1,212,858**
TOTAL PRESENT WORTH				**$1,372,087**			**$1,479,258**

Notes:

1. The total operating horsepower value presented reflect total power draw and include applicable allowances to address motor and VFD efficiencies.
2. Power costs are based on a unit cost for energy of $0.10/kWh.
3. Present worth costs are based on a discount rate of 6.5%.

TABLE 10
ESTIMATED CAPITAL, OPERATING, & PRESENT WORTH COSTS FOR
SLUDGE HOLDING TANK BLOWER AT REDUCED AIR FLOW & PRESSURE

		High Efficiency Turbo Blower			Rotary Positive Displacement Blower		
CAPITAL COSTS							
Blower Equipment				$180,000			$125,000
Piping Modifications				$17,000			$17,000
Tax, Overhead, Profit, & Installation				$102,000			$80,000
Sub-Total				$299,000			$222,000
Engineering & Contingency				$59,800			$44,400
Total Capital Cost				**$358,800**			**$266,400**
POWER COSTS							
Year	**Air Required @ AADF (SCFM)**	**Total Operating Power (HP)**	**Annual Power Cost ($/year)**	**Present Worth of Power Cost**	**Total Operating Power (HP)**	**Annual Power Cost, $/year**	**Present Worth of Power Cost**
1	2,100	67	$43,915	$41,235	72	$47,052	$44,180
2	2,100	67	$43,915	$38,718	72	$47,052	$41,484
3	2,100	67	$43,915	$36,355	72	$47,052	$38,952
4	2,100	67	$43,915	$34,136	72	$47,052	$36,574
5	2,100	67	$43,915	$32,053	72	$47,052	$34,342
6	2,100	67	$43,915	$30,096	72	$47,052	$32,246
7	2,100	67	$43,915	$28,260	72	$47,052	$30,278
8	2,100	67	$43,915	$26,535	72	$47,052	$28,430
9	2,100	67	$43,915	$24,915	72	$47,052	$26,695
10	2,100	67	$43,915	$23,395	72	$47,052	$25,066
10-Year PW of Power Costs				**$315,697**			**$338,247**
TOTAL PRESENT WORTH				**$674,497**			**$604,647**

Notes:
1. The total operating horsepower value presented reflect total power draw and include applicable allowances to address motor and VFD efficiencies.
2. Power costs are based on a unit cost for energy of $0.10/kWh.
3. Present worth costs are based on a discount rate of 6.5%.

Comparing the values shown in Tables 9 and 10 yields a couple of simple conclusions. First, it is more economical to use rotary positive displacement blowers if reduced air flow and discharge conditions are likely. Second, running the holding tanks about two-thirds full with reduced air flow could result in annual power cost reductions in the range of $97,000 to $122,000/year depending upon blower selection.

Based on the various economic analyses, it is safe to state that operational modifications can result in a large impact to both annual power and present worth costs. It is very unlikely that an aeration intensity of 30 SCFM/1,000 CF will be needed to ensure proper mixing and aerobic conditions; therefore, it is probable that the two blower options will be nearly equal in cost even if the tanks are operated at full liquid depth. Since the rotary positive displacement blower will handle liquid level variations without concerns related to overheating or surge, it would appear that this machinery is a prudent selection for this application. Further, the rotary positive displacement option carries the lowest capital cost making it even more desirable. In view of these considerations, it is suggested that the City utilize a rotary positive displacement blower as the primary source of air for the sludge holding tanks.

<u>Aerated Sludge Holding Tank Mixing</u>

In many cases the oxygen demand within aerobic digesters and sludge holding tanks results in an air demand that is not sufficient to mix the contents of the tank. Such cases are usually termed “mixing limited” because the mixing requirements dictate the necessary air delivery. In these cases it can be economically advantageous to use submersible or floating mixers to keep the contents of the tank suspended while simultaneously providing only enough air to maintain the desired aerobic conditions.

The current “aeration schedule” for the Altamonte Springs RWRF involves running one (1) 300 horsepower blower continuously and running another unit for about 16 hours per day. This scenario results in an average air delivery of about 8,000 SCFM over a typical 24-hour period. The operations staff has indicated that about two-thirds of the air flow is directed to the process basins while the remainder is sent to the aerated sludge holding tanks. The staff further indicated that the stated air distribution is based on observing the surficial turbulence within the process basins and holding tanks. Interestingly, the process basins contain about twice as much volume as the holding tanks, therefore, if the surficial turbulence is similar, the stated distribution may be fairly accurate. If this is the case, the process basins receive an air flow of about 5,300 SCFM and the holding tanks receive about 2,700 SCFM. Air demands previously presented in this memorandum indicated that the process aeration requirement equal about 5,200 SCFM, therefore, it appears that the air distribution estimate provided by the operation staff is probably quite accurate.

As stated above, it appears that the sludge holding tanks receive an air flow of 2,700 SCFM. This air flow results in an aeration intensity of approximately 17 SCFM/1,000 CF. Although this value is slightly below the generally accepted range of 20 to 40 SCFM/1,000 CF, it appears to be providing adequate mixing. With regard to oxygen transfer, the DO levels in the holding tanks average approximately 0.1 mg/L on a very consistent basis. Typically, DO levels in aerobic digester and sludge holding tanks are maintained in the range of 1.0 to 2.0 mg/L, therefore, the operational data clearly indicates that tanks are not “mixing limited.” Since supplemental mixing with decreased air delivery is only feasible in “mixing limited“ situations, the provision of submersible or floating mixers is not suggested.

Blower Recommendations

Based on the various analyses described above, it is recommended that the City install two (2) high efficiency turbo blowers or two (2) rotary positive displacement blowers rated for 3,500 SCFM each for process aeration. The final selection of machinery should be completed after visiting treatment plants for other communities to observe the operation of similar units. For sludge holding tank aeration, it is suggested that the City install a single rotary positive displacement blower adjacent to the existing holding tanks. This blower should be designed to provide an air flow of 4,800 SCFM and function with a VFD to allow the delivery to be decreased to 2,100 SCFM. Further, it is suggested that liquid depth in the holding tank should be decreased to about 11 feet on a trial basis. This operational modification will lead to significant power cost savings due to decreases in air delivery volume and blower discharge pressure.

The net impact of the new equipment on power cost is difficult to accurately ascertain for a variety of reasons. Regardless of the possible shortcomings, it is still reasonable to make some sort of estimate of the potential savings that are associated with the recommended improvements. Table 11, below, provides a comparison of the operating scenarios and costs with and without the suggested improvements.

TABLE 11
POTENTIAL POWER COST REDUCTIONS

Current Operating Scenario	
<u>1 – 300 HP Blower Operating @ 240 HP (24 Hours/Day)</u>	
Annual Energy Consumption:	1,568,000 kWh/year
Estimated Power Cost:	$156,800/year
<u>1 – 300 HP Blower Operating @ 240 HP (16 Hours/Day)</u>	
Annual Energy Consumption:	1,046,000 kWh/year
Estimated Power Cost:	$104,600/year
Total Estimated Power Cost:	**$261,400/year**
Suggested Operating Scenario	
<u>2 – 200 HP Turbo Blowers Operating @ 117 HP Each (24 Hours/Day): Process Aeration</u>	
Annual Energy Consumption:	1,529,000 KWh/year
Estimated Power Cost:	$152,900/year
<u>1 – 250 HP Rotary Positive Displacement Blower Operating @ 75 HP (24 Hours/Day): Sludge Holding</u>	
Annual Energy Consumption:	471,000 KWh/year
Estimated Power Cost:	$47,100/year
Total Estimated Power Cost:	**$200,000/year**
Estimated Savings:	**$61,400/year**

Other Related Improvements

In addition to replacing two of the multistage centrifugal blowers and providing a dedicated blower for the sludge holding tank, there are two other improvements that should be considered. These improvements are described below.

1. Air Header Repair or Replacement: The existing 24-inch air header that runs along the east end of the aeration basin and within a trough between the two basins has several leaks according to the plant operating staff. Some of the leaks can be repaired by welding plates on the existing pipe; however, the limited space within the trough will probably make several of the areas inaccessible. Removal and replacement of small sections of pipe is a possible means of addressing the leaks; however, maintenance of air supply during construction becomes an issue. In view of the space constraints and maintenance of service issues, total replacement of the air header is suggested. This could be accomplished by first installing a new 20-inch air header on the north wall of the north aeration basin and subsequently replacing the 24-inch piping in the trough with a 20-inch pipe. The north aeration basin would need to be taken out of service to facilitate installation of the new 20-inch air header along the north wall of the structure. Similarly, the south aeration basin would need to be taken out of service to allow installation of the piping within the central trough and along the east wall of the structure.

2. Submerged Air Manifold Pipe Replacement: The existing 10-inch PVC manifold piping that feeds the 4-inch PVC piping that holds the diffusers has been failing at a rate that raises concerns with respect to long-term service. This piping receives air from the droplegs which probably has a relatively high temperature, which in turn may have caused the 10-inch manifold pipes to become brittle. Regardless of the factors that have led to the pipe failures, the current situation can be remedied by simply replacing the manifold pipes with light-gauge stainless steel piping. To accomplish this, a pre-fabricated manifold pipe with the required number of welded 4-inch outlets should be installed at each dropleg. Stainless steel compression couplings can be used to connect the droplegs to the manifolds and to connect the 4-inch welded outlets to the existing PVC piping.

3. Automation of Air Delivery: Currently blowers are started and stopped manually based on observed operating conditions. Similarly, the airflows to the various zones within the process basins and holding tanks are manually controlled by adjusting the position of several butterfly valves. Providing a dedicated blower for the holding tanks will simplify the overall operation of the system; however, to provide an automated system, various modifications will be necessary. First, the number of blowers that run at any given time and the speed at which they operate should be controlled in response to DO and/or ammonia signals. Ideally, one DO probe would be installed for each dropleg zone and one ammonia probe would be installed in the central aeration zone in each train. The signals from these probes would then be used to automatically start and stop the blowers, and vary their speeds, based on the measured DO or ammonia values. Additionally, electrically actuated valves and air flow meters should be installed to control the amount of air delivered to each aeration grid. The electrically actuated valves and flow meters will necessitate the installation of entirely new droplegs due to "straight run" requirements for the flow meters. It is probable that the existing plant-wide SCADA system could be reprogrammed to achieve the desired level of control; however, it will still be necessary to invest in DO probes, ammonia probes, electrically actuated butterfly valves, air flow meters and related piping, electrical and fiber optic components. Figure 4 presents an overall schematic showing the piping improvements as well as the suggested locations for the various process monitoring probes.

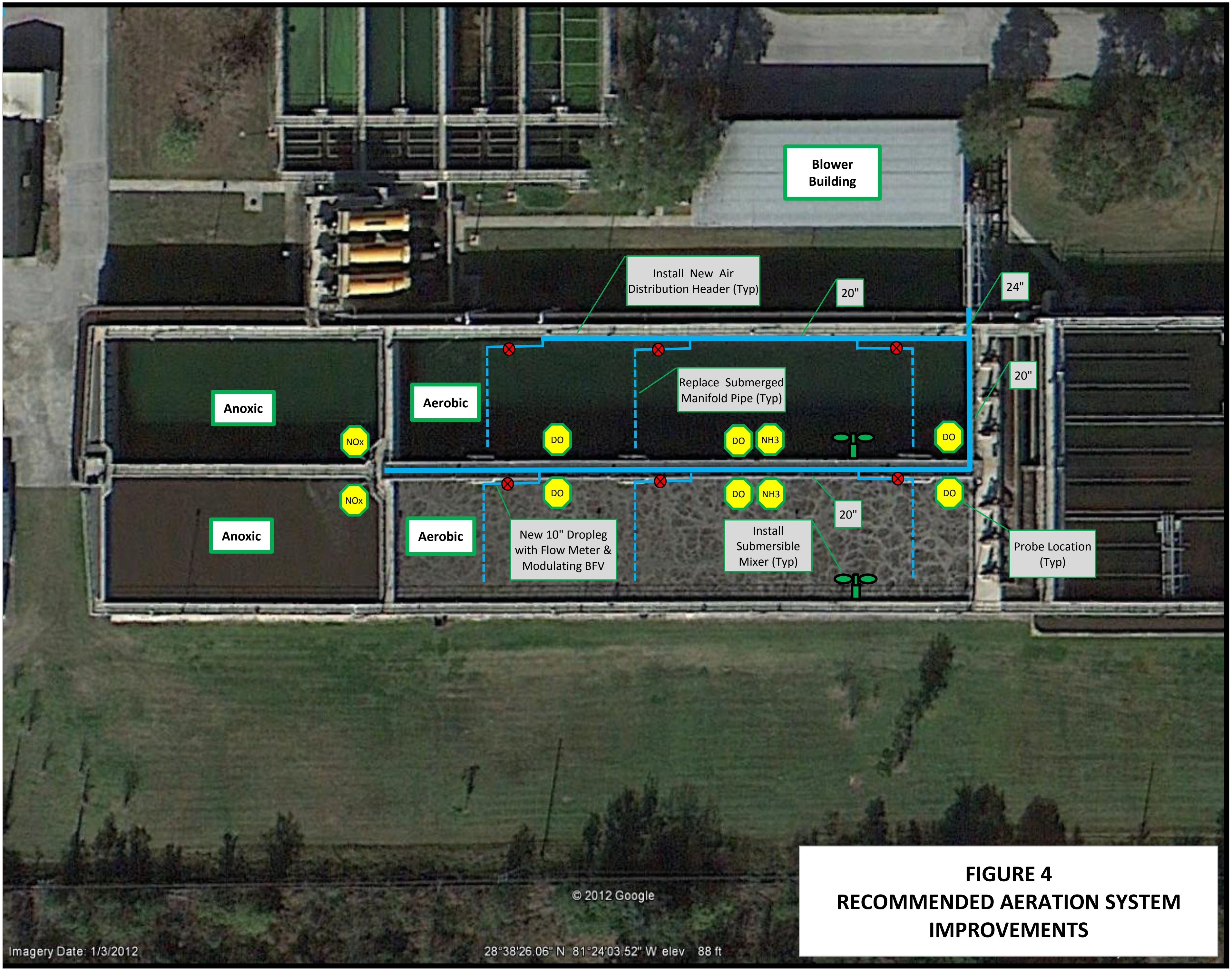


FIGURE 4
RECOMMENDED AERATION SYSTEM IMPROVEMENTS

Summary of Improvements and Costs

Based on the various analyses described herein, the following improvements are suggested.

- Install two (2) new process aeration blowers with a capacity of 3,500 SCFM each. High efficiency turbo blowers or rotary positive displacement units with axially twisted lobes both represent efficient options; however, the positive displacement machinery has a more extensive track record. Selection of two blowers can be completed after visiting several plants with similar machinery.

- Install one (1) submersible mixer in Zone 3 of each aeration basin to provide efficient mixing and to allow reduced air delivery.

- Replace the existing 24-inch air header within the aeration basin structure with two (2) separate 20-inch stainless steel air headers.

- Replace the existing 10-inch droplegs and submerged manifold pipes for each diffuser grid. Each new dropleg should include an electrically actuated butterfly valve and air flow meter for precise control of air delivery.

- Install processes monitoring probes within the anoxic and aerobic basins to measure nitrite + nitrate, ammonia, and dissolved oxygen concentrations at selected locations.

- Provide centralized aeration system control via the existing plant control system or with a new PLC-based system. The controls should automatically start and stop the blowers and adjust their speed in response to signals from the process monitoring probes. Also, the control system should automatically adjust the air delivery to each aeration grid based on process feedback.

- Install one (1) new rotary positive displacement blower adjacent to the sludge holding tanks which should be used exclusively for the holding tanks. The blower should include a VFD for adjustment of air delivery to the tanks.

The estimated costs for the various improvements are presented in Table 12, below.

TABLE 12
SUMMARY OF ESTIMATED COSTS FOR RECOMMENDED IMPROVEMENTS

Item	Estimated Cost
Two (2) Process Aeration Blowers	$367,000
Two (2) Submersible Mixers	$135,000
Replace Existing 24" Air Header, 10" Droplegs, and Submerged 10" Manifold	$365,000
Process Monitoring Equipment, Controls, and Programming	$280,000
One (1) Aerated Sludge Holding Tank Blower	$222,000
Subtotal	$1,369,000.00
Engineering and Contingency	$274,000
Total	**$1,643,000**

END OF MEMORANDUM

JPT/slh/sma/71229-12002/del-1/RWRF Blower Evaluation Memo

ATTACHMENT A
HOFFMAN/GARDNER-DENVER MULTISTAGE CENTRIFUGAL BLOWER CUT SHEETS FOR PROCESS AERATION APPLICATION

Date: 8/30/2012
Project: Altamonte Springs
Customer:
Sales Order Number:
Application Engineer: Tony Maupin
Comments:

Gas Mix: Air(100%)
Model: 751F, 6 Stage(s) (2 x 877) (4 x 221), 3550 RPM

Corrected Values	Original	Unit	English	Unit	Metric	Unit
Inlet Set # 1						
Barometer	100.00	Altitude (ft)	14.64	PSIA	1.01	Bars (A)
Inlet Pres.	0.00	PSIG	14.64	PSIA	1.01	Bars (A)
Inlet Temp.	100.00	Deg F	100.00	Deg F	37.78	Deg C
Inlet Flow	3,500.00	SCFM	3,910.48	ICFM	6,643.70	m^3/hr(A)
Dis. Pres.	8.00	PSIG	8.00	PSIG	0.55	Bars (G)
Rel. Humid.	85.00	%	85.00	%	85.00	%
Inlet Set # 2						
Barometer	100.00	Altitude (ft)	14.64	PSIA	1.01	Bars (A)
Inlet Pres.	0.00	PSIG	14.64	PSIA	1.01	Bars (A)
Inlet Temp.	85.00	Deg F	85.00	Deg F	29.44	Deg C
Inlet Flow	3,250.00	SCFM	3,458.80	ICFM	5,876.32	m^3/hr(A)
Dis. Pres.	8.00	PSIG	8.00	PSIG	0.55	Bars (G)
Rel. Humid.	85.00	%	85.00	%	85.00	%
Inlet Set # 3						
Barometer	100.00	Altitude (ft)	14.64	PSIA	1.01	Bars (A)
Inlet Pres.	0.00	PSIG	14.64	PSIA	1.01	Bars (A)
Inlet Temp.	75.00	Deg F	75.00	Deg F	23.89	Deg C
Inlet Flow	3,000.00	SCFM	3,103.13	ICFM	5,272.05	m^3/hr(A)
Dis. Pres.	8.00	PSIG	8.00	PSIG	0.55	Bars (G)
Rel. Humid.	85.00	%	85.00	%	85.00	%
Inlet Set # 4						
Barometer	100.00	Altitude (ft)	14.64	PSIA	1.01	Bars (A)
Inlet Pres.	0.00	PSIG	14.64	PSIA	1.01	Bars (A)
Inlet Temp.	60.00	Deg F	60.00	Deg F	15.56	Deg C
Inlet Flow	2,750.00	SCFM	2,736.48	ICFM	4,649.13	m^3/hr(A)
Dis. Pres.	8.00	PSIG	8.00	PSIG	0.55	Bars (G)
Rel. Humid.	85.00	%	85.00	%	85.00	%

Gas Mix: Air(100%)
Model: 751F, 6 Stage(s) (2 x 877) (4 x 221), 3550 RPM

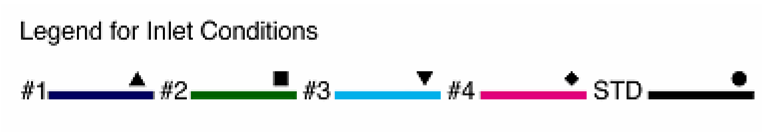
Measured Values	**Plot**	**Unit**	**English**	**Unit**	**Metric**	**Unit**
Inlet Set # 1						
Surge Flow Rate	1,745.79	SCFM	1,950.53	ICFM	3,313.85	m^3/hr(A)
Surge Pressure	8.89	PSIG	8.89	PSIG	0.61	Bars (G)
Pres. Rise to Surge	0.89	PSIG	0.89	PSIG	0.06	Bars (G)
Max. Vol. Turndown	50.12	%	50.12	%	50.12	%
Pressure @ Design	8.08	PSIG	8.08	PSIG	0.56	Bars (G)
Power @ Design	162.61	HP	162.61	HP	121.26	KW
Effic. @ Design	71.89	%	71.89	%	71.89	%
Temp. @ Design	203.18	Deg F	203.18	F	95.10	C
Inlet Set # 2						
Surge Flow Rate	1,832.78	SCFM	1,950.53	ICFM	3,313.85	m^3/hr(A)
Surge Pressure	9.01	PSIG	9.01	PSIG	0.62	Bars (G)
Pres. Rise to Surge	1.01	PSIG	1.01	PSIG	0.07	Bars (G)
Max. Vol. Turndown	43.61	%	43.61	%	43.61	%
Pressure @ Design	8.00	PSIG	8.00	PSIG	0.55	Bars (G)
Power @ Design	155.30	HP	155.30	HP	115.81	KW
Effic. @ Design	71.02	%	71.02	%	71.02	%
Temp. @ Design	193.79	Deg F	193.79	F	89.89	C
Inlet Set # 3						
Surge Flow Rate	1,885.70	SCFM	1,950.53	ICFM	3,313.85	m^3/hr(A)
Surge Pressure	9.02	PSIG	9.02	PSIG	0.62	Bars (G)
Pres. Rise to Surge	1.02	PSIG	1.02	PSIG	0.07	Bars (G)
Max. Vol. Turndown	37.14	%	37.14	%	37.14	%
Pressure @ Design	8.00	PSIG	8.00	PSIG	0.55	Bars (G)
Power @ Design	147.82	HP	147.82	HP	110.23	KW
Effic. @ Design	69.75	%	69.75	%	69.75	%
Temp. @ Design	188.50	Deg F	188.50	F	86.94	C
Inlet Set # 4						
Surge Flow Rate	1,960.16	SCFM	1,950.53	ICFM	3,313.85	m^3/hr(A)
Surge Pressure	8.99	PSIG	8.99	PSIG	0.62	Bars (G)
Pres. Rise to Surge	0.99	PSIG	0.99	PSIG	0.07	Bars (G)
Max. Vol. Turndown	28.72	%	28.72	%	28.72	%
Pressure @ Design	8.00	PSIG	8.00	PSIG	0.55	Bars (G)
Power @ Design	139.94	HP	139.94	HP	104.36	KW
Effic. @ Design	68.03	%	68.03	%	68.03	%
Temp. @ Design	178.65	Deg F	178.65	F	81.47	C

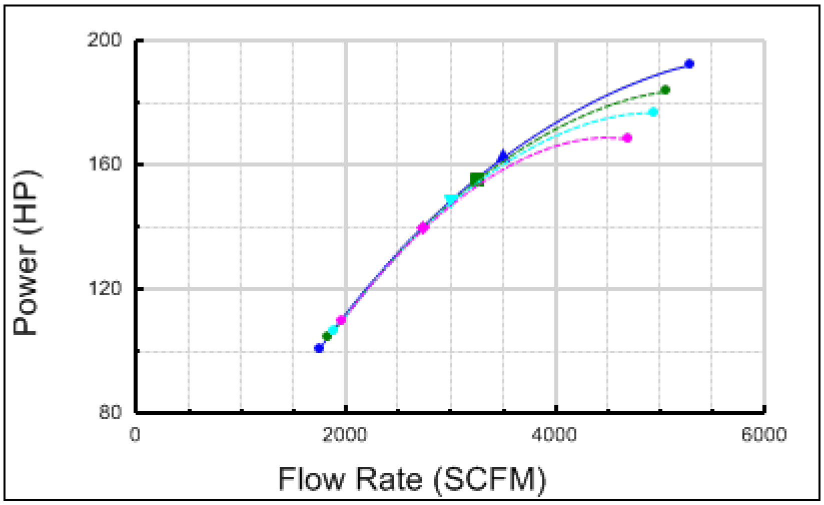
Gas Mix: Air(100%)
Model: 751F, 6 Stage(s) (2 x 877) (4 x 221), 3550 RPM

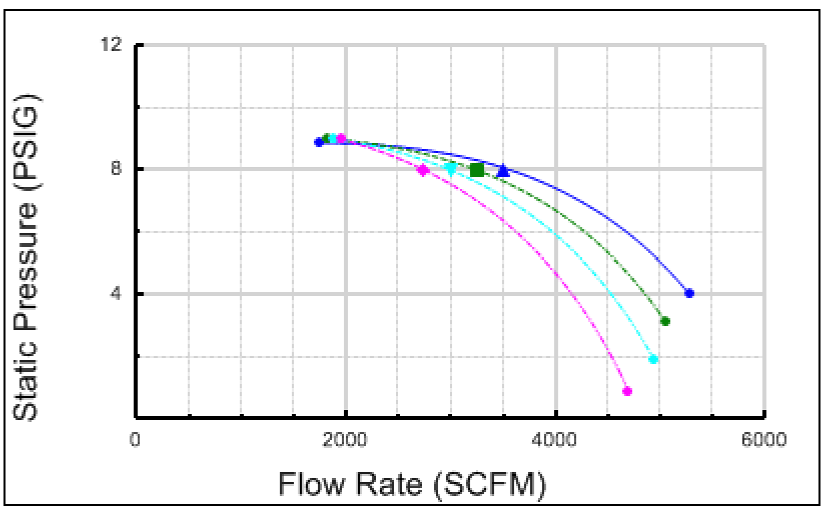
Gas Parameters	**English**	**Unit**	**Metric**	**Unit**
Inlet Set # 1				
Molecular Weight	28.37	lbm/lbmol	28.37	kg/kgmol
R Value	54.48	ft. lbf/lbm.R	0.30	kJ/kg.K
Density	0.07	lbm/ft^3	1.11	kg/m^3
Sp. Heat @ Const. P	0.25	BTU/lbm.R	1.03	kJ/kg.K
Ratio of Sp. Heats	1.40		1.40	
Saturated Vapor Pres.	0.95	PSIA	0.07	Bars (A)
Partial Pres. of Gas	13.84	PSIA	0.95	Bars (A)
Partial Pres. of Vapor	0.81	PSIA	0.06	Bars (A)
Inlet Set # 2				
Molecular Weight	28.59	lbm/lbmol	28.59	kg/kgmol
R Value	54.05	ft. lbf/lbm.R	0.29	kJ/kg.K
Density	0.07	lbm/ft^3	1.15	kg/m^3
Sp. Heat @ Const. P	0.24	BTU/lbm.R	1.02	kJ/kg.K
Ratio of Sp. Heats	1.40		1.40	
Saturated Vapor Pres.	0.60	PSIA	0.04	Bars (A)
Partial Pres. of Gas	14.14	PSIA	0.97	Bars (A)
Partial Pres. of Vapor	0.51	PSIA	0.03	Bars (A)
Inlet Set # 3				
Molecular Weight	28.70	lbm/lbmol	28.70	kg/kgmol
R Value	53.85	ft. lbf/lbm.R	0.29	kJ/kg.K
Density	0.07	lbm/ft^3	1.17	kg/m^3
Sp. Heat @ Const. P	0.24	BTU/lbm.R	1.02	kJ/kg.K
Ratio of Sp. Heats	1.40		1.40	
Saturated Vapor Pres.	0.43	PSIA	0.03	Bars (A)
Partial Pres. of Gas	14.28	PSIA	0.98	Bars (A)
Partial Pres. of Vapor	0.37	PSIA	0.03	Bars (A)
Inlet Set # 4				
Molecular Weight	28.81	lbm/lbmol	28.81	kg/kgmol
R Value	53.65	ft. lbf/lbm.R	0.29	kJ/kg.K
Density	0.08	lbm/ft^3	1.21	kg/m^3
Sp. Heat @ Const. P	0.24	BTU/lbm.R	1.01	kJ/kg.K
Ratio of Sp. Heats	1.40		1.40	
Saturated Vapor Pres.	0.26	PSIA	0.02	Bars (A)
Partial Pres. of Gas	14.42	PSIA	0.99	Bars (A)
Partial Pres. of Vapor	0.22	PSIA	0.02	Bars (A)

Gas Mix: Air(100%)
Model: 751F, 6 Stage(s) (2 x 877) (4 x 221), 3550 RPM

Date: 8/30/2012







Customer Focused Aftermarket Solutions

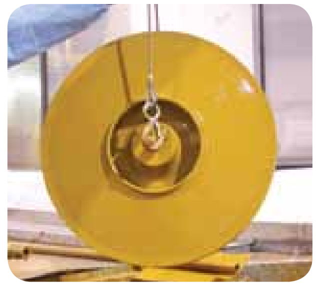
MULTISTAGE CENTRIFUGAL BLOWERS

HOFFMAN

LAMSON

Aftermarket Product Menu

SUPERIOR SERVICE AND
GENUINE HOFFMAN AND LAMSON PARTS



Field Services

- Warranty Renewal Programs
- Predictive Maintenance Programs
- Start-up
- Certified Vibration Analysis
- Laser Alignment
- Troubleshooting
- Training
- Diagnostics
- Testing
-

Products

- Genuine Factory Parts
  - — New Blower
  - — Components
  - — Factory Certified
  - — Reconditioned Components
  - — Control Components
- Factory Reconditioned Blowers
- Blower Lubricants
- Blower Accessories
- Blower Controls
- Buy-backs

Factory Services

- Worldwide Blower Repair
- Rotor Re-balance
- Machine Component Forensic Inspection
- Testing
  - — ASME
  - — Gas
  - — Mechanical
  - — Hydrostatic
  - — Overspeed
  - — Dye Penetrant
- In-House Blast Cleaning and Specialty Coatings

Engineering Services

- Blower Reconfiguration for Performance Changes
- Performance Curves
- Amp Curves
- System Consulting
- Technical Product Support
- Custom Application Engineering
- Seismic Calculations
- Product Upgrades
- Instrumentation Upgrades

HOFFMAN

LAMSON

One-Year Factory Warranty

TO PROTECT YOUR INVESTMENT

All Hoffman® and Lamson® Factory Service products and services are backed by our One-Year Factory Warranty. Since our inception over 100 years ago, Hoffman and Lamson have provided quality industrial products backed by superior service and aftermarket support. Today, the tradition continues, as Hoffman and Lamson products are supported by an international team of engineers and service professionals who know how to keep your blowers running at maximum efficiency. Our factory-trained service technicians are available for on-site/on-demand repair service, training, troubleshooting and consulting. We service Hoffman and Lamson blowers, as well as most other brands of centrifugal blowers.

For added assurance, we offer our exclusive Hoffman and Lamson Warranty Renewal Program.

Along with our superior service comes superior parts. "Unauthorized" repair shops have been known to use reconditioned parts for blower repairs, resulting in a short repair life. Improper and non-factory approved lubricants may also be incorrectly specified by unauthorized repair shops or individuals. We use only genuine Hoffman and Lamson factory-certified replacement parts and superior lubricants specifically formulated for optimal blower performance.

Protect your investment with confidence. Go with the Hoffman and Lamson team of service and customer service professionals for all of your after-the-sale service and aftermarket needs.

Products

ORIGINAL EQUIPMENT QUALITY

Remanufactured Blowers/Exhausters

Hoffman and Lamson offer a wide range of factory remanufactured blowers and exhausters available for immediate shipment. Remanufactured blowers are built to the same exacting standards as our new machines, rigorously tested and carry the same factory warranty. If we do not have a particular remanufactured blower in stock, we can build one to match your specific application. Remanufactured blowers and exhausters offer an excellent, cost-effective alternative to new machines, and they are ideal for short-term projects, spares and even permanent installations.

Why Choose Remanufactured?

- Cost effective
- Same warranty as new
- All Genuine Factory Certified Parts
- Ideal for short-term projects
- Emergency Solutions
- Same specifications as new, incorporating latest design upgrades

Remanufactured Models Available	
Hoffman® Series	Lamson® Series
42	310
741/384	510/550
751	810/850
383	1210/1250
761	1260
791	1400
671	1850/1870

Buy-Back Program

Do you have old blowers that have been abandoned or are not being used? We will buy back many popular models and pick them up at your location. Contact the Hoffman/Lamson service group or your local representative.

Genuine Hoffman and Lamson Parts and Lubricants

Keep your Hoffman and Lamson investment running smoothly for years with Genuine Hoffman and Lamson parts and lubricants from your local Authorized Hoffman and Lamson Sales and Service Representative. These professionals provide you the expert guidance you appreciate for sales assistance, installation support and maintenance advice. Whether you're replacing a typical wear component or changing the grease or oil, nothing outperforms genuine Hoffman and Lamson factory parts and lubricants. They're specifically engineered for superior performance and extended life of your blower/exhauster.

Factory Services

LOCATIONS WORLDWIDE

In-House Sandblasting and Heresite Coatings and Heresite Coatings.

Rotor Balancing

ASME PTC-10 Testing

Hoffman & Lamson Factory Repairs

Hoffman and Lamson offer complete repair capability worldwide. Factory repair specialists completely disassemble, clean, inspect, re-balance and repair your blower to its original factory specifications. All repairs are done using genuine factory certified parts. When repairs are complete, each machine is rigorously tested to factory standards and covered by a new product warranty.

Hoffman & Lamson Factory Field Service

Regionally located Factory Service Technicians can be dispatched to your facility for on-site repairs, troubleshooting and other factory services, such as laser alignment, vibration analysis, operator and maintenance training and warranty renewal services.

24 Hour Factory Service • 800-308-7245 • Locations Worldwide

HOFFMAN

LAMSON

Field Services

Preventive Maintenance Agreement/ Warranty Renewal Program

- Exclusive to Hoffman and Lamson
- Comprehensive set of service and maintenance procedures
- Designed to return your blower to a rewarrantable condition
- Provides increased reliability and performance

Work Scope

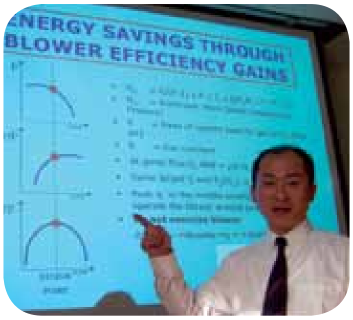
- On-site inspection
- Work performed on-site with factory-trained technicians
- Complete inspection and repair report provided
- Worn or defective parts replaced or repaired with genuine factory certified parts
- New equipment warranty is re-initiated

Benefits

- Lower overall repair and reinstallation cost
- Quicker return of unit to service
- On-site equipment and operator training
- Customer is provided with a comprehensive insurance program covering equipment, process operation and operator training

Engineering Services

In addition to the many field services, we offer engineering services performed by an experienced, dedicated staff to provide amp curves, performance curves and seismic calculations. They are also available for general consulting and technical support. In most cases, they can also reconfigure your Hoffman or Lamson blower/exhauster to meet the precise requirements of any application or process changes. Need more airflow, pressure or vacuum? Our application engineers can determine what modifications would be needed, and our specialists will add the necessary stages and impellers to meet your needs. The modified blower will be built to factory specifications with genuine Hoffman or Lamson parts and will receive a one-year warranty like a new blower.



Gardner Denver®

www.HoffmanandLamson.com cf.blowers@gardnerdenver.com

Gardner Denver, Inc. 100 Gardner Park, Peachtree City, GA 30269
New Equipment Sales: (800) 543-7736 Phone: (770) 632-5000 Fax: (770) 486-5628
Aftermarket Parts Sales: (800) 982-3009 Phone: (770) 632-5000 Fax: (770) 486-5530

ENERGY STAR PARTNER

Member

CAGI COMPRESSED AIR AND GAS INSTITUTE

CERTIFIED QUALITY MANAGEMENT SYSTEM ISO 9001:2008 ANAB DNV

Specifications subject to change without notice.

Please recycle after use.

CF-A-MAIN 1st 3/11
Supersedes GDCF-1-400 3rd Ed. 10/10

Technical & Performance Data
HOFFMAN 751 Series
Centrifugal Products

DESIGN STANDARD

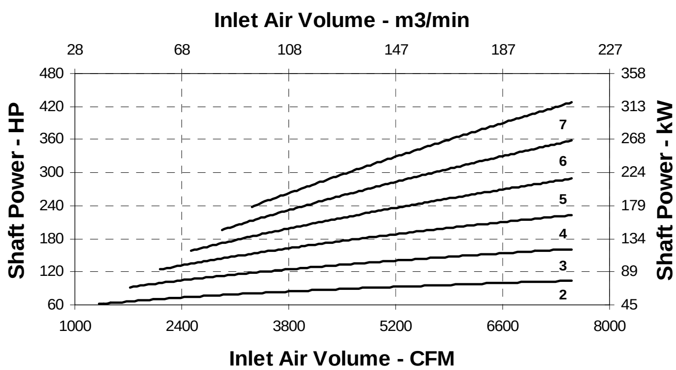
Number of Stages	2-7 (60 Hz) 2-8 (50 Hz)
Inlet Connection	12” Flange, ANSI 125# Drilling
Outlet Connection	12” Flange, ANSI 125# Drilling
Operating Speed	3550 RPM (60 Hz), 2960 RPM (50 Hz)
Casing Pressure	25 PSIG (1.73 bar)
Air Seals	Labyrinth Type - *Carbon Ring Optional*
Bearings	Anti-friction, designed for extended L_{10} life
Lubrication	AEON® CF Oil
Impeller	25.0 inches (635 millimeters) Diameter (statically balanced)
Impeller Tip Speed	387 feet/second (118 meters/second)
Drive Type	Direct Coupled (Inlet drive is standard)
Drive Shaft	2.375 inches (60.33 millimeters) Diameter
Vibration	.235 in/sec. (5.97 mm/sec.) Peak Velocity
Rotor	Balanced Per ISO 1940, ANSI S2.19

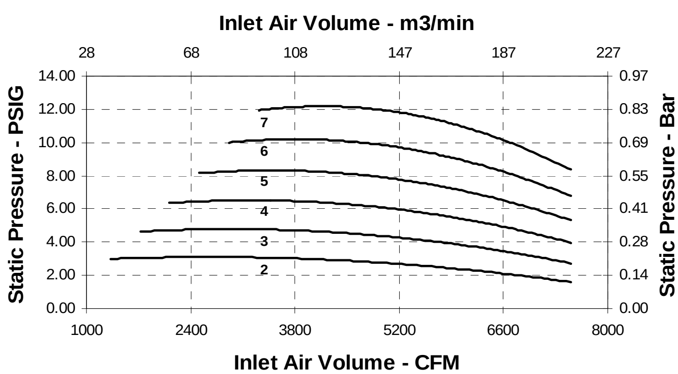
MATERIAL STANDARD

Casing	ASTM A48 Class 30 Gray Cast Iron
Bearing Housings	ASTM A48 Class 30 Gray Cast Iron
Bearing Cap	ASTM A48 Class 30 Gray Cast Iron
Tie Rods	ASTM F1554 GR.36 Zinc Plated Thrd. Rod
Labyrinth Seal	ASTM B86 Z35631 Alloy Zinc Aluminum 12
Carbon Ring Seal Optional	ASTM C695 Fine Grain Molded Graphite
Joint Sealing	RTV Silicone Compound
Baffle Rings	ASTM A240 Grade 304 Stainless Steel
Shaft	ASTM A108 Grade 1045 HRS *Stainless Steel Optional*
Impeller	ASTM SC64C Sr-319 Cast Aluminum or ASTM 6061-T6 Fabricated Aluminum
Blower Base	ASTM A36 Hot Rolled Structural Steel
Motor Pedestal	ASTM A36 Hot Rolled Structural Steel
Isolation Base Pads	Suitable Resilient Material
Finish	Universal Primer - Acrylic Topcoat

PRESSURE PERFORMANCE

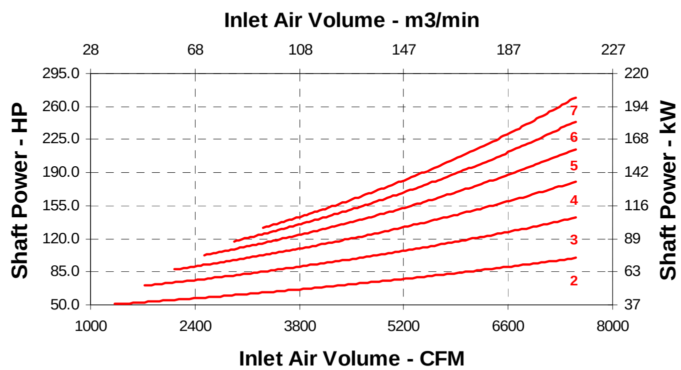
14.7 PSIA [1 Bar], 68°F [20°C], 36% RH, Speed: 3550 RPM

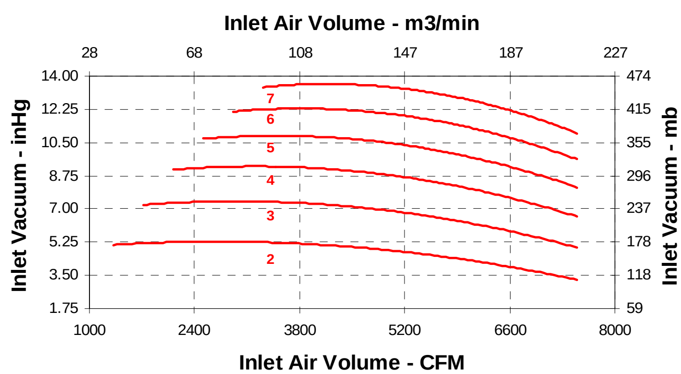




VACUUM PERFORMANCE

29.9 inHg [1 Bar], 68°F [20°C], 36% RH, Speed: 3550 RPM





PRODUCT NOTES

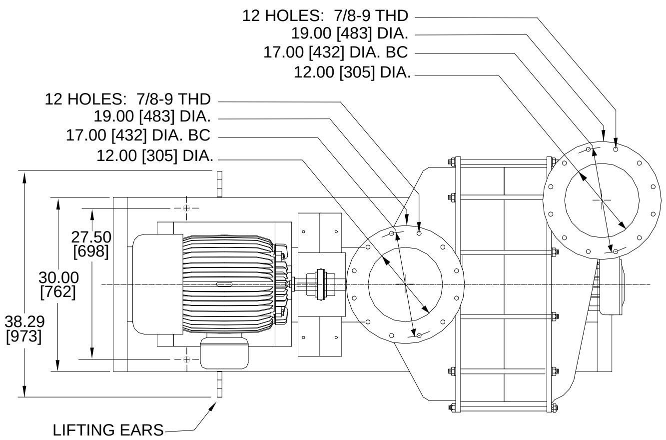
1. Information is approximate and subject to change without notice
2. Performances noted above are typical and not job specific
3. Consult authorized Hoffman/Lamson sales representative for job specific blower or exhauster performance sizing
4. Factory ASME PTC-10 test offered for performance verification

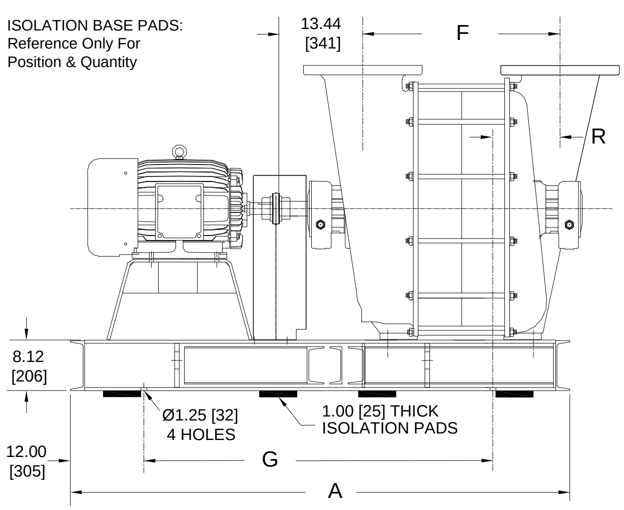
Gardner Denver, Inc.
100 Gardner Park, Peachtree City, GA 30269
Phone: 800-982-3009 / 770-632-5000
Fax: 770-486-5628
E-mail: cf.blowers@gardnerdenver.com
Web: www.**Hoffman**and**Lamson**.com

“Over 150 Years of Leadership”

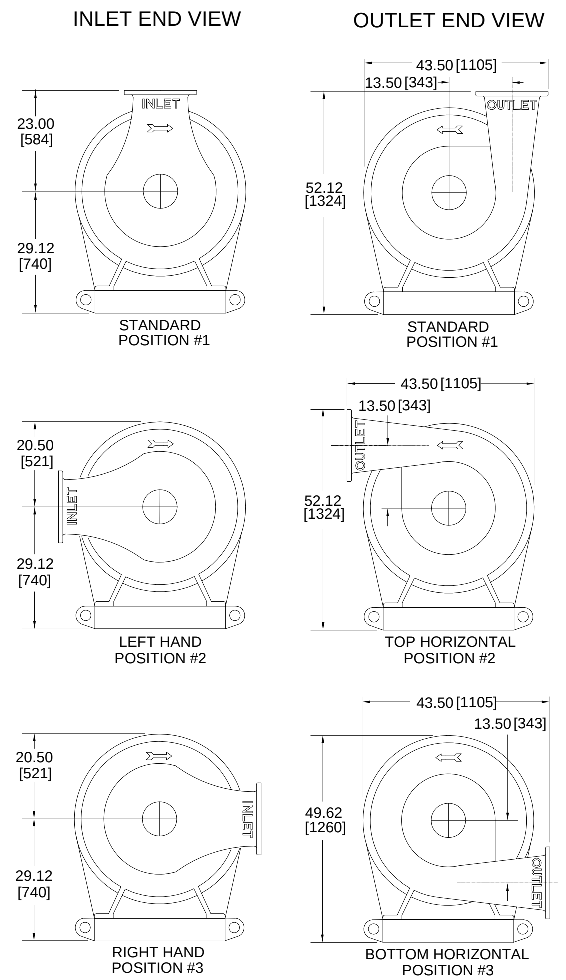
Dimensional Data
HOFFMAN 751 Series
Centrifugal Products

GENERAL ARRANGEMENT





FLANGE ORIENTATIONS



DIMENSIONAL DATA – inches [millimeters]

FRAME	A	F	G	R
75102	84.00 [2134]	24.75 [629]	60.00 [1524]	10.25 [260]
75103	84.00 [2134]	31.25 [794]	60.00 [1524]	10.25 [260]
75104	108.00 [2743]	37.75 [959]	84.00 [2134]	10.25 [260]
75105	108.00 [2743]	44.25 [1124]	84.00 [2134]	10.25 [260]
75106	114.00 [2896]	50.75 [1289]	90.00 [2286]	10.25 [260]
75107	126.00 [3200]	57.25 [1454]	102.00 [2591]	10.25 [260]

WEIGHTS – lb [kg] & INERTIA – lb-ft² [kg-m²]

FRAME	PKG. LESS MOTOR	BARE UNIT	*WK^2
75102	4050 [1837]	2550 [1157]	31 [1.31]
75103	4450 [2018]	2950 [1338]	46 [1.95]
75104	5050 [2291]	3350 [1520	62 [2.60]
75105	5450 [2472]	3750 [1701]	77 [3.25]
75106	5850 [2654]	4150 [1882]	37 [1.57]
75107	6300 [2858]	4600 [2087]	44 [1.83]

PRODUCT NOTES

1. Information is approximate, subject to change without notice, and not for construction use unless certified
2. Position #1 is standard inlet & outlet orientation
3. A and G dimensions may vary depending on motor frame size
4. *Based on cast impellers except 75107 (fabricated impeller)

Gardner Denver, Inc.
100 Gardner Park, Peachtree City, GA 30269
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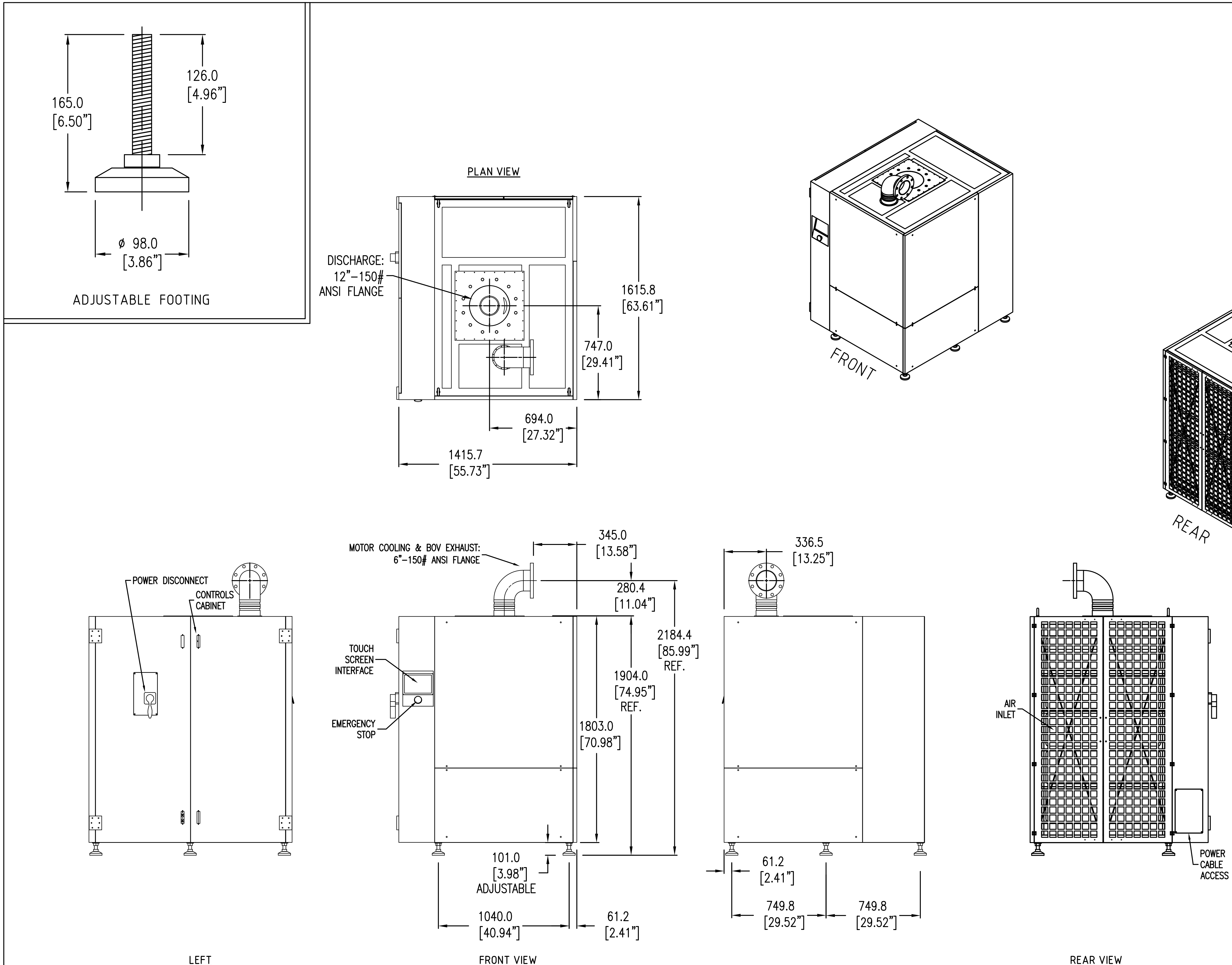
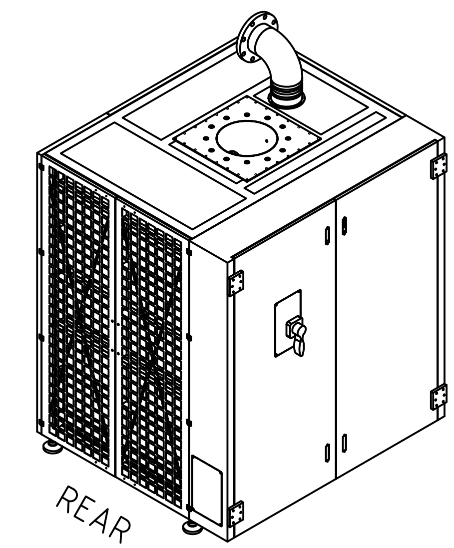
ATTACHMENT B
AERZEN HIGH-EFFICIENCY TURBO BLOWER CUT SHEETS FOR PROCESS AERATION APPLICATION





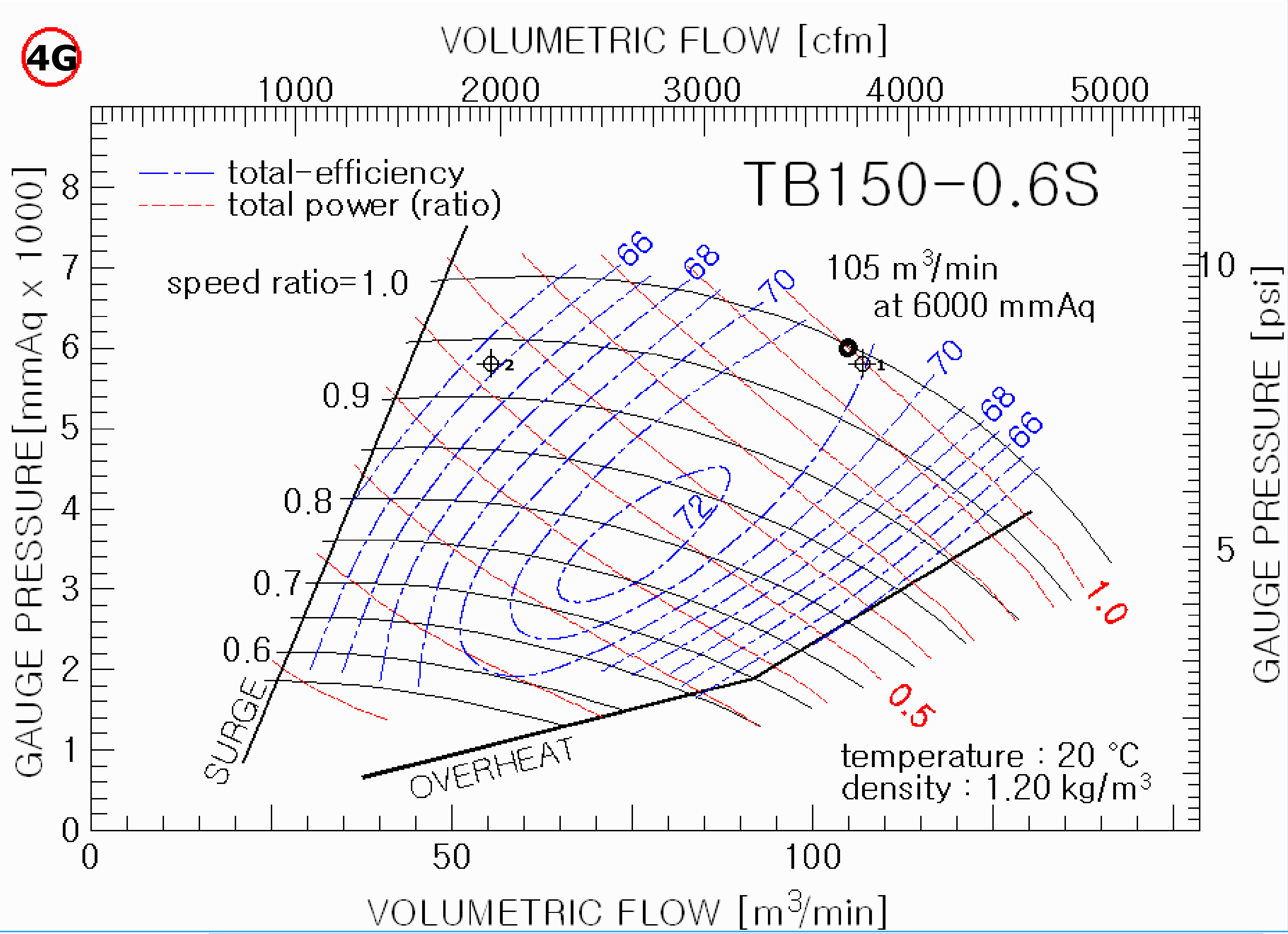
NOTES

1. TOLERANCE ON DIMENSIONS = ±12mm [0.5"]
2. CUSTOMER PIPING TO BE INDEPENDENTLY SUPPORTED
3. LIFTING OF PACKAGE: WITH FORKLIFT, DETACH INLET PLENUM FROM BLOWER CABINET PRIOR TO LIFTING
4. ALLOW APPROX. 915mm [36"] FREE SPACE FOR MAINTENANCE ON ALL FOUR SIDES

AERZEN
AERZEN USA CORP.
108 Independence Way, COATESVILLE PA 19320
(610) 380-0244 PH, (610) 380-0278 FX

TITLE: TURBO BLOWER ASSEMBLY AT150-0.6S 12" - 150# ANSI FLANGE DISCHARGE				
DATE 12/28/2011	DRAWN BY: JPS	CHECKED BY: RJP	P.M. APPROVAL:	SCALE: MODEL SPACE 1 :1
DRAWING NO: GB-006096-150-0.6S			REVISION NO: –	SHEET: 1/1

4 G · TB150-0.6S



- TITLE Altamonte Springs
- UNIT SYSTEM US (ft-lb)

* Typically 0%RH or 36%RH @ 68˚F(20˚C), 14.696psia(101.325kPa) for USA. 65%RH @ 20˚C, 101.325kPa for Japan

STANDARD CONDITION			Altitude [ft]	Ambient Pressure [psi(A)]
T_{st} [˚F]	$R.H_{st}$ [%]	P_{st} [psi(A)]		
68	36	14.696	85	14.651

COMMENT

Save | Copy to my Account

* Built-in Filter : Fresh 0.03 psi / Dirty 0.22 psi

Pt	T_1 [˚F]	R.H [%]	Q_{std} [CFM]	# of Units	$P_{2(G)}$ [psi(G)]	$\triangle P_{filter}$ [psi]		$Q_{in/unit}$ [CFM]	$Q_{act/unit}$ [CFM]	$Q_{corr/unit}$ [CFM]	Mass Flow [lbm/s]	P_{corr} [psi]	η_{total} [%]		Total Input [kW] Unit	Total Input [kW] Total	remark	Del
1	100	85	3,500	1	8	0.1	▶	3,908.23	3,935.09	3,820.93	4.534	8.181	71	▶	123.8	123.8		X
2	50	60	2,000	1	8	0.1	▶	1,935.75	1,949.05	1,983.17	2.511	8.181	65	▶	67.0	67.0		X
+							▶							▶				

+ : add additional line with copied data.

AERZEN

One step ahead.

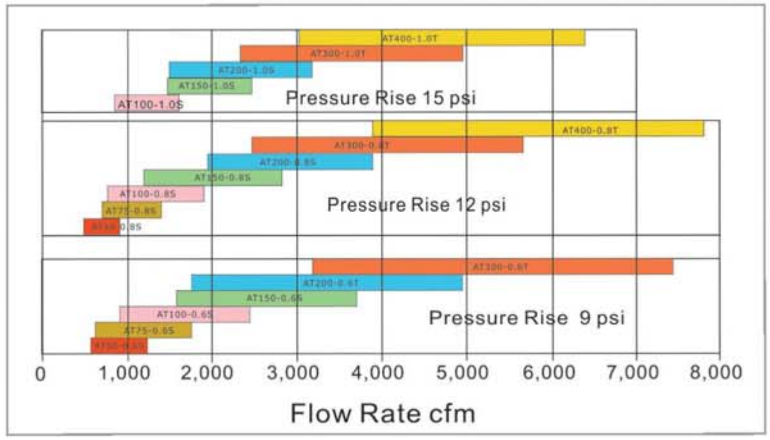
Aerzen AT Turbo Packages

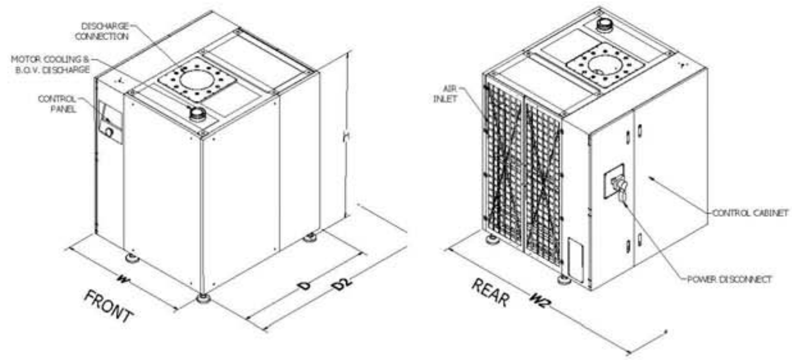
Energy-efficient
Compact
Quiet

Aerzen AT Turbo Blowers

Aerzen AT Turbo blowers are single stage high-speed turbo blowers designed for lowest energy usage over a wide range of varying air flows and pressures. This modern frequency-controlled, gearless driven machine, along with lubricant-free aerodynamic bearings, guarantees an economical, reliable and maintenance-free compressor operation.

The high energy efficiency and the superior rise-to-surge characteristics of the AT Blowers result from the optimal integration of its core components: the permanent magnet motor, the Aerzen Turbo Inverter, the impeller design and the inherent control system. At the top of its class in energy efficiency, with rotating speeds of up to 60,000 RPM and drive power to 400HP, these industrial machines perform reliably in such applications as wastewater aeration systems, pneumatic conveying, and flue gas desulphurization.





	W = Width		D = Depth		H = Height		W2 = Width with Maintenance Access		D2 = Depth with Maintenance Access	
	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches
AT 100	1150	45.28	1236	48.66	1530	60.24	1930	75.98	1657	65.24
AT 200	1423	56.02	1616	63.62	1900	74.80	2177	85.71	2175	85.63
AT 400	1616	63.62	1913	75.31	2210	87.01	2410	94.88	2575	101.38

High-frequency Permanent Magnet Motor

The motor is specifically designed for high frequency applications; it steadily maintains its high efficiency over a wide range of operating speeds and loads. The motor is entirely air-cooled. The motor is maintenance free. Its integration with the Aerzen Turbo proprietary high frequency inverter helps reduce heat generation and the system's high speed response provides for a wider operating range with a high rise-to-surge. To maintain the high overall efficiency, the cooling air management aims at separating the cooling air from the processed air streams, therefore avoiding pre-heating the compressor inlet air.

High-frequency Turbo Inverter

The Aerzen Turbo Inverter is a high frequency inverter designed for highest efficiency in conjunction with the Aerzen permanent magnet motor. A DC choke and RFI filter are standard and integrated in the blower package. Other types of optional harmonic filters can be supplied for separate installation.

Impeller Design

The impeller is made of 17-4PH stainless steel (X5CrNiCuNb174 or 1.4542) sourced in the USA. Before being inspected, machined and dynamically balanced by Aerzen Turbo to ISO 1940 Q 1.0, the impeller has been produced in an expert high accuracy investment casting process. The high yield strength gives the design engineer the flexibility needed for optimizing the impeller for efficiency and very high safety factors.

Air-foil Bearings: Absolutely Oil-free Operation

The high frequency direct drive does not require any speed increasing gear. The bearings of the motor and impeller shaft are aerodynamic radial and thrust bearings. There is no oil in the machines and therefore no risk of oil leakage or disposal problems.

Easy Installation at Minimal Cost

The Aerzen Turbo AT Blower is a compact, factory tested, ready-to-install sound dampened unit. It is lightweight and designed to be easily moved to its final location by forklift truck. There is no need for any special foundation.

Minimum Maintenance

The entire adjustment and operating system is electronically controlled. Only the air filters need to be exchanged regularly. No oil or oil filters need to be changed.

Integrated Control System and Surge Protection

The control panel is mounted in a panel of the blower enclosure. It features a display with a water and dust-proof touch-screen interface (HMI) as well as pushbuttons for start, stop and emergency shutdown. Fastest surge protection, achieved with the Aerzen CPU-based control system, combined with the Turbo Inverter characteristic provides the Aerzen Turbo its unique high-rise-to-surge capability.

Accessories such as harmonic filter, discharge silencer, check valve, expansion joint can be provided.

AERZEN
One step ahead.

Aerzen USA
108 Independence Way
Coatesville, PA 19320
Phone: (610) 380-0244
Fax: (610) 380-0278
Service Hotline: (800) 444-1692
www.aerzenusa.com
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Aerzen Canada
Phone: (450) 424-3966
www.aerzen.ca
E-mail: info@aerzen.ca

Aerzen Mexico
Phone: (728) 282-5508
E-mail: ventosa@aerzen.com.mx

ATTACHMENT C
UNIVERSAL BLOWER PAC ROTARY POSITIVE DISPLACEMENT BLOWER CUT SHEETS FOR PROCESS AERATION APPLICATION

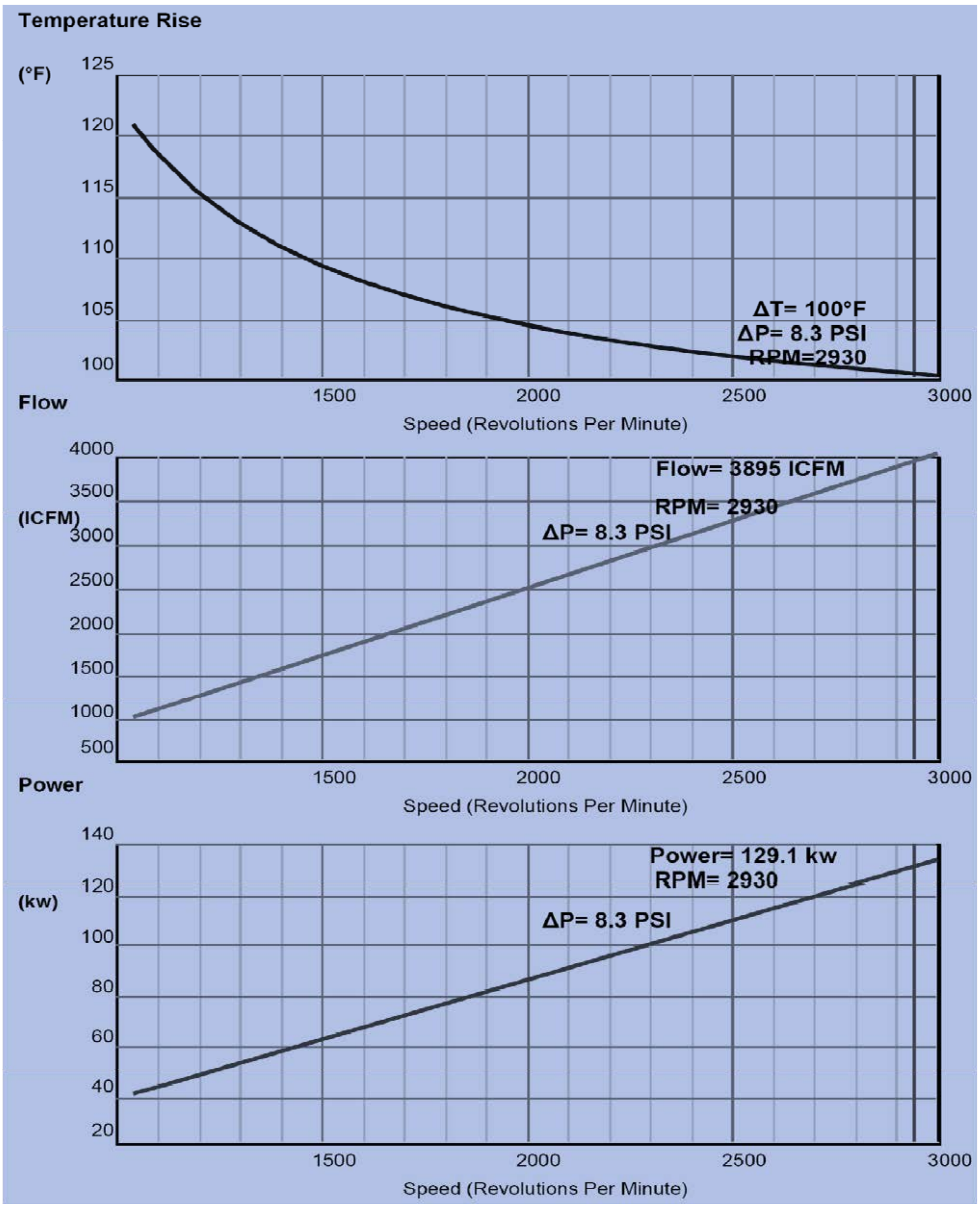
Andrew Placek, PE
Universal Blower Pac, Inc.

8/27/2012

EE-PAC Design - Altamonte Springs, FL

Customer: Tetra Tech, c.o. TSC Jacobs North

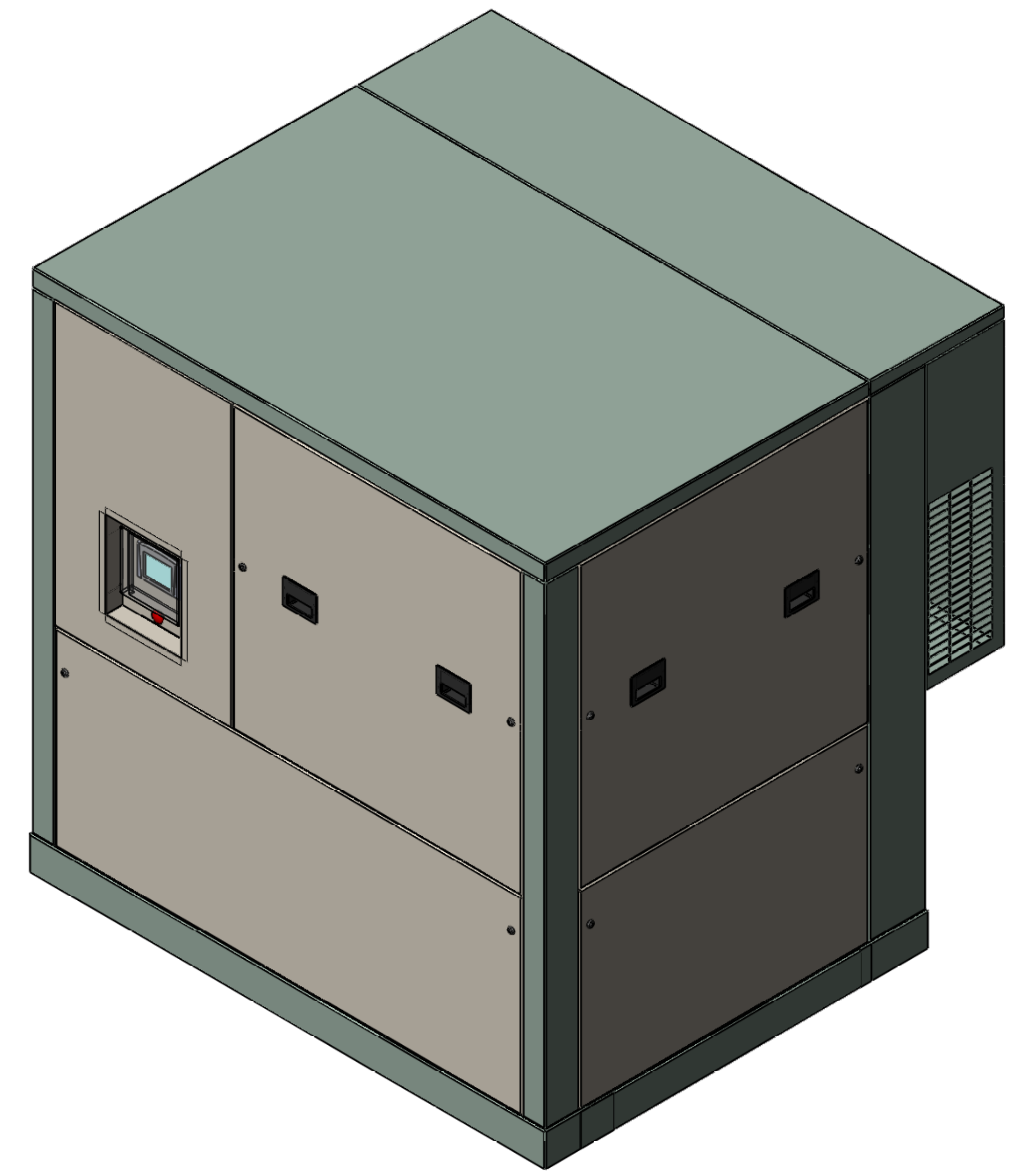
130 kW (175 HP) EE-PAC 3112 (Modified)	100 %Design	60% Design	30% Design
Mass Airflow Requirement (SCFM)	3500	2100	1050
Volume Airflow Requirement (ICFM)	3895	2337	1169
System RPM	2930	1921	1164
Compressor Power Draw (kW)	129.1	80.9	44.9
EE-PAC Total System Power Draw (kW)	146.9	87.7	48.2

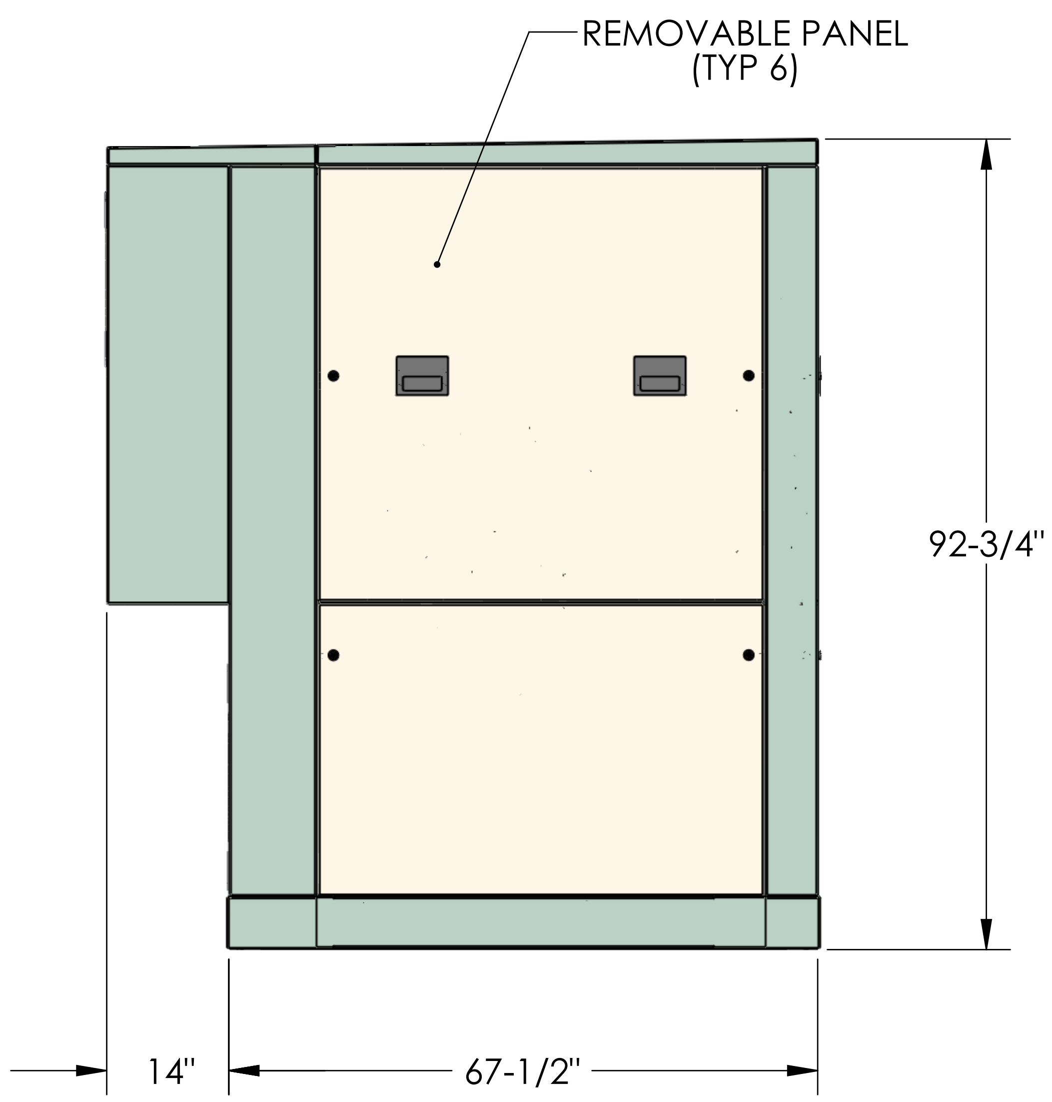


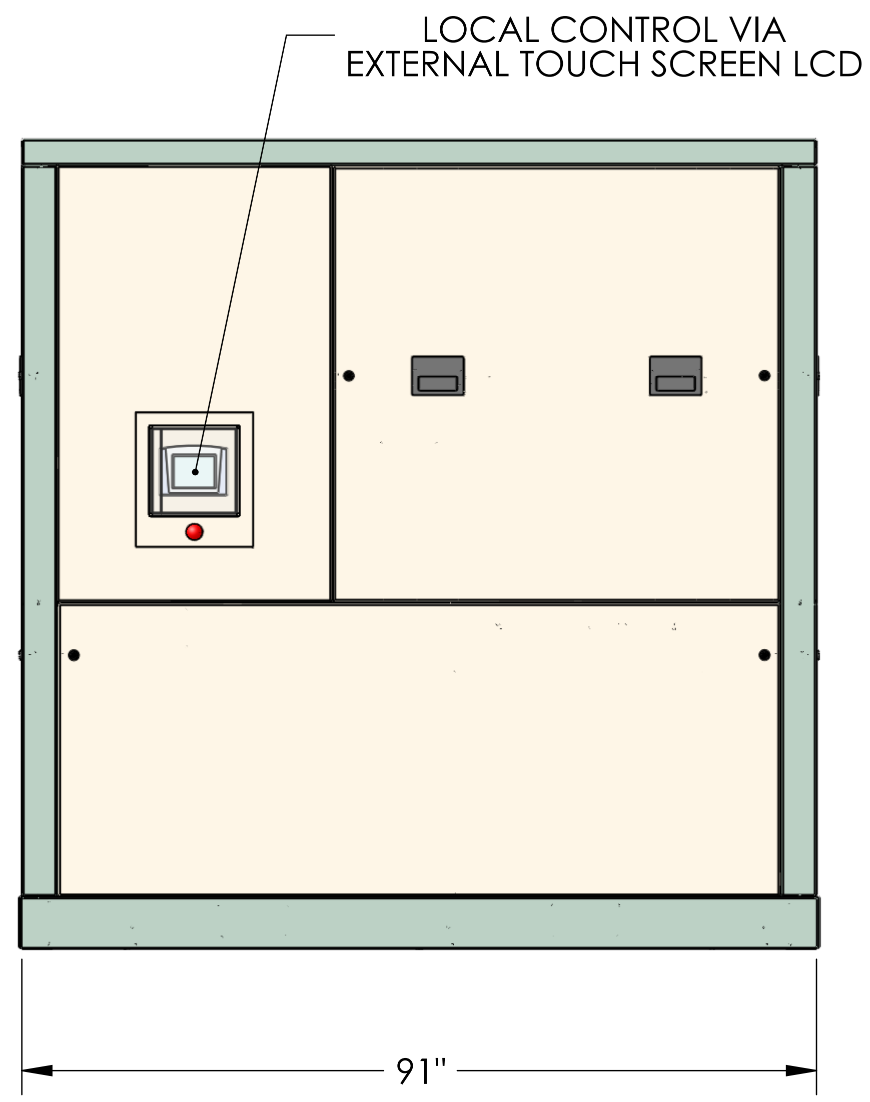
Notes

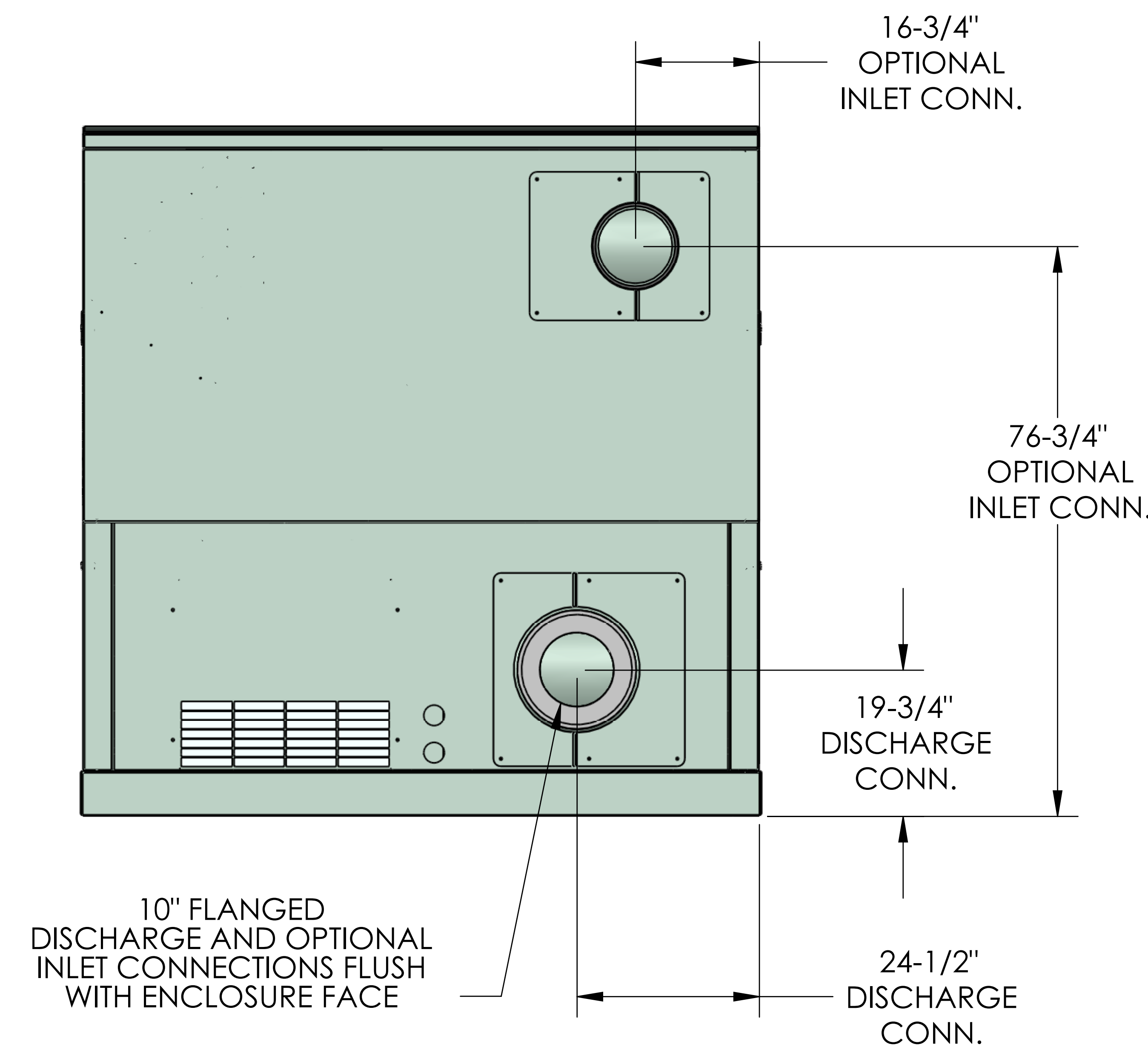
1. All blowers sized at 8.3 psig differential pressure
2. Site conditions for conversion of SCFM assumed to be 0' msl, 100F, and 85% RH.
3. This proposal is for a EE-PAC model 3112 modifed to operate at higher airflow.
4. This system will ship with an external NEMA 1 motor controller cabinet.

ENCLOSURE: ALL SURFACES POWDER COATED
ALL INTERIOR SURFACES LINED WITH 2" ACOUSTICAL FOAM
14-GA. CARBON STEEL MAIN BODY
QTY. (6) ALUMINUM REMOVABLE ACCESS PANELS
QTY. (3) INTERNAL COOLING FANS









MOTOR: 130-kW / 175-HP SR DRIVE
CONTROLS: INTERNAL SR DRIVE PANEL AND SUPPLEMENTAL PLC PANEL
LOCAL OPERATION VIA EXTERNAL TOUCH SCREEN LCD
REMOTE OPERATION VIA ETHERNET CABLE INPUT

APPROXIMATE UNIT WEIGHT: 5450 LBS

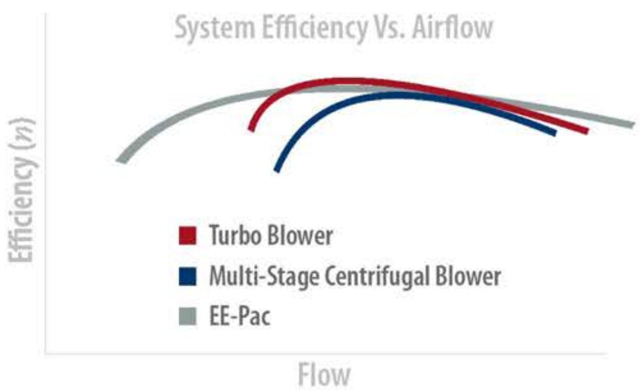
EE-PAC

BY UNIVERSAL BLOWER PAC

HIGH EFFICIENCY BLOWER SYSTEM

UBP has designed this technologically advanced system with your bottom line in mind!

- Drastically reduce your operating expenses
- Increased functionality
- High efficiency with reliable, proven technology



ONBOARD CONTROL SYSTEM TURNKEY OPERATION

Operate indepently or integrate with your plant computer for control.

- No separate control panel required
- Constant flow
- Variable Flow
- Dissolved Oxygen Monitoring System (Requires probe)
- Control locally or remotely

UNIVERSAL BLOWER PAC, INC

The Original Manufacturer

POSITIVE DISPLACEMENT, NEVER WORRY ABOUT SURGE AGAIN!

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website: www.universalblowerpac.com | email: sales@universalblowerpac.com

EEPAC™
BY UNIVERSAL BLOWER PAC

INCREASED FUNCTIONALITY WITH PROVEN RELIABILITY

UNIVERSAL BLOWER PAC, INC
The Original Manufacturer

LOW MAINTENANCE

- Direct coupling - No belt tightening or replacement
- Programmed maintenance schedule for oil change indication
- No hidden refit or rebuild cost
- Coupling drive eliminates power transfer losses
- Local service available throughout the United States

AXIALLY TWISTED ROTORS

- No drive losses
- Positive displacement compression allows for steady efficiency over entire operating range
- Highest efficiency
- Lower noise levels

LOW NOISE

- High density acoustic foam
- Removable panels for easy maintenance

EASY INSTALLATION
PLUG AND PLAY

INDOOR OR OUTDOOR USE

- Powder coated aluminum and steel enclosure
- Durability in corrosive environments

UTILIZING SR TECHNOLOGY

- Exclusively in the US with Universal Blower Pac
- Higher Electrical Efficiency
- Robust Design
- Flexible Operation

US MOTORS® SR DRIVES®

CONTACT US FOR MORE INFORMATION

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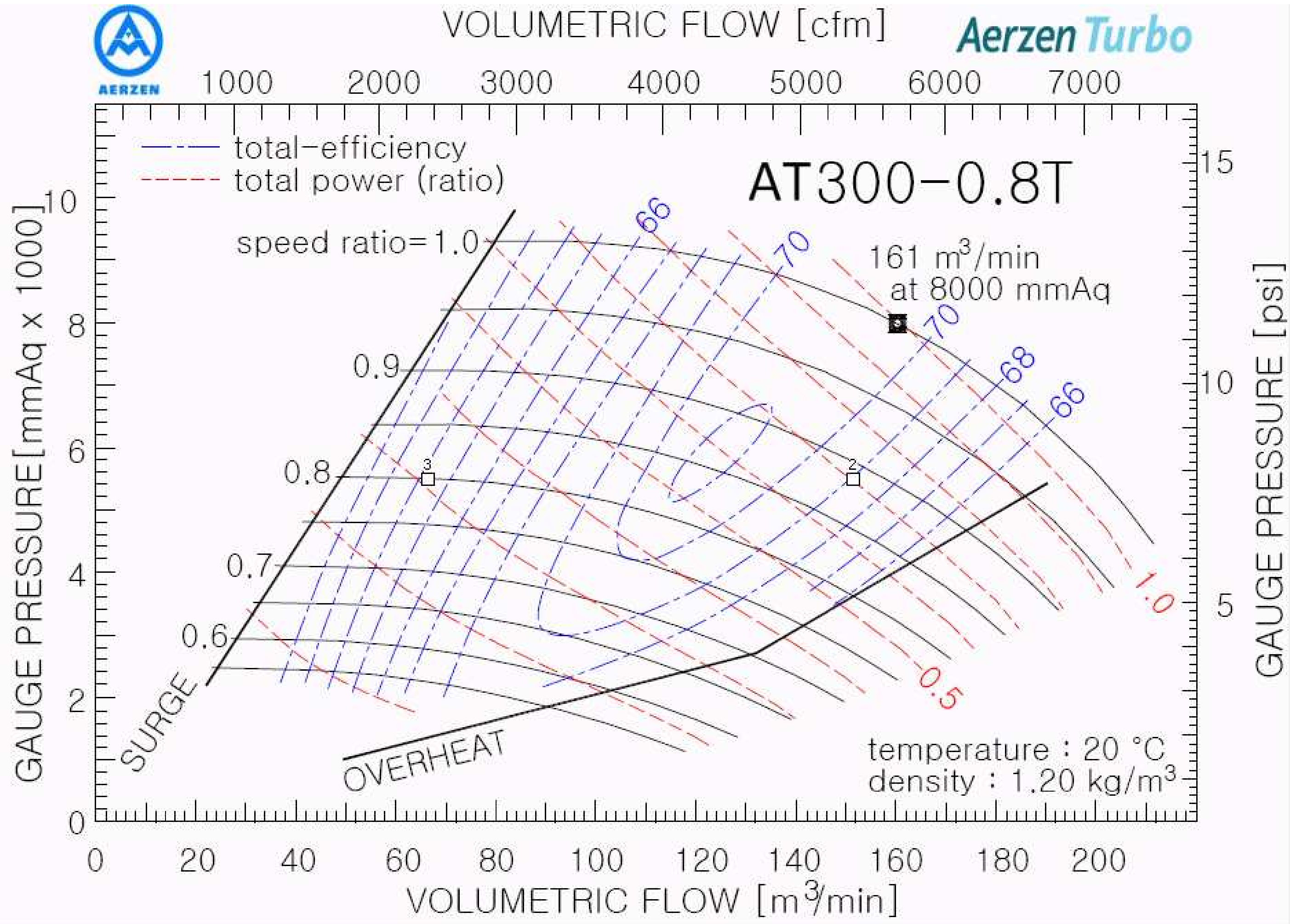
website: www.universalblowerpac.com | email: sales@universalblowerpac.com

TETRA TECH

ATTACHMENT D
AERZEN HIGH-EFFICIENCY TURBO BLOWER CUT SHEETS FOR AERATED SLUDGE HOLDING TANK APPLICATION



No	Tt	RH	Qstd	No of	p2	dpfilter	Qin/unit	Qact/unit	Qcorr/unit	Pcorr	ntotal	Total	
-	[F]	[%]	[CFM]	Units	[PSI]	[PSI]	[ICFM]	[ACFM]	[CFM(corr)]	[PSI(corr)	[%]	Unit [kW]	
2	95	85	3000	1	8	0.1	5615	5650	5327	8.1	69	181.51	
3	95	85	2118	1	8	0.1	2507	2514	2367	8.1	64	86.97	Turndown

ATTACHMENT E
UNIVERSAL BLOWER PAC ROTARY POSITIVE DISPLACEMENT BLOWER CUT SHEETS FOR AERATED SLUDGE HOLDING TANK APPLICATION

UNIVERSAL BLOWER PAC, INC
The Original Manufacturer

August 29, 2012

Project: Altamonte Springs, FL

Customer: Tetra Tech, c.o. TSC Jacobs

Proposal: Two UBP Blower Systems

Notes:

1. **This proposal is for two, variable flow, Universal Blower Pac blowers utilizing 250 HP motors.**
2. **The attached drawing is from a similar project. It does not denote the exact scope of supply we anticipate, but is representative of the configuration and footprint requirement. This configuration can be modified to meet dimensional constraints or other customer needs.**
3. **The compressor and motor will be connected through use of a drive coupling. This eliminates lateral loading on the blower and motor shafts that shortens bearing life. It also eliminates v-belt maintenance and the 3-5% power transfer losses normally incurred with a v-belt drive.**
4. **The unit's speed and flow will be controlled with a variable frequency drive. The system will have an operating range of 1000 – 4800 SCFM.**
5. **The unit will operate in an Attenu-Pac acoustical enclosure at an estimated noise level <= 75 dBA at 1m in a free field.**
6. **Specifications and a sample AutoCAD drawing are available.**

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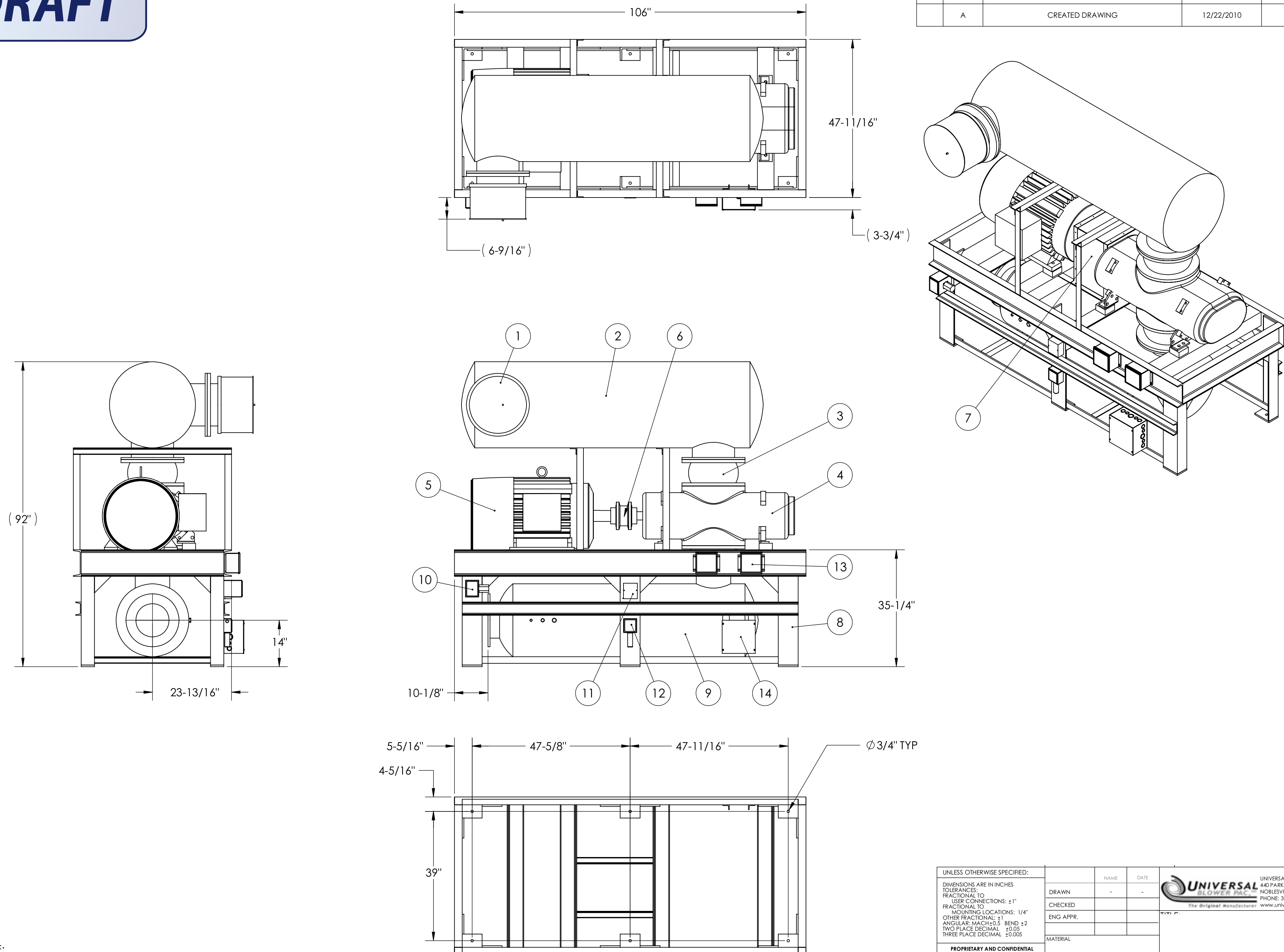
website: www.universalblowerpac.com email: sales@universalblowerpac.com

DRAFT

ZONE	REV.	DESCRIPTION	DATE	APPROVED
REVISIONS				
	A	CREATED DRAWING	12/22/2010	AP



NOTE:

1. INSTALL AND OPERATE ACCORDING TO O&M MANUAL.
2. SOME ITEMS, USUALLY SILENCERS, MAY BE DISASSEMBLED FOR SHIPMENT. REASSEMBLY MAY BE REQUIRED.

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL TO
USER CONNECTIONS: ±1"
FRACTIONAL TO
MOUNTING LOCATIONS: 1/4"
OTHER FRACTIONAL: ±1
ANGULAR: MACH±0.5 BEND ±2
TWO PLACE DECIMAL ±0.05
THREE PLACE DECIMAL ±0.005

	NAME	DATE
DRAWN	-	-
CHECKED		
ENG APPR.		
MATERIAL		
STOCK SIZE		
FINISH		

DO NOT SCALE DRAWING

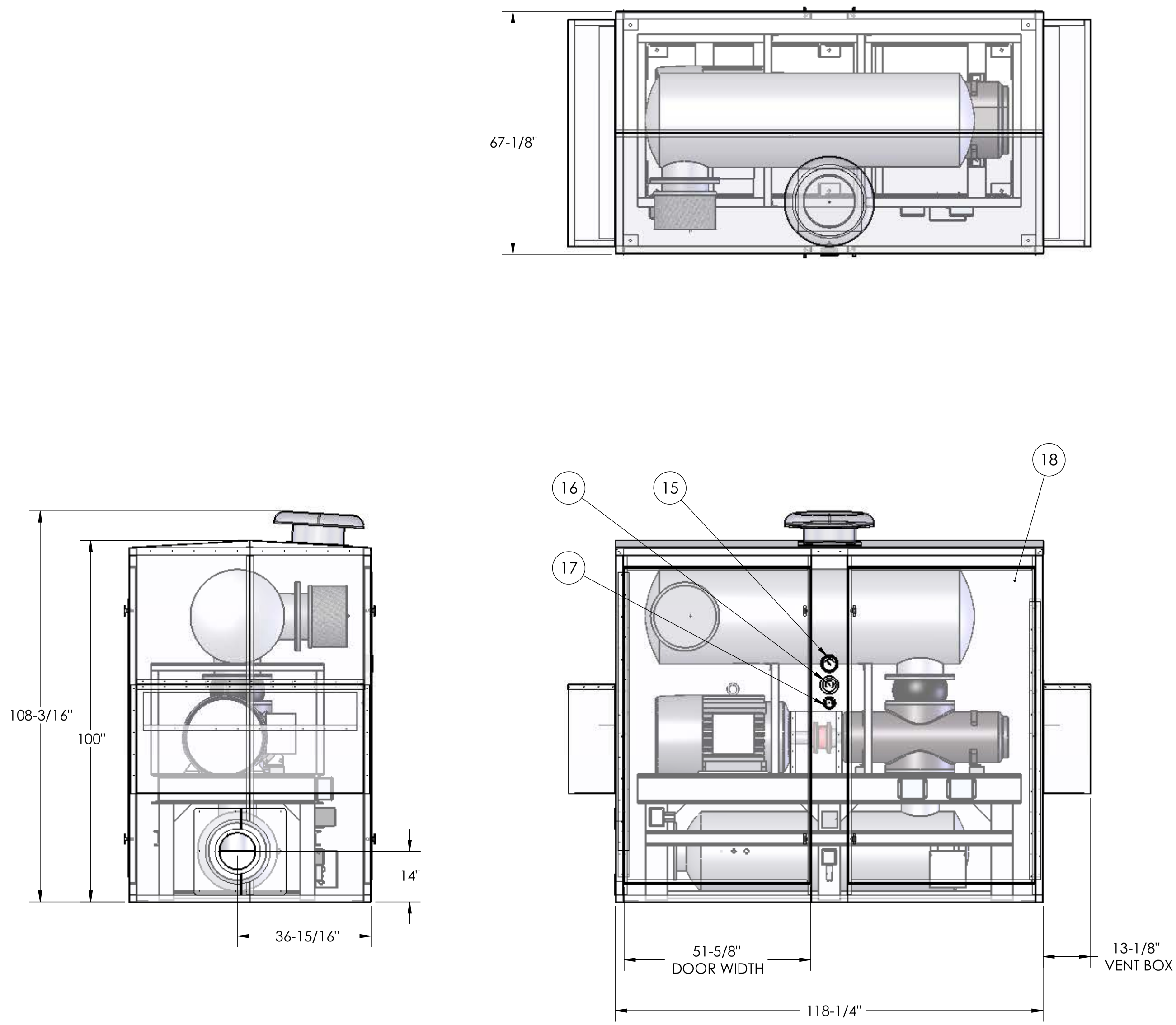
UNIVERSAL BLOWER PAC
The Original Manufacturer
UNIVERSAL BLOWER PAC, INC.
440 PARK 32 WEST DRIVE
NOBLESVILLE, IN 46060-9252
PHONE: 317-773-7256
www.universalblowerpac.com

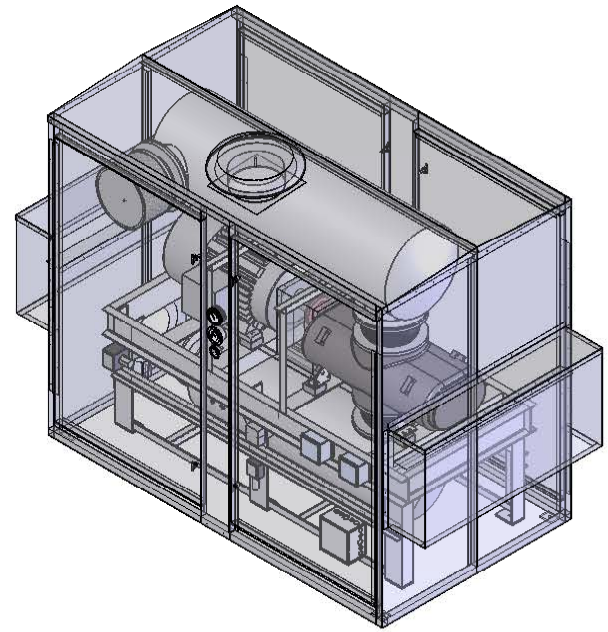
SIZE C

SCALE: 1:20 | WEIGHT: 9600 lbs | SHEET 1 OF 2

DRAFT

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
-	-	See Sheet1	-	-





NOTE:

1. INSTALL AND OPERATE ACCORDING TO O&M MANUAL.
2. SOME ITEMS, USUALLY SILENCERS, MAY BE DISASSEMBLED FOR SHIPMENT. REASSEMBLY MAY BE REQUIRED.

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL TO
USER CONNECTIONS: ±1"
FRACTIONAL TO
MOUNTING LOCATIONS: 1/4"
OTHER FRACTIONAL: ±1
ANGULAR: MACH±0.5 BEND ±2
TWO PLACE DECIMAL ±0.05
THREE PLACE DECIMAL ±0.005

PROPRIETARY AND CONFIDENTIAL

	NAME	DATE
DRAWN	-	-
CHECKED		
ENG APPR.		

MATERIAL

STOCK SIZE

FINISH

DO NOT SCALE DRAWING

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PHONE: 317-773-7256
www.universalblowerpac.com

SIZE C

SCALE: 1:24 | WEIGHT: 9600 lbs | SHEET 2 OF 2

Application Summary

Elevation: 0' msl
Operation: Variable, 1 duty, one standby
Differential Pressure: 8.3 psig
Design Temperature: 100 F
Design Relative Humidity: 85%

Design Points:

100% – 4800 SCFM (5342 ICFM) @ 8.3 psig differential
60% – 2880 SCFM (3205 ICFM) @ 8.3 psig differential
30% – 1440 SCFM (1603 ICFM) @ 8.3 psig differential

Operating Schedule			
	100% Flow	60% Flow	30% Flow
Compressor Power Draw (bhp)	233.4	150.6	88.5
Operating Speed (RPM)	1852	1195	702
% Maximum Operating Speed (%)	97	63	37
Discharge Temperature (°F)	204	211	231
System Noise Level, (dBA @ 1m)	75	<75	<75
Anticipated System Power (kW)[1]	190.1	133.0	84.4

1. Estimate includes motor electrical loss and Idealized VFD efficiency factor.

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Operating Curve