VAV Systems

Design, Performance and Commissioning Issues

Fan Flow and Static Control

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Facility Dynamics Engineering

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What's in this Module?

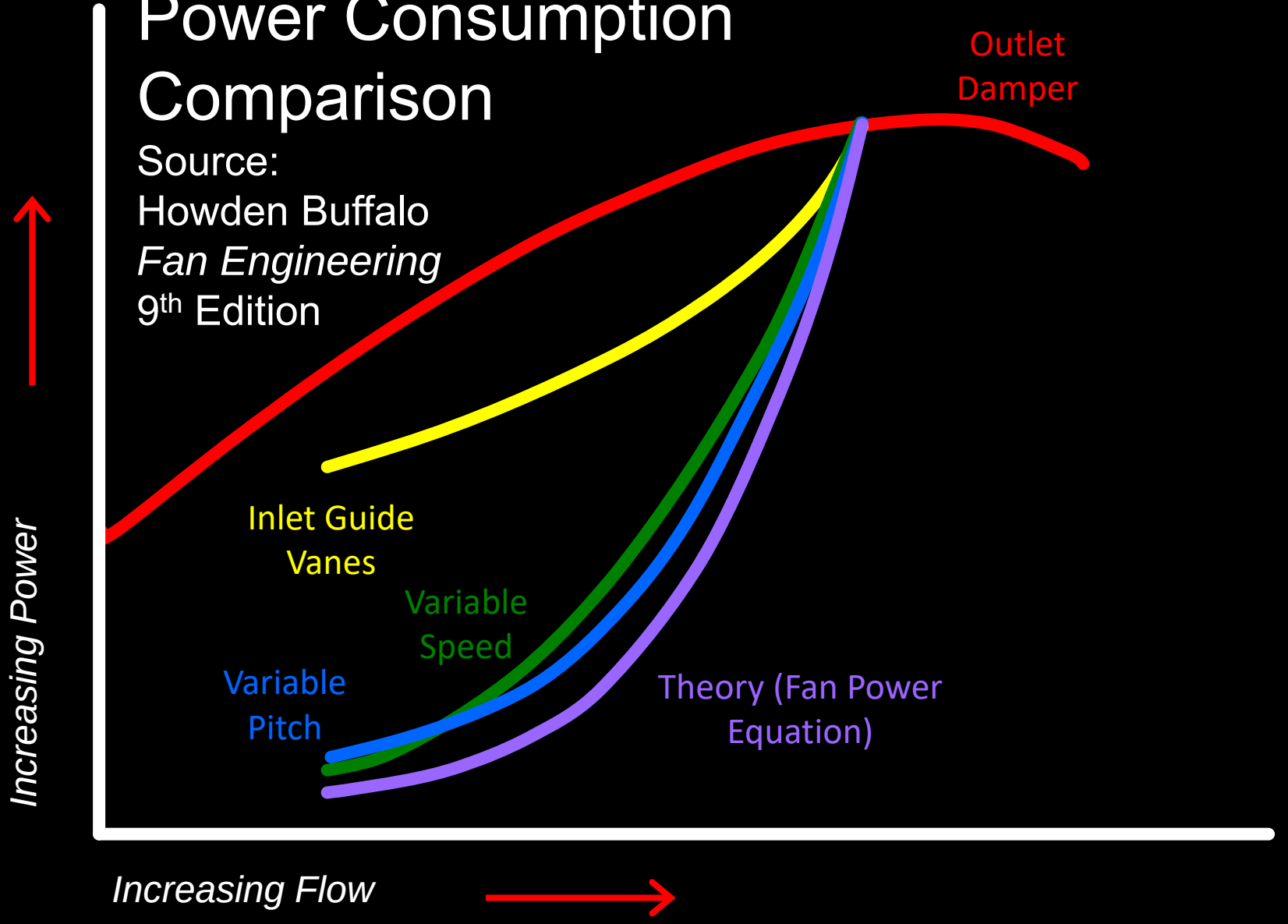
- Fan flow variation techniques and technologies
- Parallel fan considerations
- Lags and VAV systems
- The two-thirds rule applied to VAV systems
- Optimizing DDC AHUs with pneumatic terminal units or terminal units on a separate control system

Flow Variation Technologies

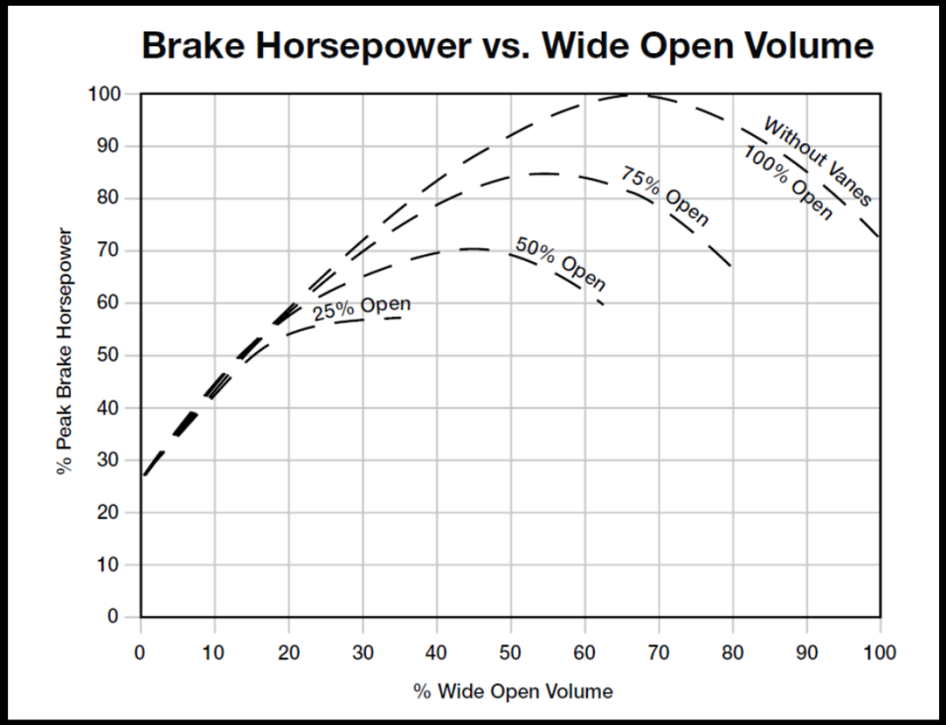
- Discharge Dampers
- Inlet Guide Vanes
- Variable Speed
- Variable Pitch

Power Consumption Comparison

Source:
Howden Buffalo
Fan Engineering
9th Edition



Power Consumption Comparison



Greenheck publishes inlet vane performance metrics and other useful information like torque requirements in *Dampers for Centrifugal Fans – Inlet and Outlet*

http://www.greenheck.com/media/pdf/catalogs/centrifugal_damper_catalog.pdf

Parallel Fan Considerations

- Backdraft dampers are desirable
- Back draft dampers are not perfect
  - Fan wheels can be massive

Parallel Fan Considerations

- Backdraft dampers are:
  - Desirable
  - Not perfect
- Fan wheels can be massive
- Fan wheels can have large moment's of inertia

$$Moment\ of\ Inertia = I = \sum mr^2$$

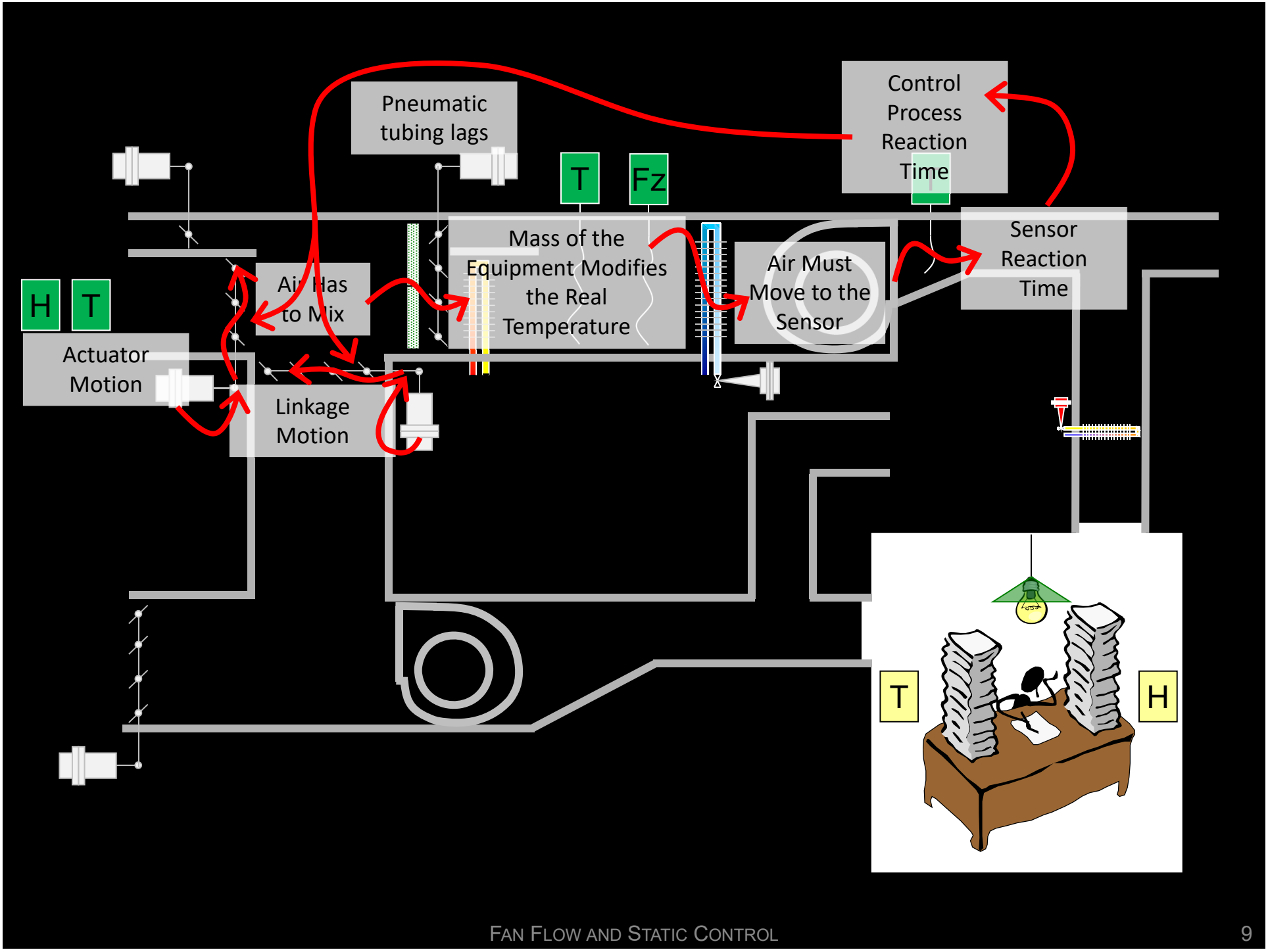
- Things with a lot of inertia tend to stay in motion once they are set in motion
  - VSD have to deal with this when starting against a spinning motor
  - Hub bolts and shafts have to deal with this when starting against a spinning motor

Twin City Fan and Blower Type BAE Airfoil Centrifugal Fans

Size	Wheel Diameter, in.	Maximum RPM	Class 1 Weight, lb	Class 1 WR^2, lb-ft^2	Maximum RPM	Class 2 Weight, lb	Class 2 WR^2, lb-ft^2
Aluminum DWDI Wheels							
122	12.25	3,957	14	1	5,158	15	1
135	13.50	3,374	15	2	4,398	18	2
150	15.00	3,232	22	2	4,213	24	2
165	16.50	2,761	25	4	3,599	28	5
182	18.25	2,248	29	10	2,930	29	10
200	20.00	2,051	36	11	2,674	40	14
222	22.25	1,837	45	18	2,395	53	21
245	24.50	1,668	53	32	2,175	62	37
270	27.00	1,541	62	45	2,009	69	50
300	30.00	1,387	80	75	1,808	86	81
330	33.00	1,261	108	122	1,644	114	129
365	36.50	1,114	109	154	1,452	123	174
402	40.25	1,010	133	236	1,317	144	256
445	44.50	914	191	353	1,191	222	416
490	49.00	830	245	584	1,082	260	619
542	54.25	750	339	945	977	337	939
600	60.00	678	380	1,388	883	376	1,372
660	66.00	616	495	1,972	803	499	1,987
730	73.00	557	593	2,949	726	716	3,832
807	80.75	504	727	4,382	656	819	4,955
890	89.00	457	1,131	8,259	596	1,295	9,429
982	98.25	414	1,340	12,230	539	1,541	13,979
Steel DWDI Wheels							
270	27.00	1,541	152	116	2,009	170	117
300	30.00	1,387	201	176	1,808	197	176
330	33.00	1,261	263	272	1,644	254	272
365	36.50	1,114	326	439	1,452	335	440
402	40.25	1,010	395	640	1,317	390	640
445	44.50	914	516	981	1,191	557	984
490	49.00	830	585	1,427	1,082	618	1,430
542	54.25	750	739	2,128	977	771	2,247
600	60.00	678	906	3,338	883	897	3,338
660	66.00	616	1,349	5,213	803	1,375	5,217
730	73.00	557	1,571	8,239	726	1,582	8,243
807	80.75	504	1,876	12,195	656	1,992	12,933
890	89.00	457	2,827	21,881	596	2,842	21,887
982	98.25	414	3,329	31,933	539	3,343	31,941

It All Depends on the Lags

David W. St. Clair


Pneumatic tubing lags
Control Process Reaction Time
T
Fz
Mass of the Equipment Modifies the Real Temperature
Air Must Move to the Sensor
Sensor Reaction Time
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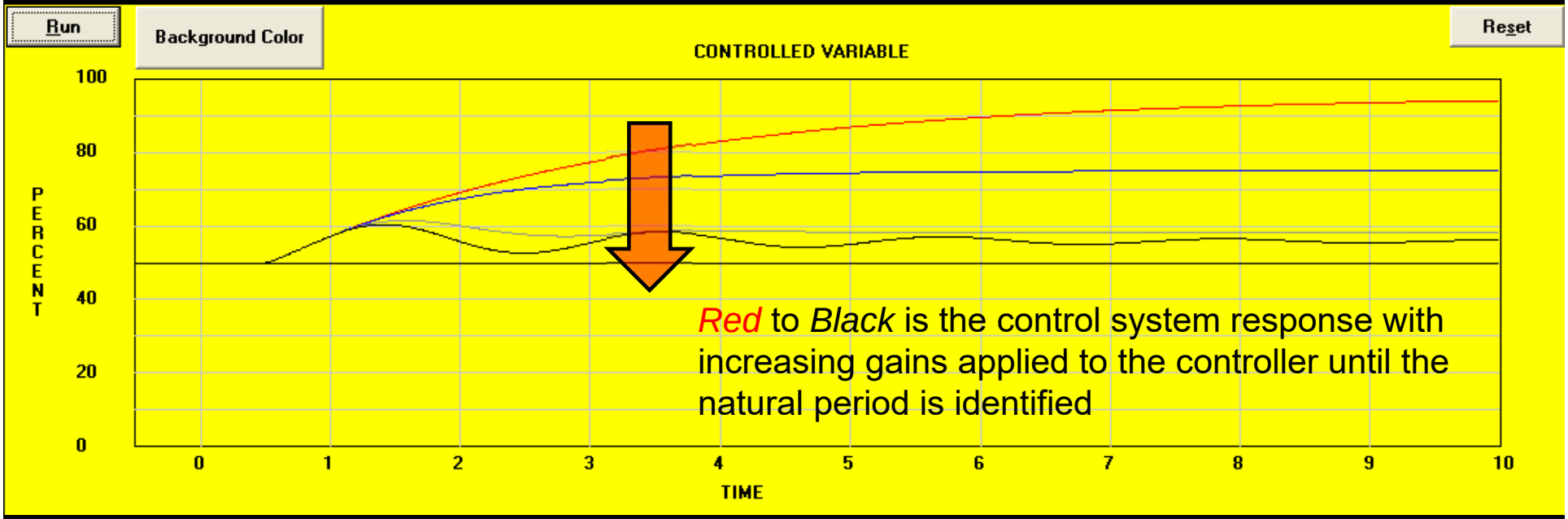
Actuator Motion
Air Has to Mix
Linkage Motion
T
H

Some Observations



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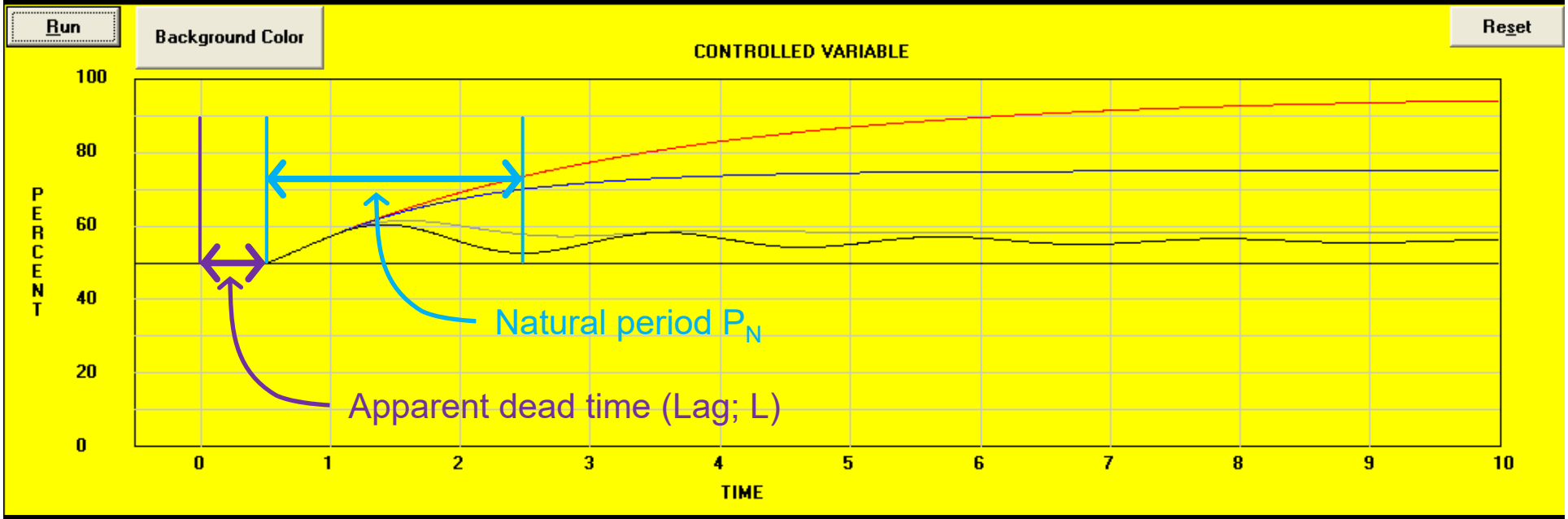

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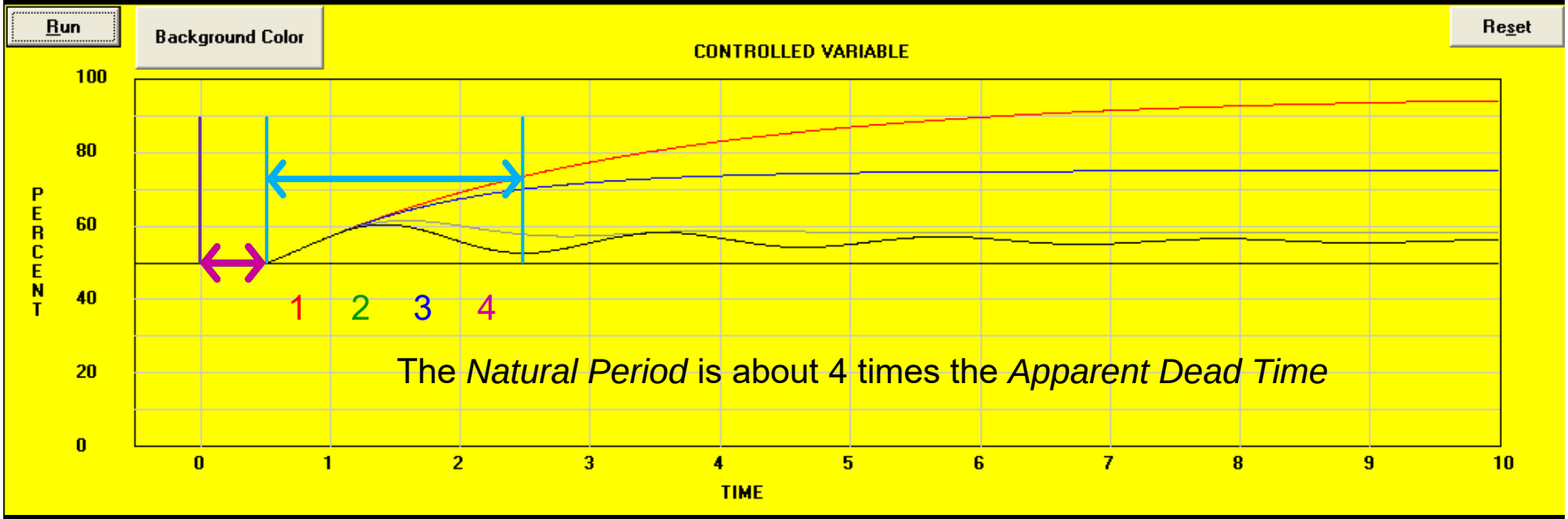

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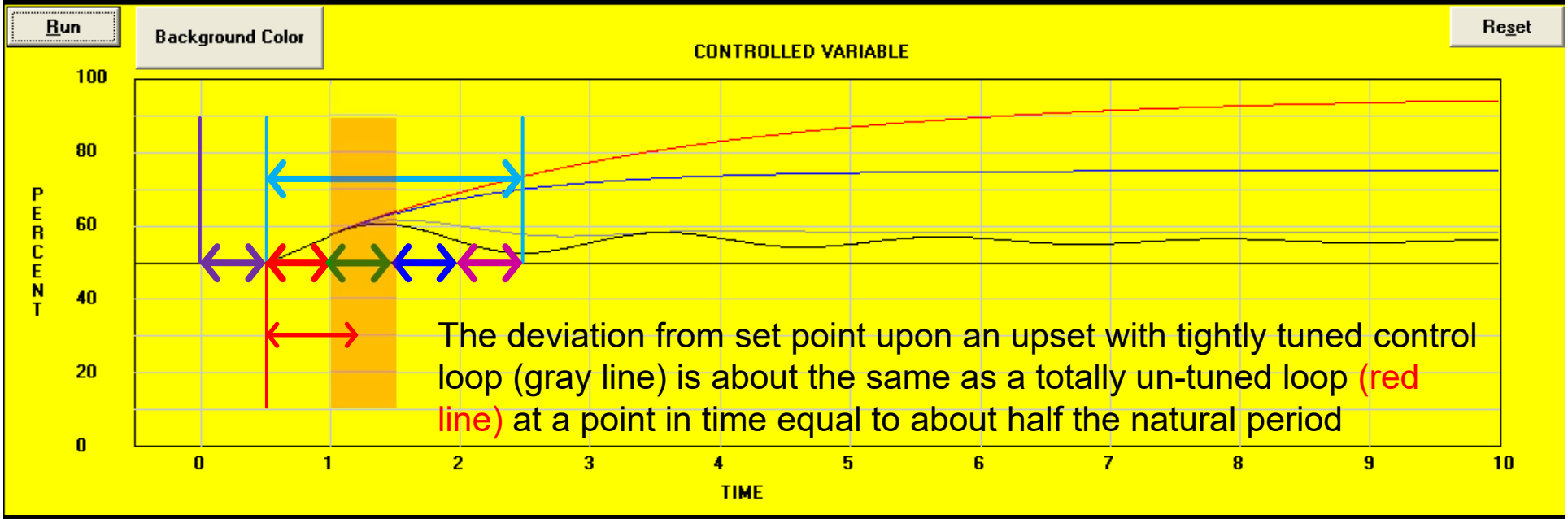

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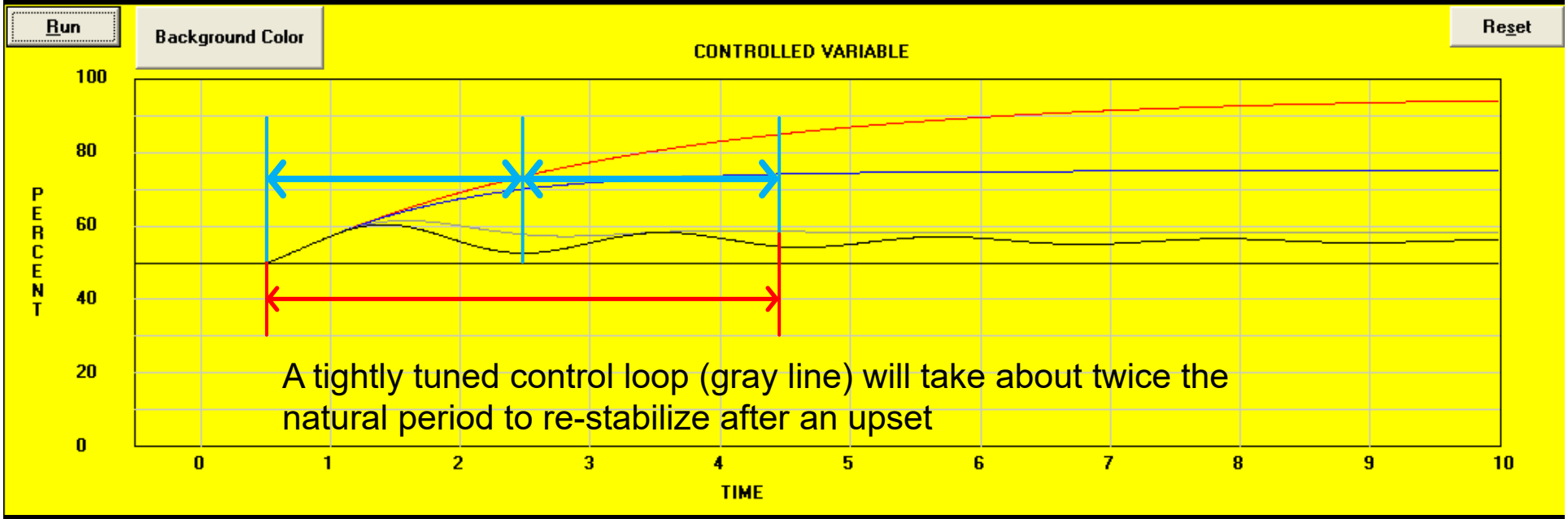


VSD Acceleration Settings and Ramps are Two Different Things

Acceleration Settings

- Applies any time the drive speed changes
- Is part of the lag chain
- Can work against tight control

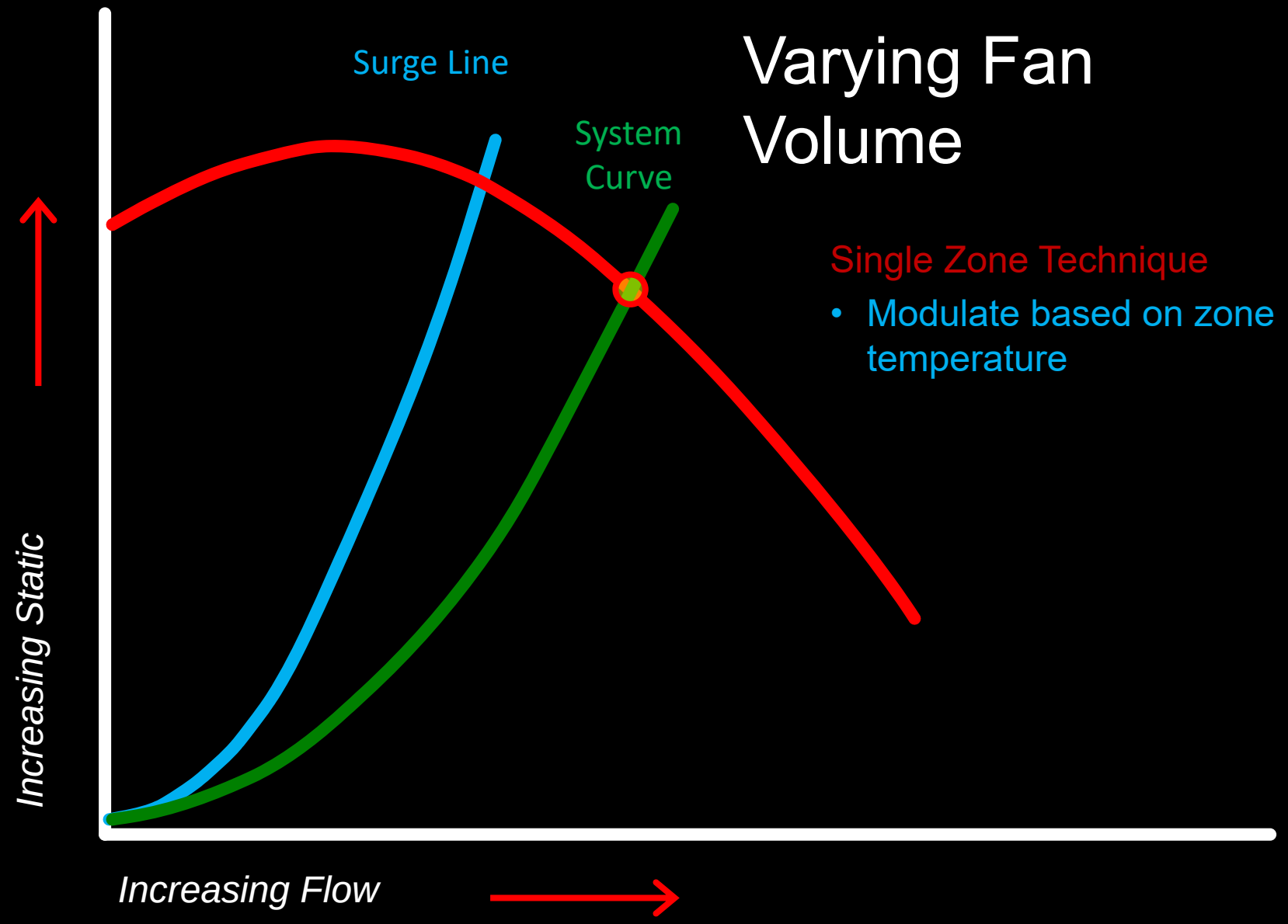
Ramp

- Applies on a start until the system discharge pressure gets into the normal control ranges then drops out of the picture
- Is not part of the lag chain
- Helps achieve stable start-up and operation and tight control

Bottom Lines

- There are a number of ways to vary fan flow
  - Different levels of sophistication and complexity
  - Different levels of power consumption reduction with flow
- You need to be careful with parallel fans
- VAV systems have unique lags which can make them harder to bring on line and control
- Just because your terminal units are not on the DDC system serving the AHU does not mean you can't optimize the system

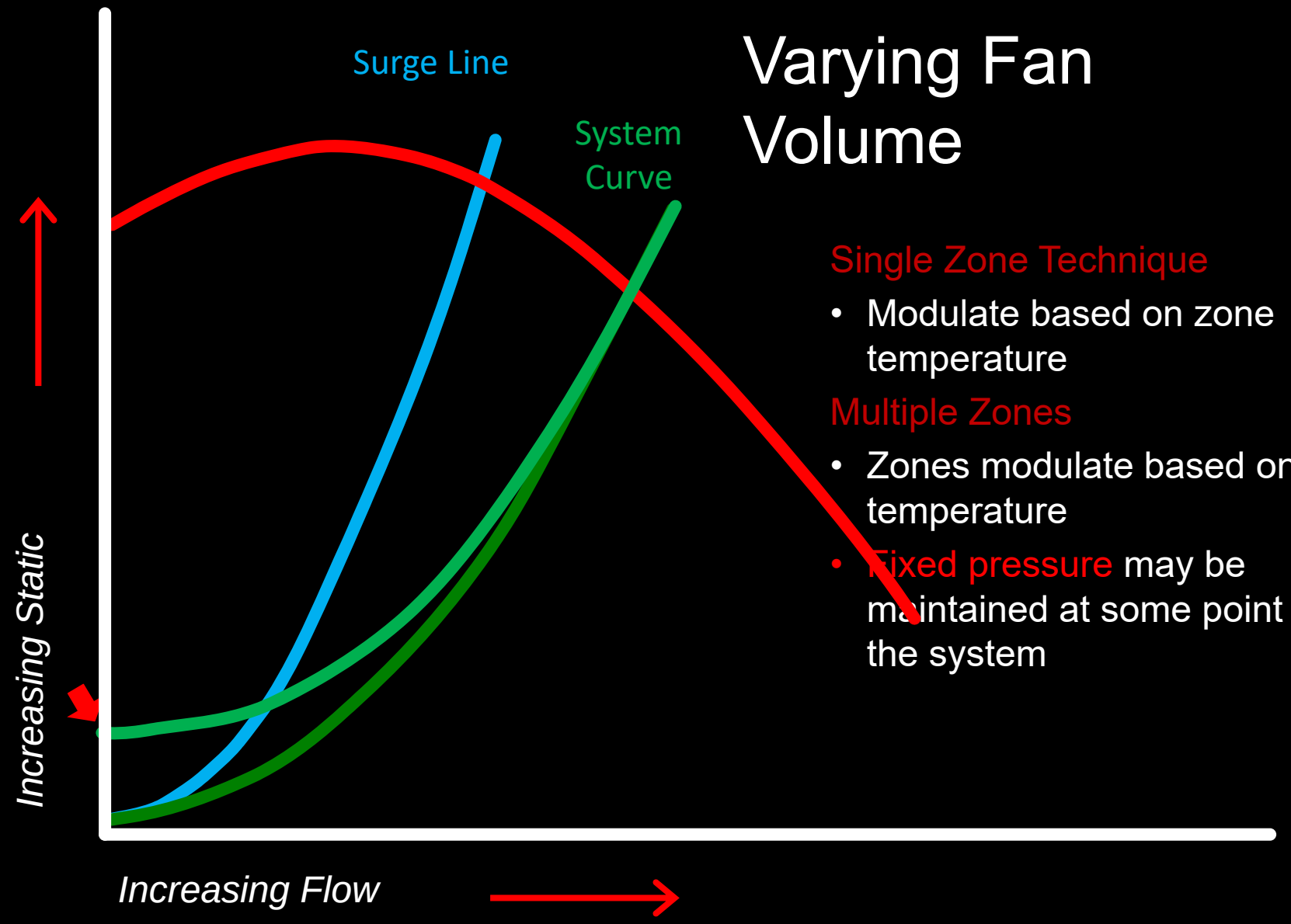
Varying Fan Volume



Single Zone Technique

- Modulate based on zone temperature

Varying Fan Volume

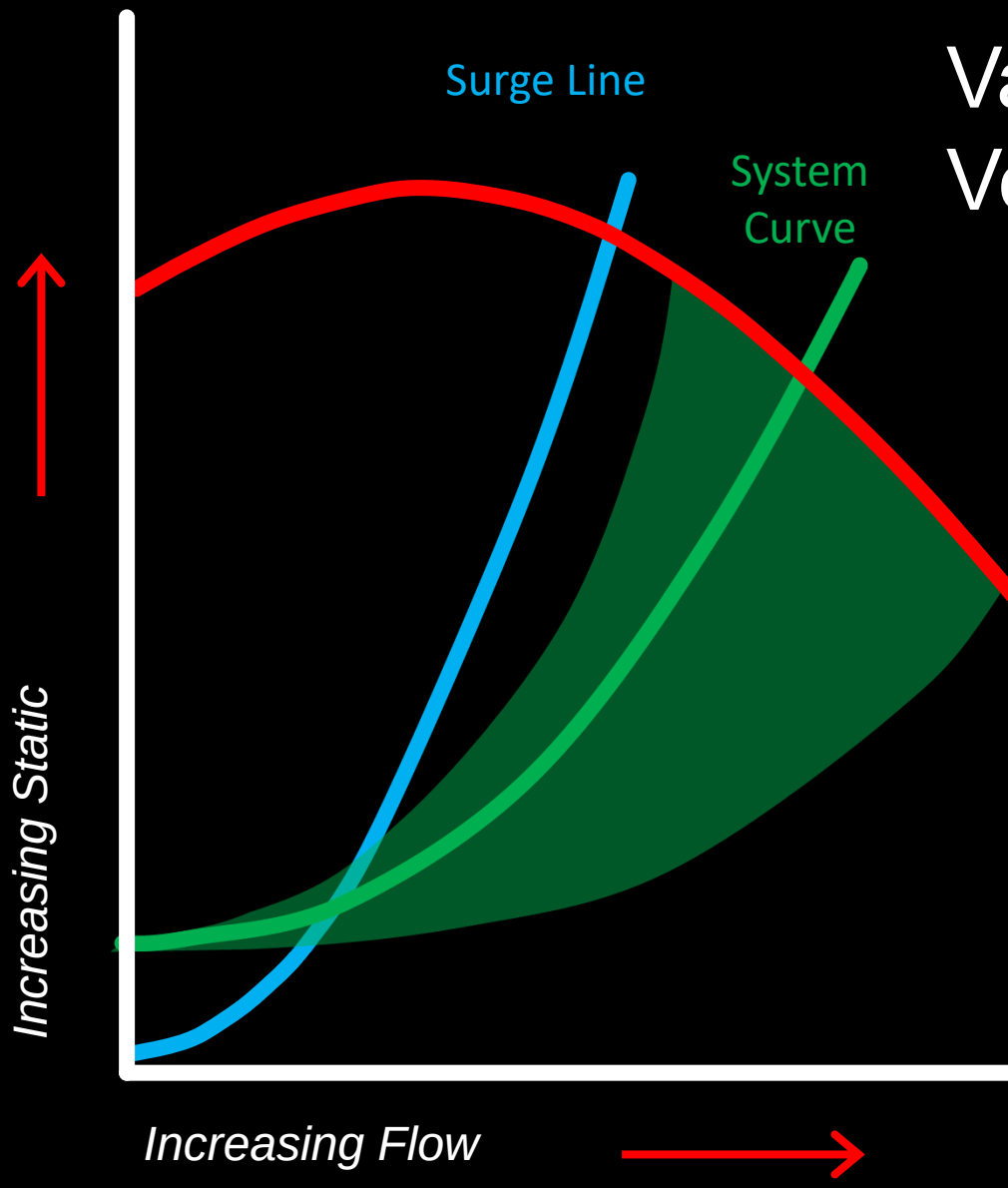


Single Zone Technique

- Modulate based on zone temperature

Multiple Zones

- Zones modulate based on temperature
- Fixed pressure may be maintained at some point in the system



Varying Fan Volume

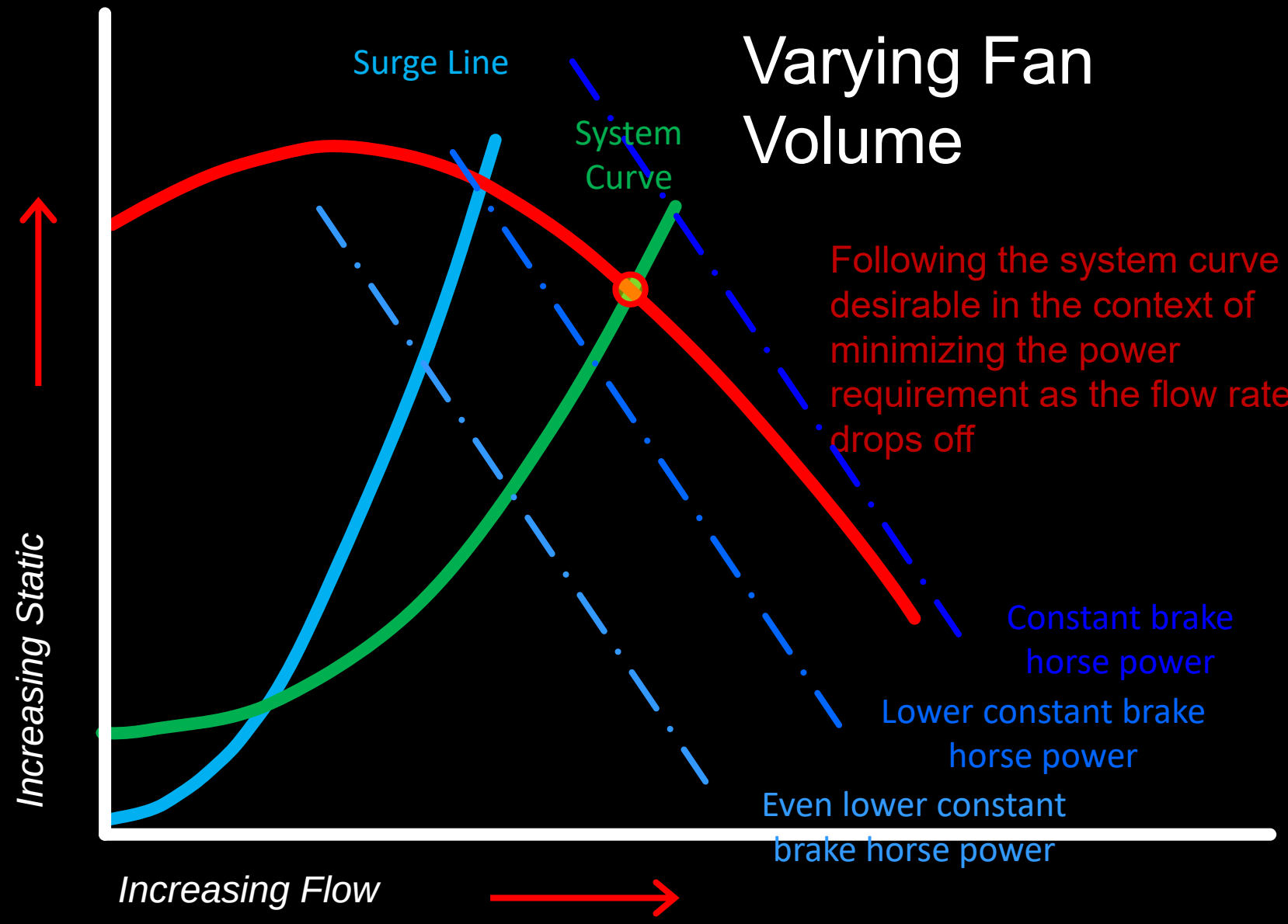
Single Zone Technique

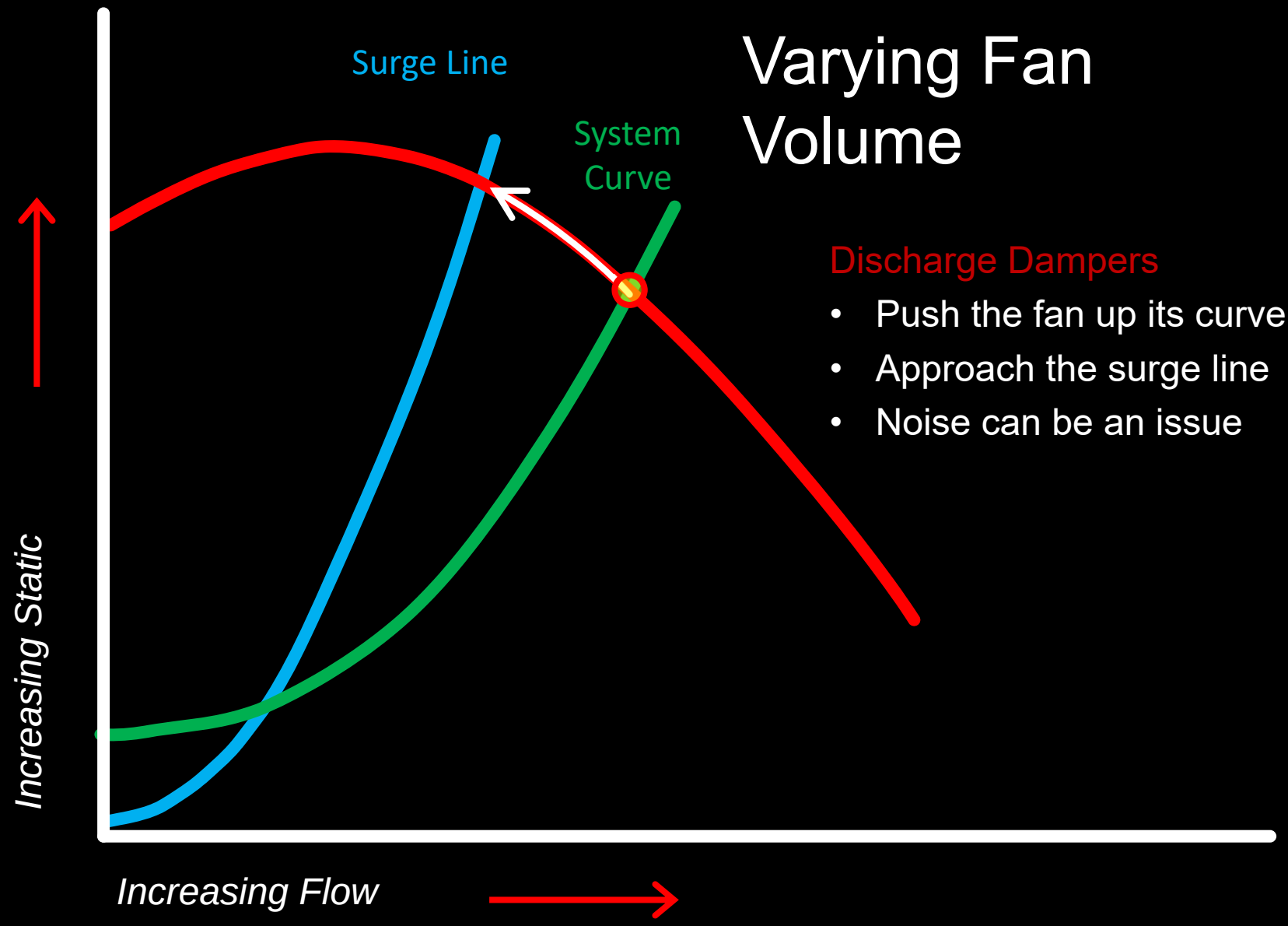
- Modulate based on zone temperature

Multiple Zones

- Zones modulate based on temperature
- Fixed pressure may be maintained at some point in the system
- Fan follows the total zone flow requirement
- Work on a family of system curves

Varying Fan Volume



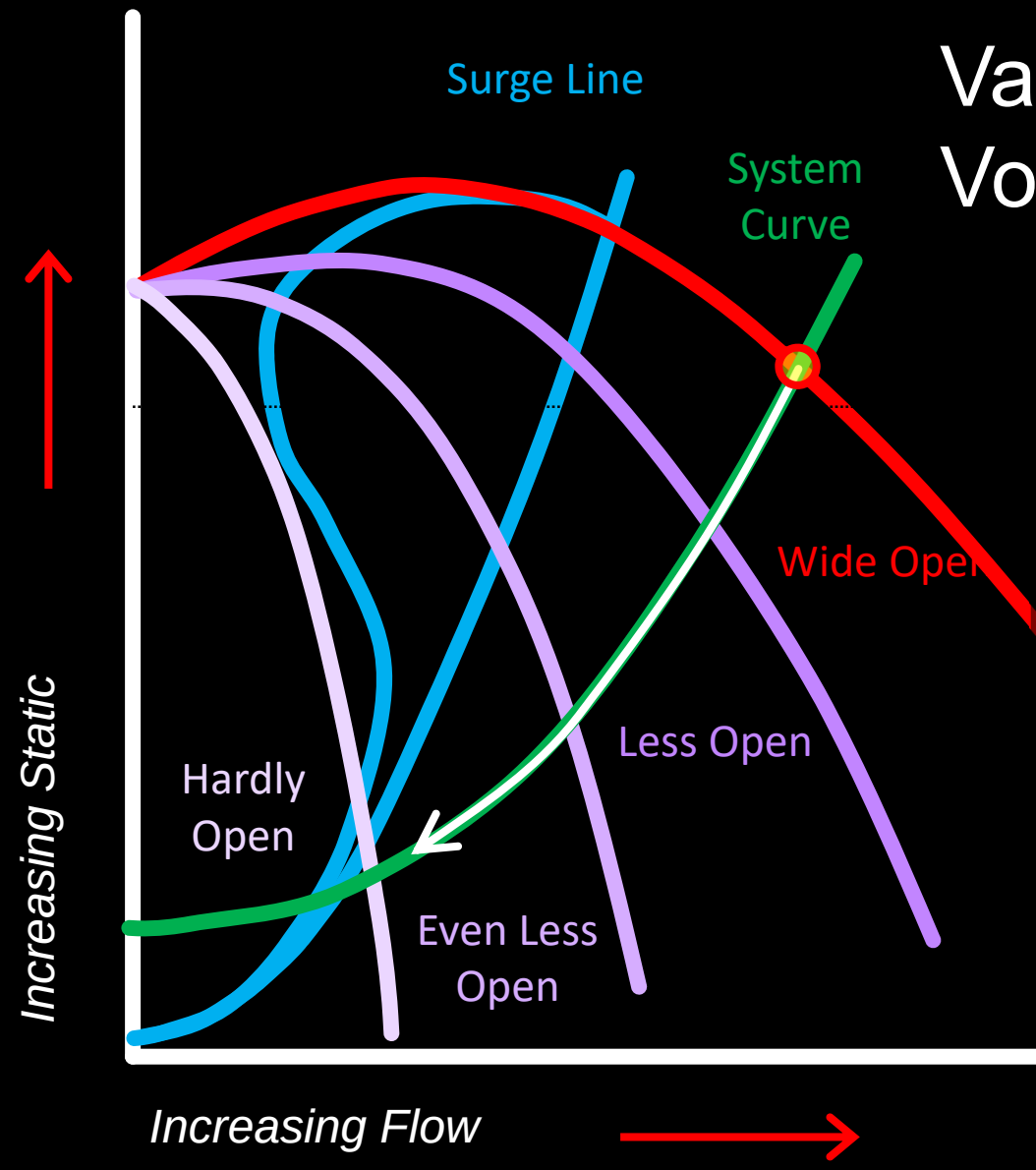


Varying Fan Volume

Discharge Dampers

- Push the fan up its curve
- Approach the surge line
- Noise can be an issue

Varying Fan Volume



Inlet Guide Vanes

- Direct the flow into the fan wheel imparting “swirl”
- Changes the shape of the surge line
- Droops the fan curve
- Tend to follow the system curve
- May be integral to the fan’s peak efficiency point

Inlet Guide Vanes; Directing Airflow into the Fan Wheel

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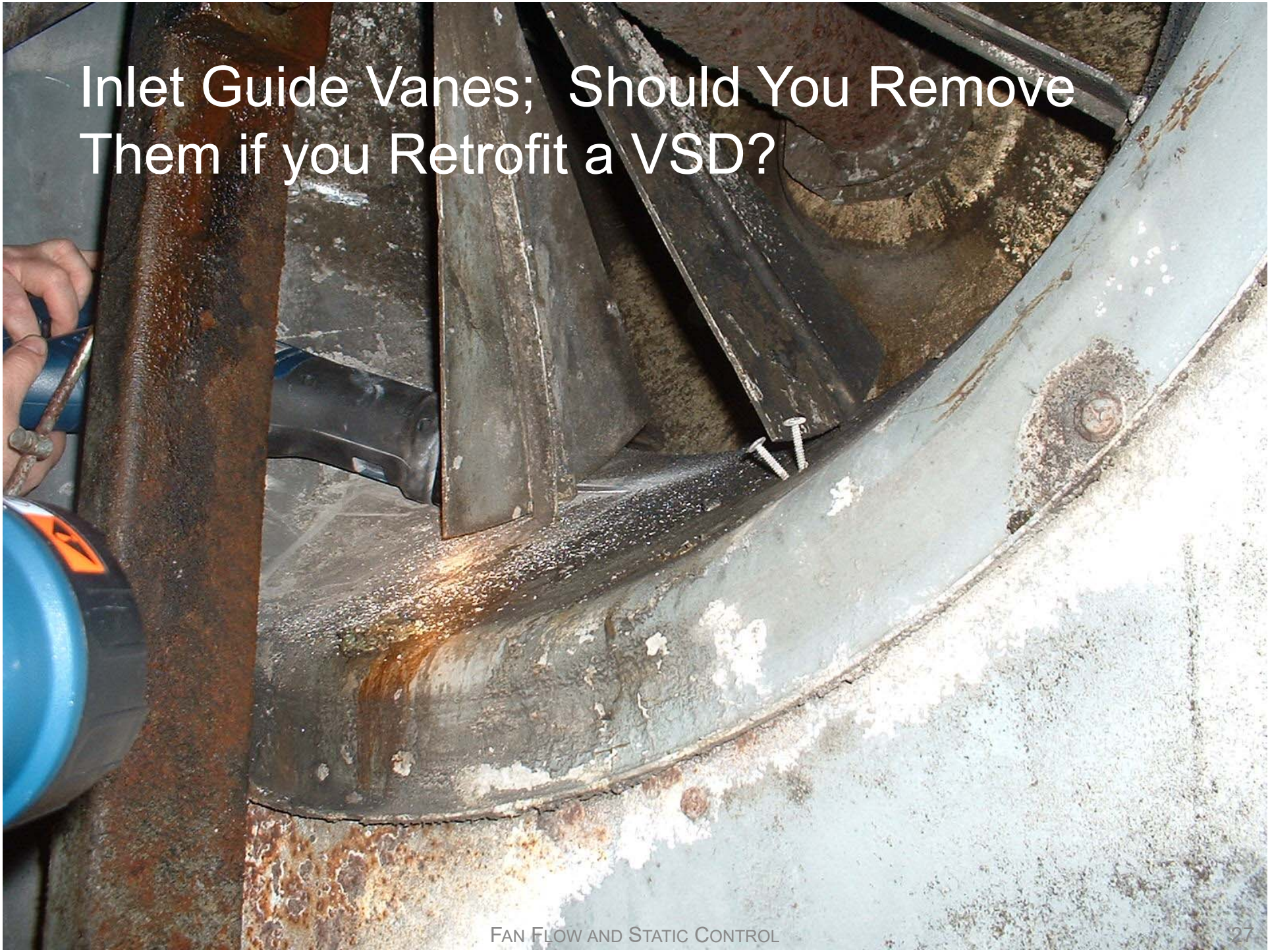
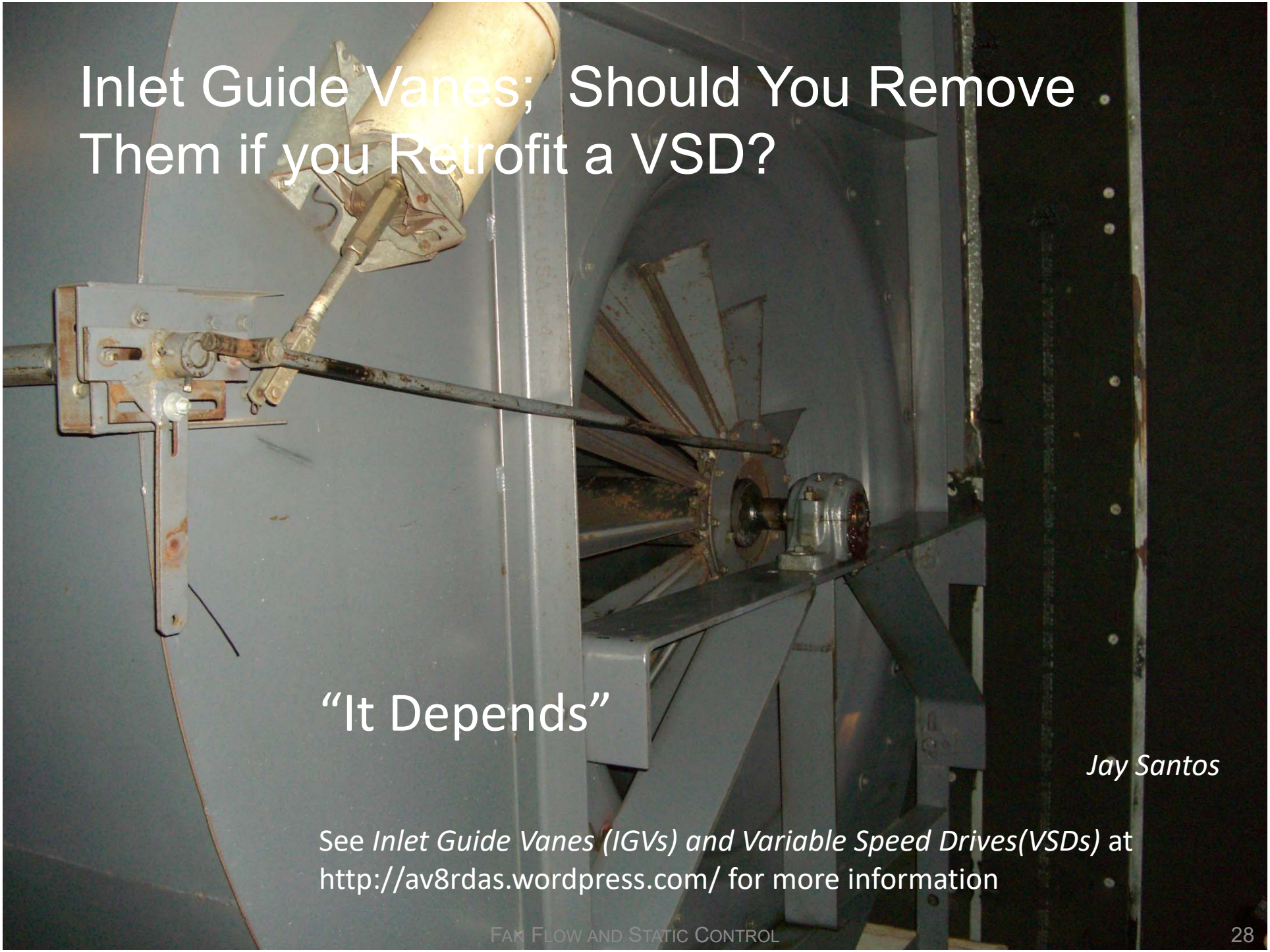
Inlet Guide Vanes; Should You Remove Them if you Retrofit a VSD?



Inlet Guide Vanes; Should You Remove Them if you Retrofit a VSD?



"It Depends"

Jay Santos

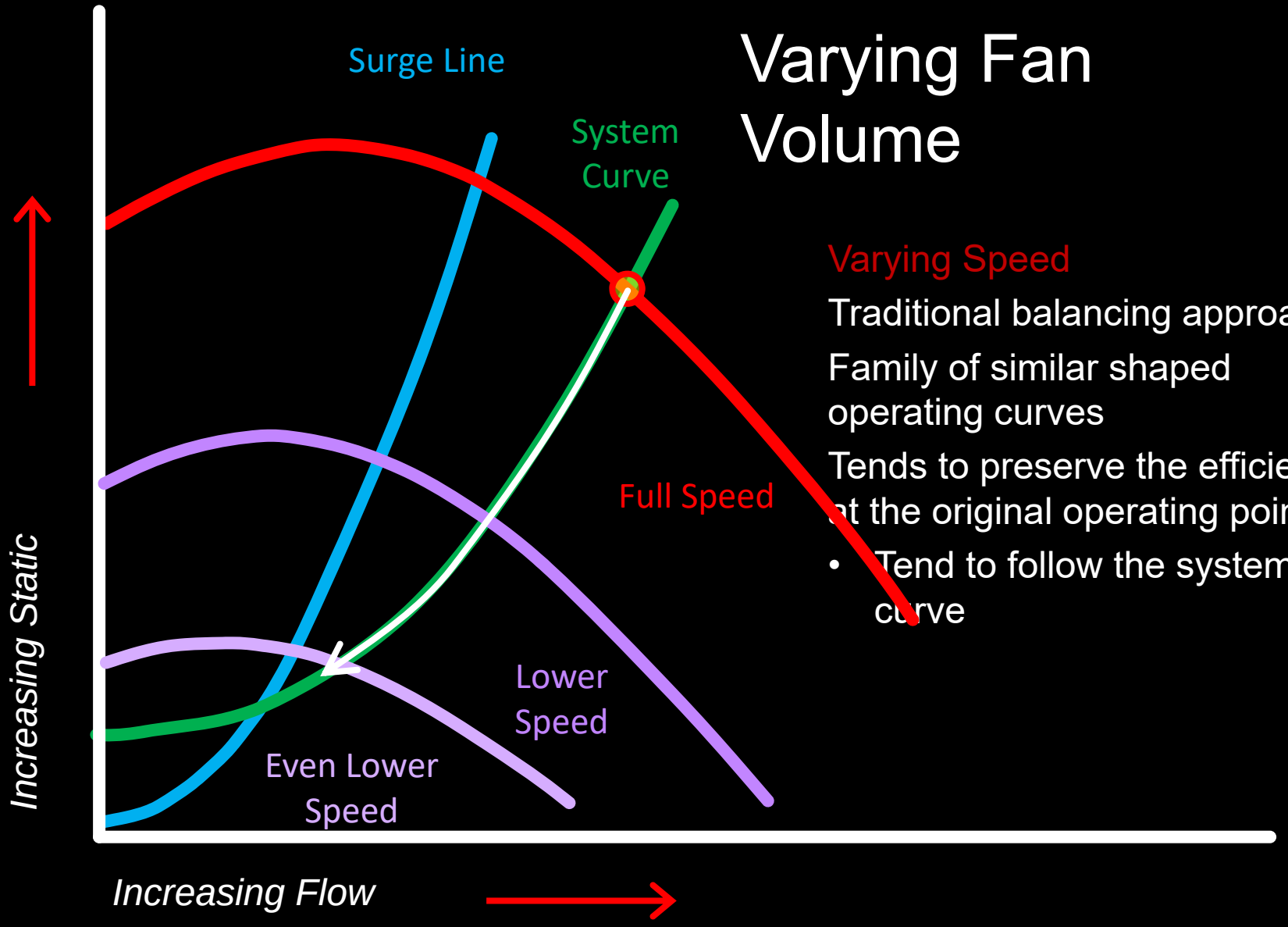
See *Inlet Guide Vanes (IGVs) and Variable Speed Drives(VSDs)* at http://av8rdas.wordpress.com/ for more information

Image courtesy Bill Michell – DOE – NY Marriott Marque

Adding VFDs?

Remove the Vanes (Maybe), Leave the Inlet Cone (For Sure)

Varying Fan Volume



Varying Speed

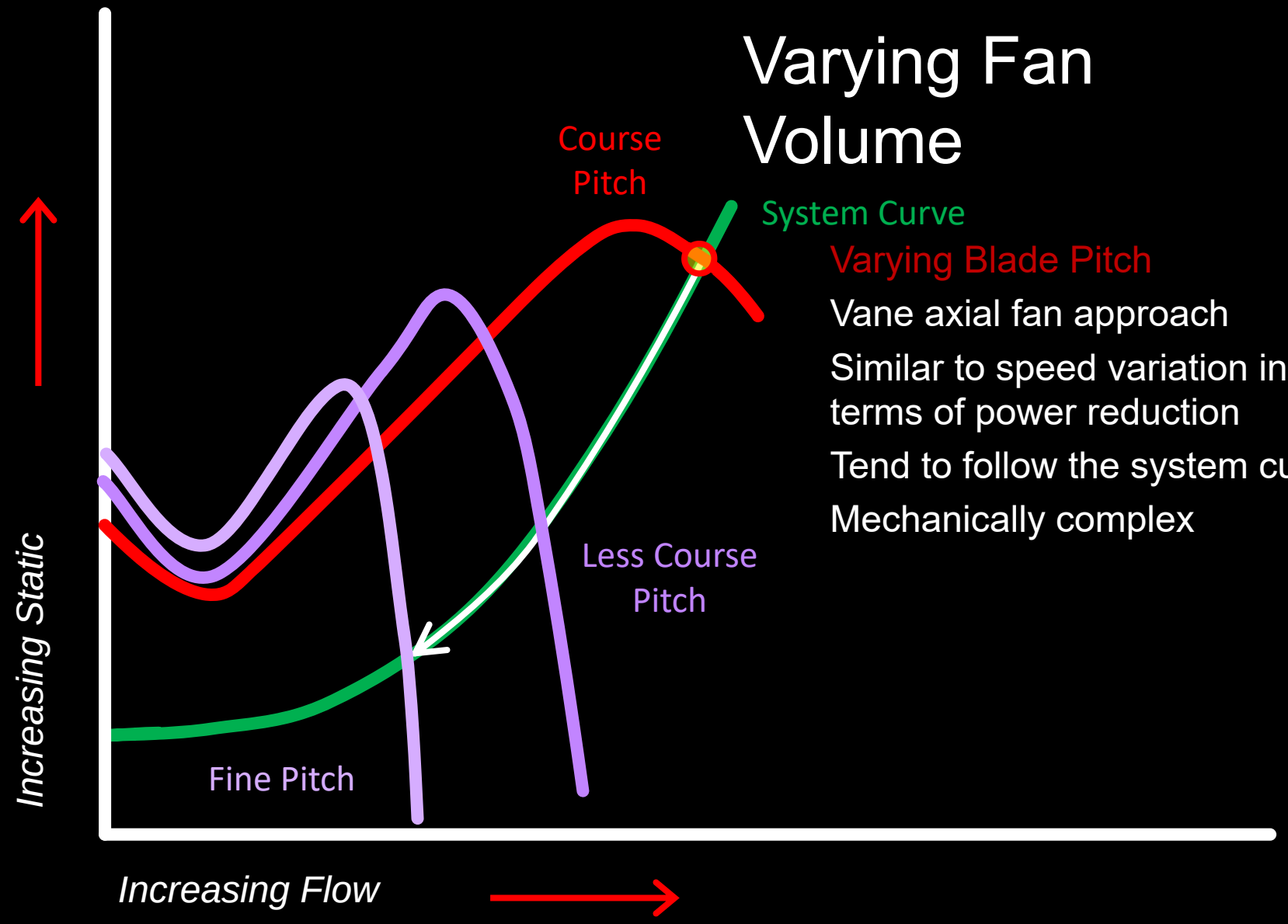
Traditional balancing approach

Family of similar shaped operating curves

Tends to preserve the efficiency at the original operating point

- Tend to follow the system curve

Varying Fan Volume



- Varying Blade Pitch
- Vane axial fan approach
- Similar to speed variation in terms of power reduction
- Tend to follow the system curve
- Mechanically complex

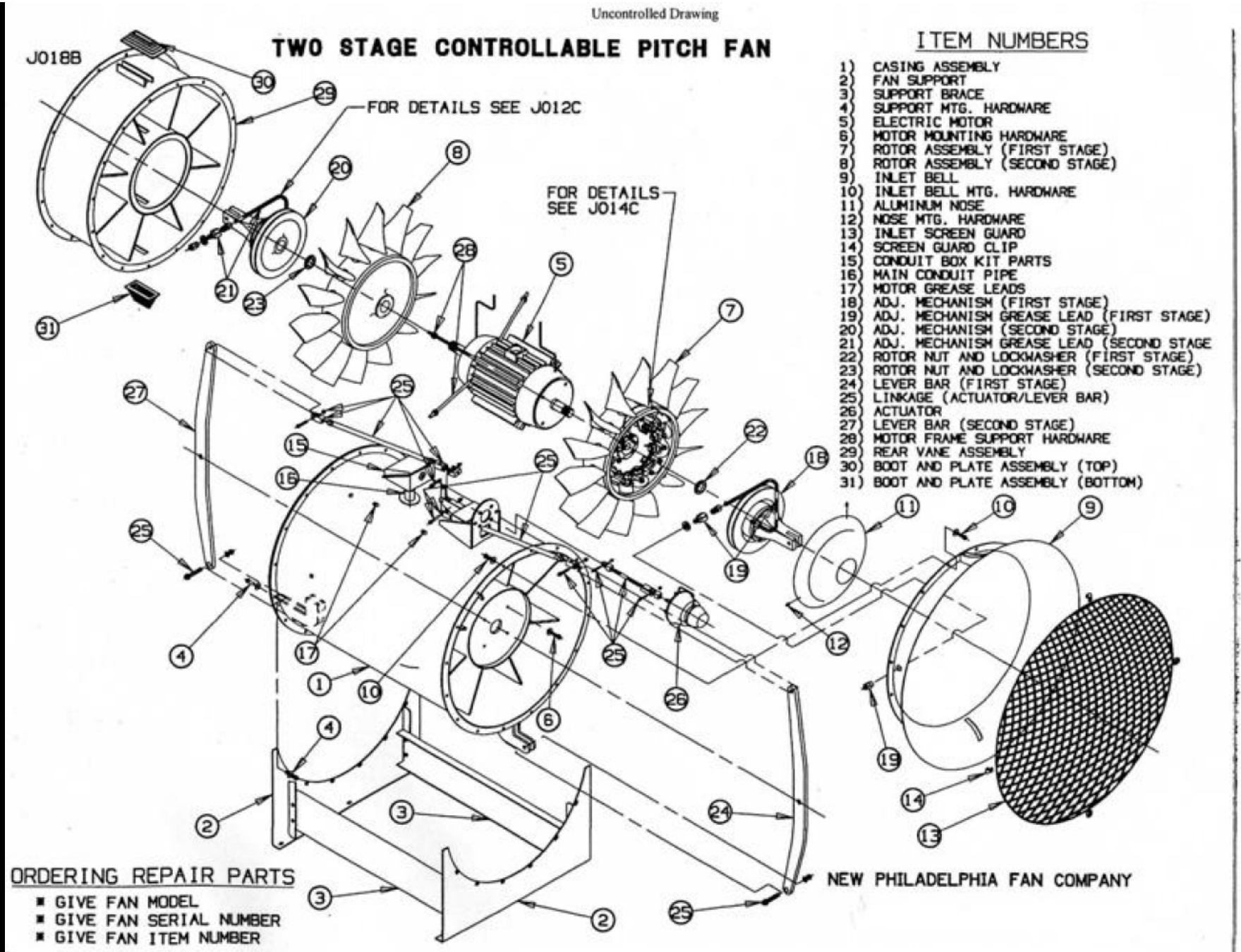
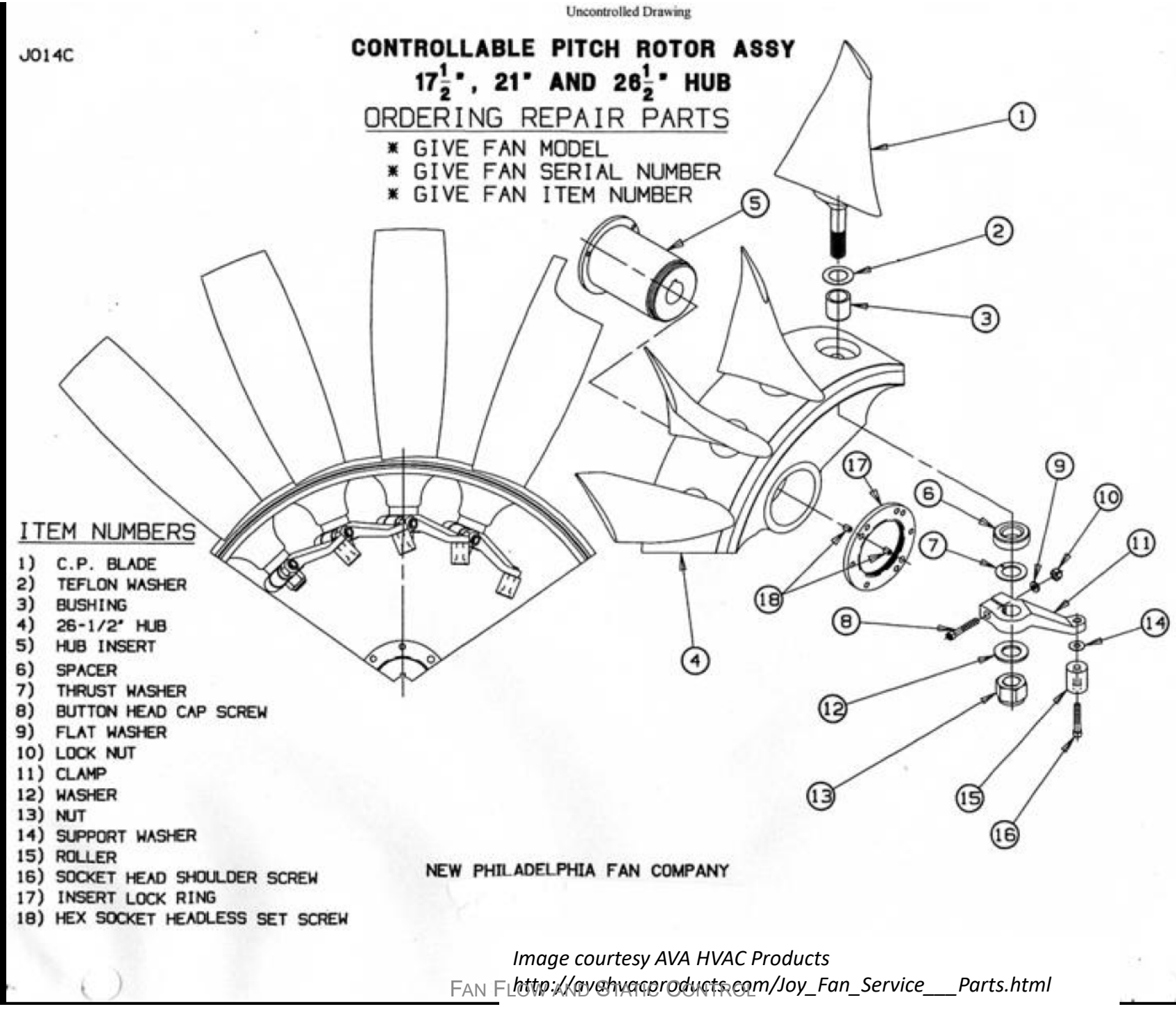


Image courtesy AVA HVAC Products
http://avahvacproducts.com/Joy_Fan_Service___Parts.html



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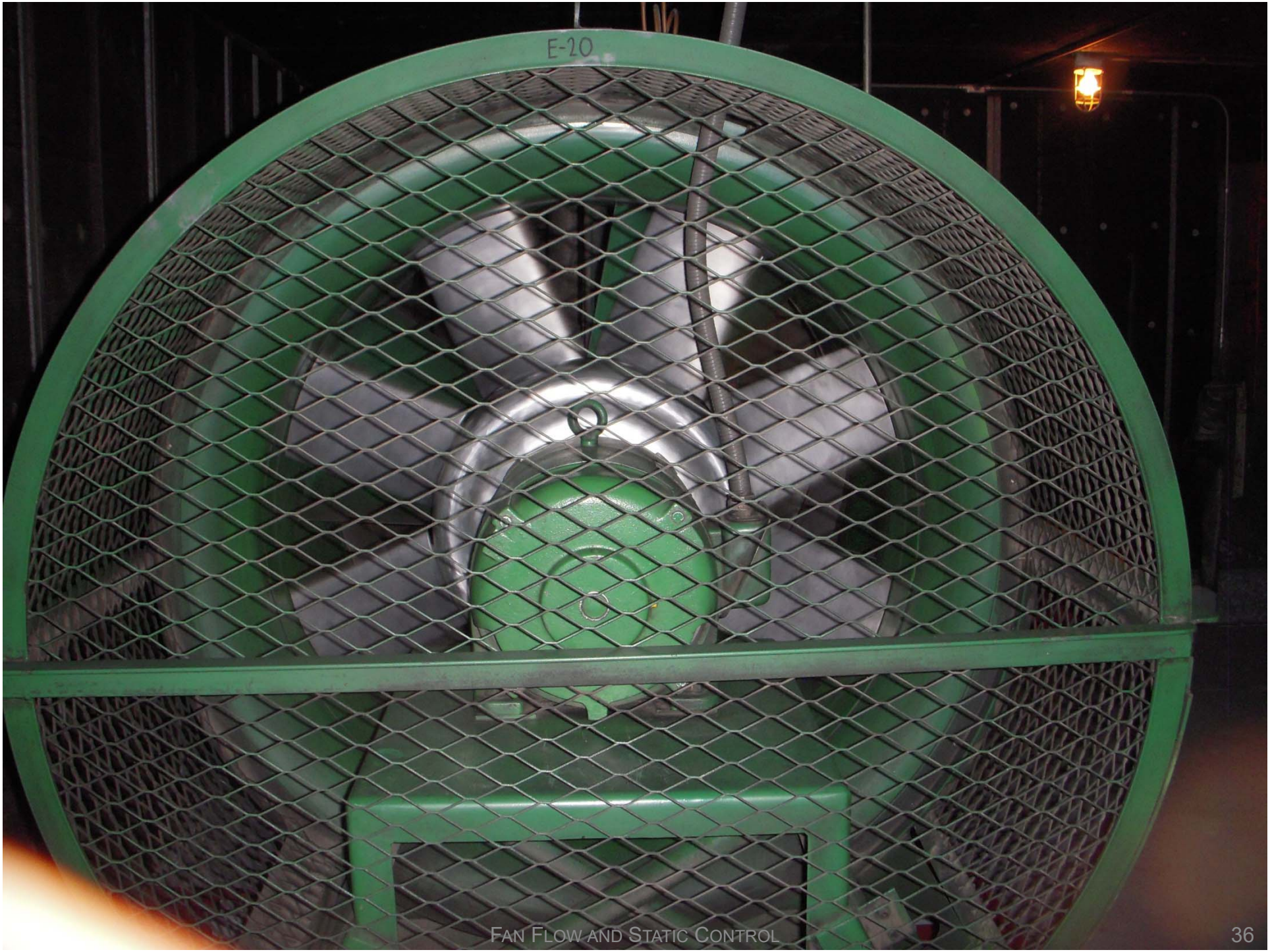
ACCESS SECTION
UP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