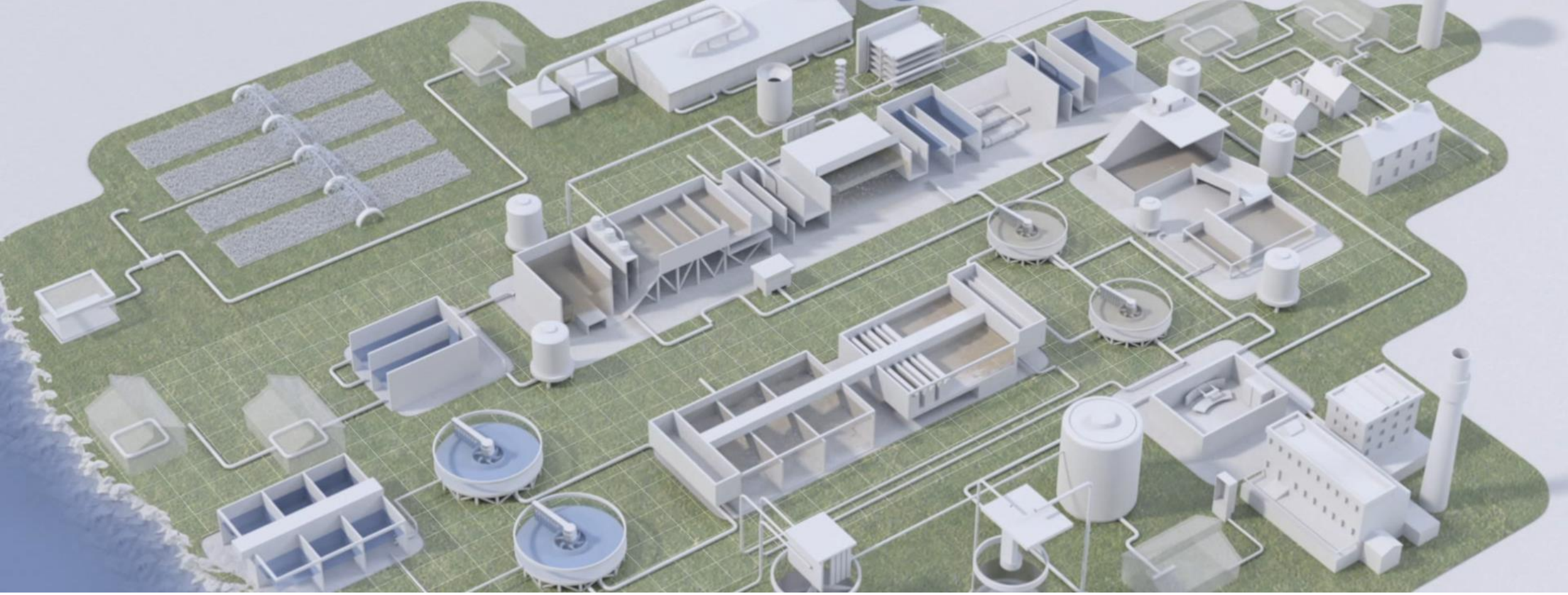
The ABC's of VFD's

JEFF BERGMAN
ABB



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The ABC's of VFD's

JEFF BERGMAN

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STRENGTHS

Exceptional knowledge of the workings of the WWW Market from consultant all the way through to the end user.

Deep understanding of water and wastewater processes from over 30yrs experience, from using automation with VFDs to enhance processes improving efficiency, preventing downtime and reducing water loss.

Proficient in speaking events, presenting product, technical and industry hot topics to W&WW trade organizations, consulting engineers and end user audiences using extensive experience of customer pains to train on topics that matter to them.

BACKGROUND

ABB – 2016 to today
Water Segment Business Development Manager

Danfoss – 22 years
- Global key account manager
- Product manager
- Sales manager
- OEM sales manager
- Regional Sales manager
- Field application engineer

Westinghouse/Cutler Hamner – 6 yrs
Electrical Distribution Sales Manager, covering the Central Florida market

Clemson University
Mechanical Engineering Technology

EXPERTISE

More than 30 years of experience working with all aspects of low-voltage AC power.

Strong background in MCCs, motor controls, and switchgear (including electrical one-lines and pump schedules), and how VFDs interact with electrical equipment.

Long-time member of the Hydraulic Institute, chairing committees on training, specification, industry coordination, as well as governing regulation and industry effect.

Featured speaker for municipal, environmental, and industry organizations as well as frequent industry publication editorial contributor.

ABB Drives in Water and Wastewater

- Drives applications in Water segment, benefits and customer cases.

Health and Safety

As we involve ourselves more in the process of wastewater treatment, we also expose ourselves to live sewers, sewage treatment plants and sewage sludge and need to be aware of the risks.

- Don't look the other way
  - To reduce risk of illness and infection ensure that employees understand the risks through proper instruction, training and supervision for working on water sites.
  - All must have suitable personal protective equipment, which may include waterproof/abrasion-resistant gloves, footwear, eye and respiratory protection. Face visors are particularly effective against splashes.

Learning objectives:

After this course, you will be able to:

- Understand the basics of how a VFD operates
- Understanding the ways VFDs are mounted

Course contents:

- A very basic “look” at a Drive.
- How does the VFD work?
- Cost efficiencies….Why are Drives Used?
- Different applications where drives are used
- Expressed concerns or considerations
- A real-life application case study

The ABC's of VFD's

- A very basic "look" at a Drive.
- But, how does the VFD work?
- Cost efficiencies….Why are Drives Used?
- Different applications where drives are used
- Expressed concerns or considerations
- Fact! A real-life application case study

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What is in a name?

- Inverter
- Adjustable frequency drive (AFD)
- Variable frequency drive (VFD)
- Adjustable speed drive (ASD)
- Variable speed drive (VSD)
- Frequency Converter
- AC Drive
- That “@#%$&” thing on the wall

- …or just plain “Drive”

What does it do?

- Understanding a VFD makes it easier:
- VFDs are designed for applications like maintaining pressure, flow, Dissolved Oxygen, level, or many others, but it important to understand some basics:
  - VFDs convert input AC power to DC and then invert it back into a modified 3 phase AC output
  - VFDs don’t produce horsepower
  - VFDs don’t produce torque
  - VFDs supply the correct voltage and frequency to allow the motor run at the desired speed and supplies current to allow the motor to produce torque

What does a drive look like?

- Input Disconnect (PD) or Circuit Breaker Package (PC)
- Classic 3 contactor bypass
- N1, N12, N3R, N4x rated enclosures
- Active filter, passive filter, 18Pulse, Active Front End

What do they look like installed?

OK, so this is an outdoor enclosure?

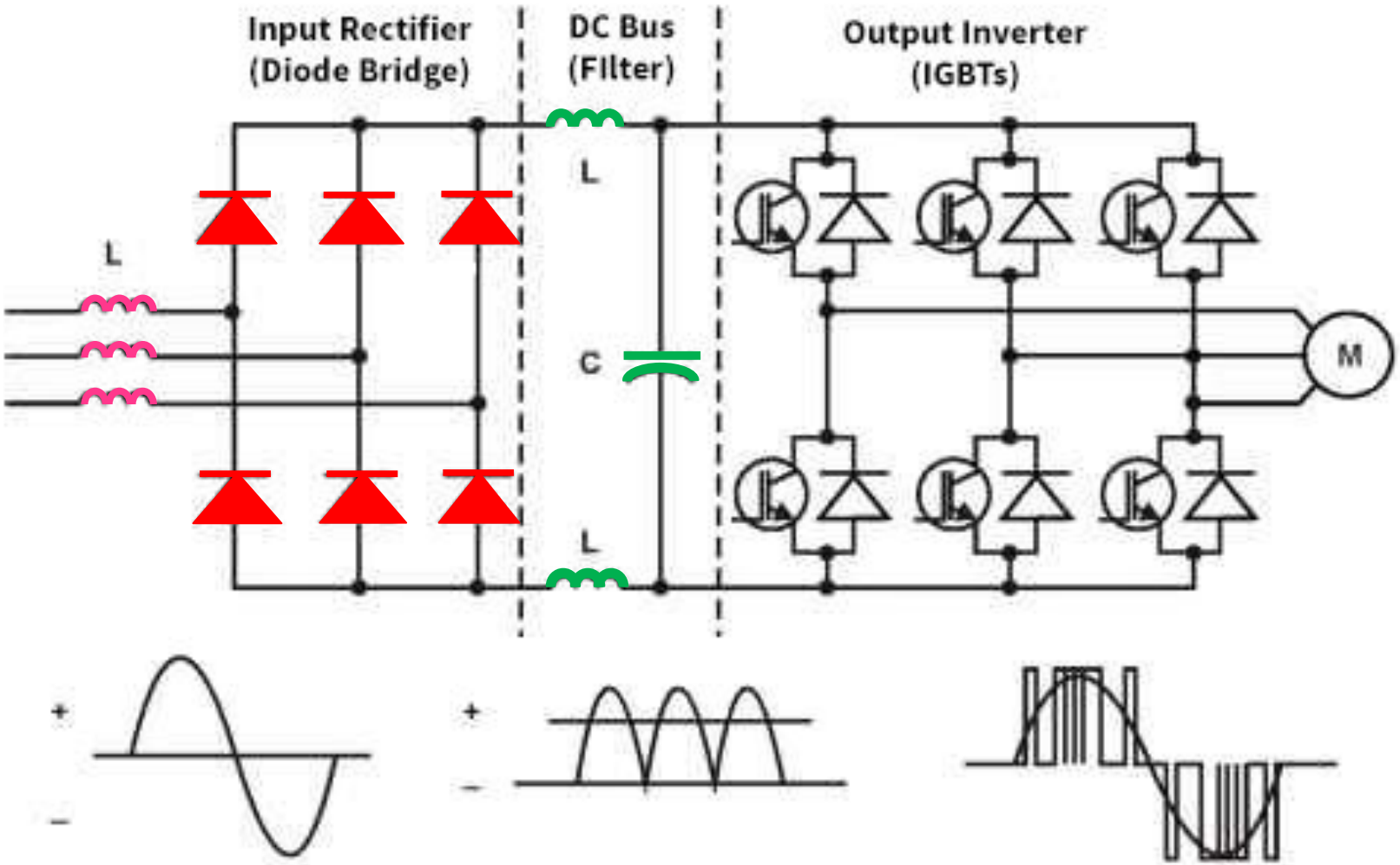
Maybe in MCC's

- Required for some applications due to space limitations
- Higher initial cost
- Replacement cost / compatibility

And sometimes they might get splashed!

- Ambient Temperature
- UL rated
  - UL Type 1 dry, clean indoor
  - UL Type 12 dirty, dripping water
  - UL Type 3R outdoor
  - UL Type 4 hose down
- NEMA ratings are self certifying
  - UL has very specific requirements

Let's look at how it works.
Basic 6 Pulse Construction



Why Are Drives Used?

- Soft start – Controlled acceleration and deceleration
  - Greatly reduces inrush current
  - Eliminates mechanical shock & stress to equipment
  - Extends mechanical life of equipment
  - Eliminates Water Hammer
- Automation of Control and Protection
  - Flow, Pressure or Level control
  - Simple on-board protection for pump jam, thrust bearing, etc..
- Improved power factor
- Reduced demand charge

- **…..ENERGY SAVINGS**

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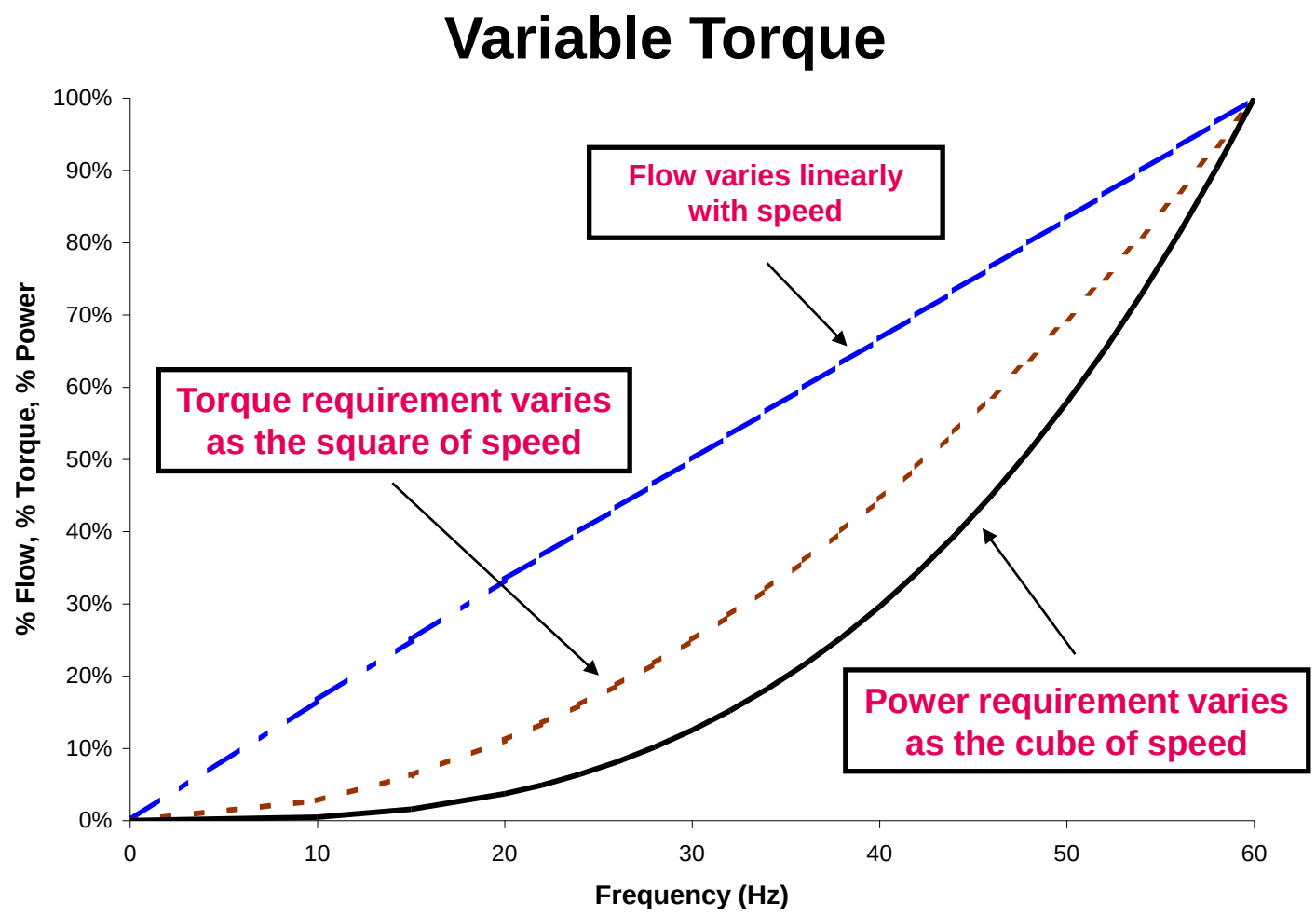
What about functionality?

- PID control
  - Sleep and boost?
- Single Phase Conversion
- Pump Alternation
- ANTI-JAM pump protection
- Critical frequency avoidance
- Minimum speed
  - Seals minimum speed
  - System minimum speed
- Ramp time to speed
  - Thrust bearing protection

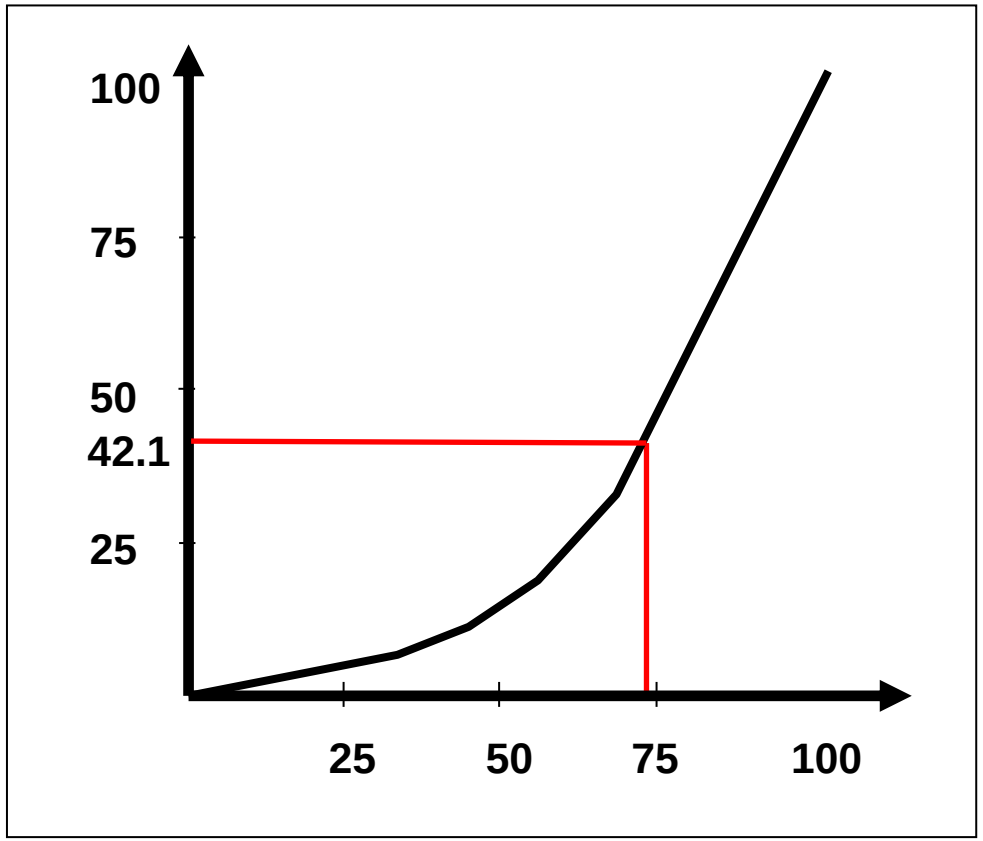
- Output Relay
  - 3 Programmable
- 2 Analog Input Front Flash/Outputs
  - 0-10 Vdc or 4-20 mA
- Supervisory functions
  - Drive and System
- Auto Restart
- Loss of sensor or SCADA control

An Affinity Law for Energy Savings



Saving Energy by Changing Speeds

Power versus Speed - Variable Torque Load

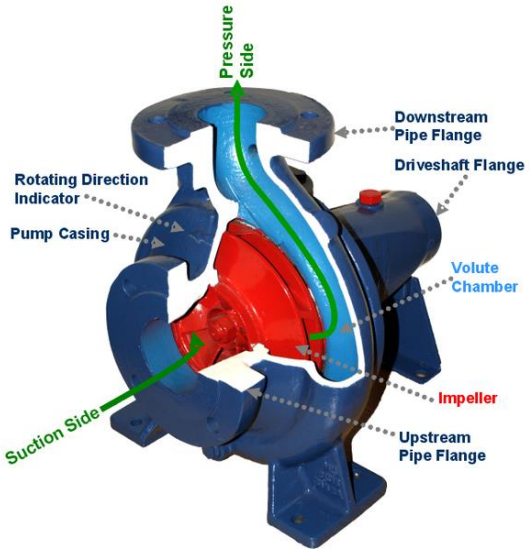


Power is Proportional to **(Speed)^3**

Where do we use VFDs?

Applications

- There are two basic load types:
  - Variable Torque (VT)
    - Centrifugal Pumps
    - Centrifugal Blowers
  - Constant Torque (CT)
    - Positive Displacement Pumps
    - Positive Displacement Blowers
    - Sludge Pumps
    - Chemical feed pumps



Installation Considerations

- Environment

- What's the environment?
  - Fresh Water – Chlorine
  - Waste Water – Hydrogen Sulfide

- Important considerations are:
  - Temperature
  - Altitude
  - Indoor/outdoor - exposure moisture and sunlight
  - Space requirements
  - VFD manufacturers provide a variety of enclosures that are certified to UL standards

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Installation Considerations

- Temperature and Altitude

- **VFDs are rated for a specific ambient temperature**
  - Typical temperature range is -10°C to 40°C (104°F).
  - Typical altitude is 1000 meters.
  - The VFD must have the ability to dissipate heat generated during the power conversion process.
  - If actual values exceed the VFD manufacturer's assumptions, the drive may have to be de-rated. Consult the manufacturer.

Installation Considerations

- Space Requirements

- VFDs may have a restriction on space between adjacent equipment or machinery.
- The issue may relate to heating from adjacent heat sources or more likely the possible restriction of air flow which is required by the VFD cooling system.

Frame size	Free space, IP21 (UL Type 1)											
	Vertical mounting stand alone						Vertical mounting side by side					
	Above		Below[1]		Beside		Above		Below[1]		Between	
	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
R1	150	5.91	86	3.39	150	5.91	200	7.87	200	7.87	0	0
R2	150	5.91	86	3.39	150	5.91	200	7.87	200	7.87	0	0
R3	200	7.87	53	2.09	150	5.91	200	7.87	200	7.87	0	0
R4	53	2.09	200	7.87	150	5.91	200	7.87	200	7.87	0	0
R5	100	3.94	200	7.87	150	5.91	200	7.87	200	7.87	0	0
R6	155	6.10	300	11.81	150	5.91	200	7.87	300	11.81	0	0
R7	155	6.10	300	11.81	150	5.91	200	7.87	300	11.81	0	0
R8	155	6.10	300	11.81	150	5.91	200	7.87	300	11.81	0	0
R9	200	7.87	300	11.81	150	5.91	200	7.87	300	11.81	0	0

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[1] Free space below is always measured from the drive frame, not from the cable box.

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What about the wiring and maybe a new motor?

- Motor Leads (Discuss this with your manufacturer)
  - Shorter is better, metallic conduits, VFD rated cable
  - NEVER EVER run control wiring with motor leads
- Grounding
  - PE Ground each VFD individually – do not daisy chain or loop
  - Motor ground should be terminated on VFD ground
- Motor
  - MG1, Part 31 – covers the windings
  - Shaft grounding device for common mode voltage
  - Use invertor cable or pull high strand count ground wire

Case Study

- Audubon Aquarium of the Americas

Audubon Aquarium
of the Americas
A Facility of Audubon Nature Institute

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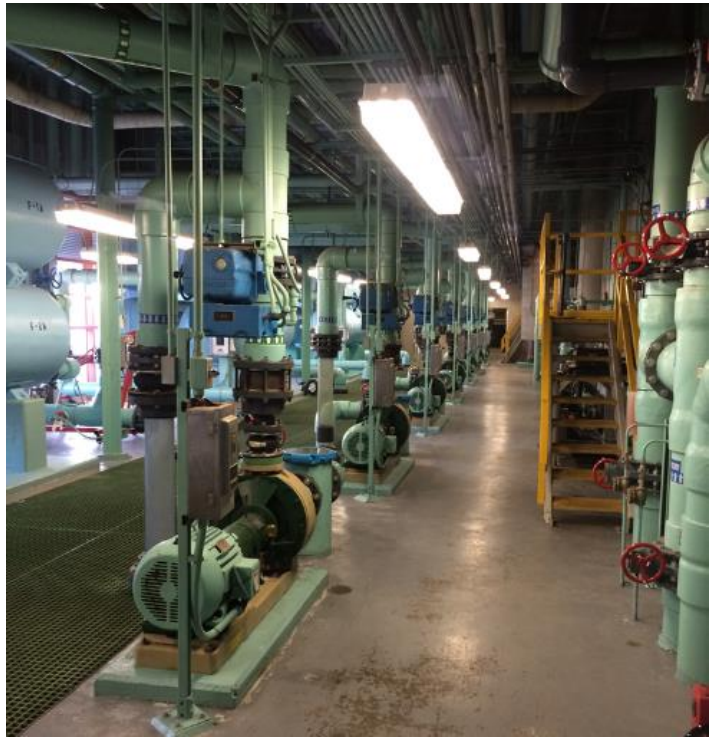
How It All Flows

- Pump Alley
  - 7 - 25HP pumps
  - 14 Sand filters
  - Gulf contact and degas towers
  - Ozone generators
  - Wastewater recovery system
  - Storage water



Concerns

- Mechanical stress – especially during startup
  - Energy costs
  - Available rebates
  - Maintaining correct head pressure with flow reduction
  - VFD control method
  - Start-up and commissioning

Economic Justification

- Energy Cost
  - Audubon buys energy at .08 / KWH
- Pump Qualifications
  - Originally controlled via a flow restriction valve
  - Flow typically between 40 and 100 %
  - Average flow under 50%
- Payback calculation
  - Calculations set motor speed between 70% and 100%
  - Payback expectation of UNDER 6 months
  - 51 additional pump applications

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Economic Justification

- Value
  - Local Support
  - Energy Savings
  - Automated Control (PID)
  - Mechanical stress reduction
  - Total payback
  - Reliability
  - Warranty

Audubon Aquarium
of the Americas
A Facility of Audubon Nature Institute

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Economic Justification

- ROI
  - 4 months
- Why what you provide is important to us
  - ROI
  - Numbers: In 5 years the aquarium was set to save $100,000
- Plan going forward.
  - Additions in other systems in the aquarium
  - Use ClearResults rebates to pay
  - http://www.clearesult.com/