MANAGEMENT OF CHANGE

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It happens to everyone. We miss a detail that mucks up the works. In this edition of Epic Fails, we will look at a failure to manage a change fully.

In this example, we have an upblast fan that was installed in 2016 to provide emergency ventilation for a small machinery room. IIAR2-2014, which was the current edition when this project was planned and executed, stated:

6.14.7.1 *Emergency mechanical ventilation systems shall provide not less than 30 air changes per hour based on the gross machinery room volume. The emergency ventilation system shall be permitted to include temperature control ventilation fans that meet the requirements of Section 6.14.3.7 and Section 6.14.6.3, Item 2.

Note that IIAR2-2021 has the same requirement for emergency exhaust rate.

The machinery room volume is 9690 ft^3. At 30 air changes per hour, this requires an exhaust rate of 4845 CFM. To limit the temperature to the maximum of 104°F as required by IIAR2-2014.

6.14.6.1 *Temperature control mechanical ventilation design capacity shall be the volume required to limit the room dry bulb temperature to 104°F (40°C), taking into account the ambient heating effect of machinery in the room and with the make-up air entering the room at a 1% design dry bulb temperature. The emergency ventilation system shall be permitted to be used to supplement temperature control ventilation, and vice versa.

EXCEPTION: A reduced temperature control ventilation rate shall be permitted where a means of cooling is provided or room electrical equipment and wiring is designed to accommodate temperatures exceeding a dry bulb temperature of 104°F (40°C), in accordance with UL listings and the Electrical Code.

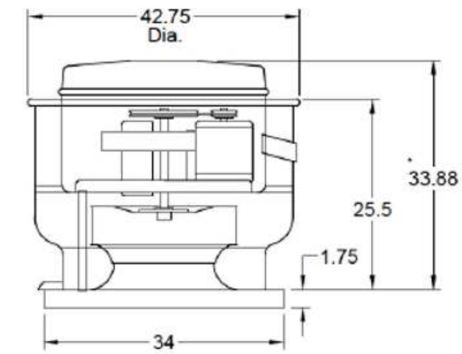
IIAR2-2021 makes a change to this paragraph as follows:

*Temperature control mechanical ventilation design capacity shall be the volume required to limit the room dry bulb temperature to 104°F (40°C), taking into account the ambient heating effect of machinery in the room and with the make-up air

GREENHECK
Building Value in Air.

Model: CUBE-220-20
Belt Drive Upblast Centrifugal Roof Exhaust Fan

Dimensional	
Quantity	1
Weight w/o Acc's (lb)	137
Weight w/ Acc's (lb)	170
Max T Motor Frame Size	184
Optional Damper (in.)	24 x 24
Roof Opening (in.)	26.5 x 26.5



Performance	
Requested Volume (CFM)	6,000
Actual Volume (CFM)	6,000
External SP (in. wg)	0.5
Total SP (in. wg)	0.5
Fan RPM	870
Operating Power (hp)	1.59
Elevation (ft)	837
Airstream Temp.(F)	70
Air Density (lb/ft3)	0.073
Drive Loss (%)	5.2
Tip Speed (ft/min)	5,580
Static Eff. (%)	31

Motor	
Motor Mounted	Yes
Size (hp)	2
Voltage/Cycle/Phase	460/60/3
Enclosure	ODP
Motor RPM	1725
Windings	1
NEC FLA* (Amps)	3.4

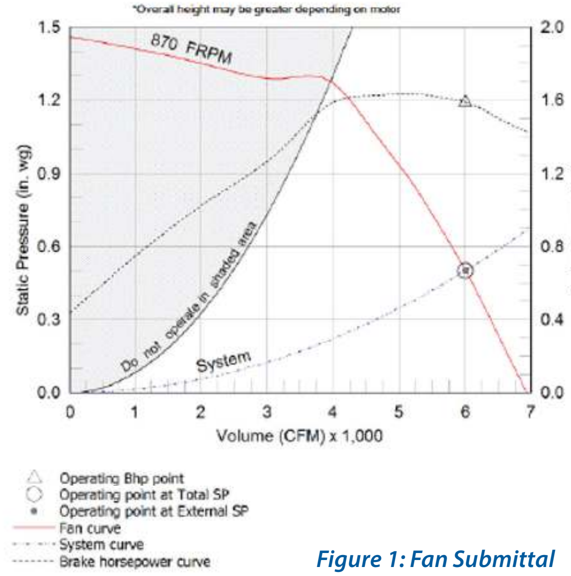
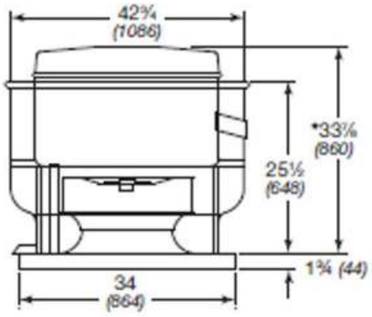


Figure 1: Fan Submittal

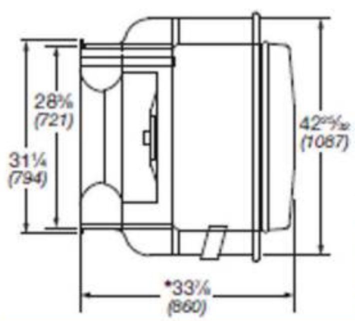
Roof Upblast/Sidewall Exhaust
Size-220: CUBE
CWB

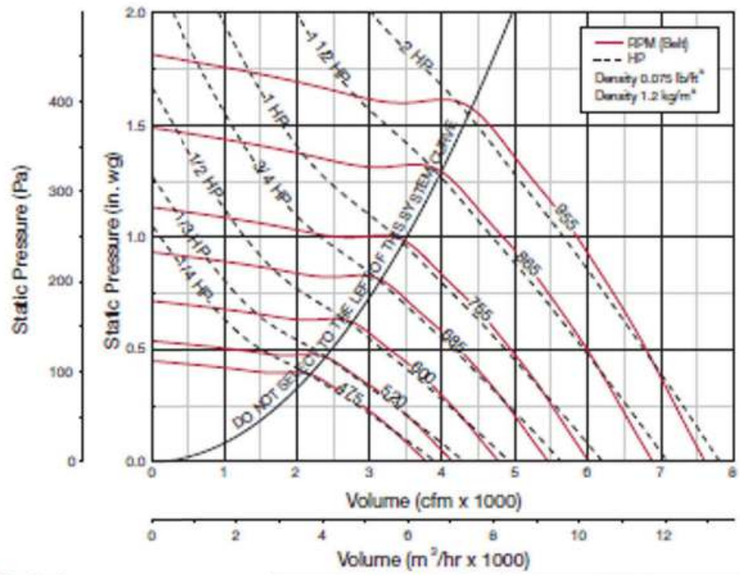
GREENHECK
Building Value in Air.



CUBE

CWB





All dimensions in inches *(millimeters)*, weight in pounds *(kilograms)*.
* May be greater depending on motor.
^Weight shown is largest cataloged open drip-proof motor.
Specifications and image for each model located at back of catalog.

	CUBE	CWB
^Approximate Weight	174 *(79)*	174 *(79)*
Damper Size	24 x 24 *(610 x 610)*	20 x 20 *(508 x 508)*
Roof/Wall Opening	26½ x 26½ *(673 x 673)*	20½ x 20½ *(521 X 521)*

Motor HP	Fan RPM		Static Pressure in Inches wg 0	0.125	0.25	0.375	0.5	0.625	0.75	1	1.25	1.5
220												
1/4	450	CFM	3585	3155	2624							
		BHP	0.19	0.21	0.22							
		Sones	7.4	6.8	6.2							
	475	CFM	3784	3377	2896	2268						
		BHP	0.23	0.25	0.26	0.25						
		Sones	8	7.3	6.7	6.2						
1/3	520	CFM	4142	3771	3357	2845						
		BHP	0.3	0.32	0.34	0.34						
		Sones	9.3	8.5	7.7	7.2						
1/2	600	CFM	4779	4457	4124	3736	3279					
		BHP	0.46	0.48	0.51	0.52	0.52					
		Sones	12	11.1	10.2	9.5	8.9					
3/4	645	CFM	5138	4838	4539	4194	3811	3346				
		BHP	0.57	0.6	0.63	0.64	0.65	0.64				
		Sones	13.6	12.7	12	11.3	10.6	10				
	685	CFM	5457	5174	4893	4581	4234	3836	3383			
		BHP	0.68	0.71	0.74	0.76	0.78	0.78	0.77			
		Sones	15	14.2	13.7	13.2	12.3	11.7	11.2			
1	755	CFM	6014	5758	5502	5239	4944	4620	4258			
		BHP	0.91	0.94	0.98	1.01	1.03	1.04	1.04			
		Sones	17.7	17	16.6	16.3	15.8	14.9	14.4			
1½	810	CFM	6452	6213	5975	5737	5470	5185	4883	4156		
		BHP	1.13	1.16	1.2	1.24	1.26	1.28	1.29	1.27		
		Sones	19	18.5	17.9	17.6	17.2	16.5	15.7	14.8		
	865	CFM	6890	6667	6443	6220	5987	5729	5453	4835	4111	
		BHP	1.37	1.41	1.45	1.49	1.52	1.54	1.56	1.57	1.53	
		Sones	21	20	19.6	19.2	18.7	18.1	17.4	16.5	16.1	
2	910	CFM	7249	7036	6823	6612	6400	6158	5909	5365	4704	
		BHP	1.6	1.64	1.68	1.72	1.76	1.78	1.81	1.83	1.81	
		Sones	23	22	22	21	21	20	19.3	18.3	17.4	
	955	CFM	7607	7405	7202	7000	6799	6580	6347	5844	5261	4602
		BHP	1.85	1.89	1.93	1.97	2.02	2.05	2.07	2.11	2.11	2.07
		Sones	25	25	24	24	23	23	22	20	19.4	18.9

MAXIMUM BHP AT A GIVEN RPM = (RPM/743)³
MAXIMUM RPM = 955
TIP SPEED (ft/min) = RPM x 6.413
MAXIMUM MOTOR FRAME SIZE = 184T
AVERAGE DISCHARGE VELOCITY (FPM) = CFM/3.76

Figure 2: Fan Catalog

entering the room **at the annual 1% design dry bulb temperature.**

This change was to provide clarity to the required values. For our purposes here, it makes no difference. A review of the motors in the room, gives a required exhaust rate to limit the temperature rise to 104°F of 7680 CFM.

If we review the submittal sheet for the fan in Figure 1, we see that this model is capable of 6000 CFM, more than enough for the required emergency ventilation rate, but not enough to limit the temperature rise in the room properly. Since this was the only fan to be installed in the machinery room, it does not meet the requirements of IIAR2.

Another requirement in IIAR2 is that the fan motor must be of the totally enclosed type if it is in the airstream or inside the machinery room. This requirement is identical between IIAR2-2014 and IIAR2-2021. Since the motor on this fan is on top of the fan unit outside of the air stream, the ODP type motor called out in the submittal is acceptable.

Let's look at the construction of the fan unit. IIAR2-2014 stated that,

6.14.3.6 Machinery room exhaust fans, regardless of function, shall be equipped with non-sparking blades.

In the 2021 edition of IIAR2, this was updated to state

6.14.3.5 Emergency exhaust fans shall be constructed such that radial or axial displacement of the impeller or shaft will not permit two ferrous parts of the fan to rub or strike.

This re-wording of the requirement was done to clarify what is meant by non-sparking construction. Note that the submittal sheet does not state if this fan is "non-sparking" construction. However, a look at the manufacturer catalog shows that this fan and housing is of aluminum construction, making it non-sparking.

Another requirement of IIAR2-2014 is a minimum discharge velocity. Section 6.14.3.5 states, Machinery room exhaust shall discharge vertically upward with a minimum discharge velocity of 2,500 ft/min (762 m/min) at the required emergency ventilation flow rate. The language in the 2021 edition of IIAR2 is identical.

Now, where might we find the discharge velocity for this fan? It is not clearly indicated on the submittal sheet. In fact, the only place to find the discharge velocity for the fan outside of placing a call to the manufacturer's representative is a formula buried in the catalog. As figure 2 shows, the average discharge velocity for the model fan that was selected is calculated by using the following formula:

$$fpm = \frac{CFM}{3.76}$$

$$fpm = \frac{6000}{3.76} \quad 1595.7\ fpm$$

As you can see, the fan is well under the minimum 2,500 fpm as required by IIAR2.

So far, we have identified two deficiencies in this fan installation merely by reviewing the exhaust fan submittal itself. We have not reviewed the placement of the fan relative to air intakes, building entries, and property lines. We have not looked at the control scheme for the exhaust fan. Will it be run at full speed upon detection of an ammonia concentration of no higher than 150ppm in the machinery room? If the ammonia level detected exceeds 150ppm, will it continue to run until a reset is pushed inside the machinery room? Is the fan able to be started with a manual switch outside the primary machinery room door? Will it run at a minimum 0.5 cfm/ft2 of machinery room area or 20 cfm per occupant, whichever is greater, during occupied conditions? Is the emergency exhaust fan powered independently of the machinery room equipment and continue to run if the emergency shutdown for the machinery room has been activated? If the emergency exhaust fan loses power, or fails to achieve the emergency ventilation rate, will an alarm be sent to a monitored location?

We have also not reviewed the air intakes to the room to ensure that enough air can be supplied to limit the negative pressure in the room to no more than 0.25" WC. Nor have we ensured that the intakes, if they are supplied with motorized louvers, fail to the open position. We have also not evaluated the mesh size for any screens on the intakes. IIAR2 limits the mesh size to no smaller than ¼". IIAR2-2021 now includes an exception that allows for smaller screen mesh, or air filters, to be installed providing that engineering or administrative controls are in place to ensure that the maximum negative pressure does not exceed 0.25" WC.

Finally, we have not evaluated the airflow in the machinery room after upgrading this ventilation system. Any time the exhaust system is modified, a smoke study should be conducted to ensure that all air in the room is exchanged every two minutes and that there are no areas in which the ventilation air does not flow and thus does not properly exchange the air.

As you can see from this simple example, managing changes to your ammonia refrigeration system can get heavy on details that can easily be overlooked. If you do not have subject matter expertise on the applicable codes and standards for your ammonia refrigeration system, you should consider finding someone who does to review a project as even the best contractors can overlook code details.