Everything You Always Wanted to Know About Variable Speed Pumps But Were Afraid to Ask

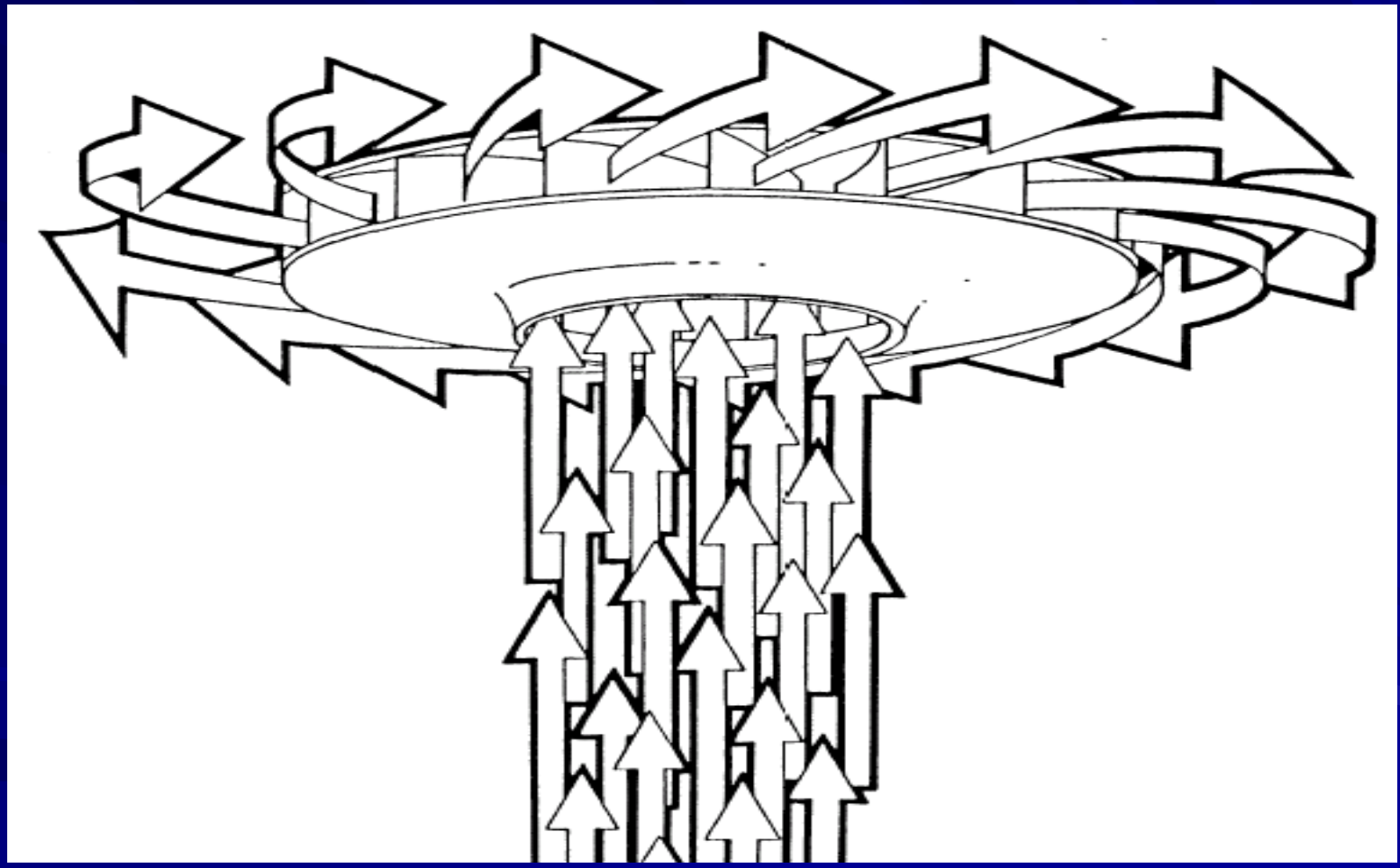
NGWA

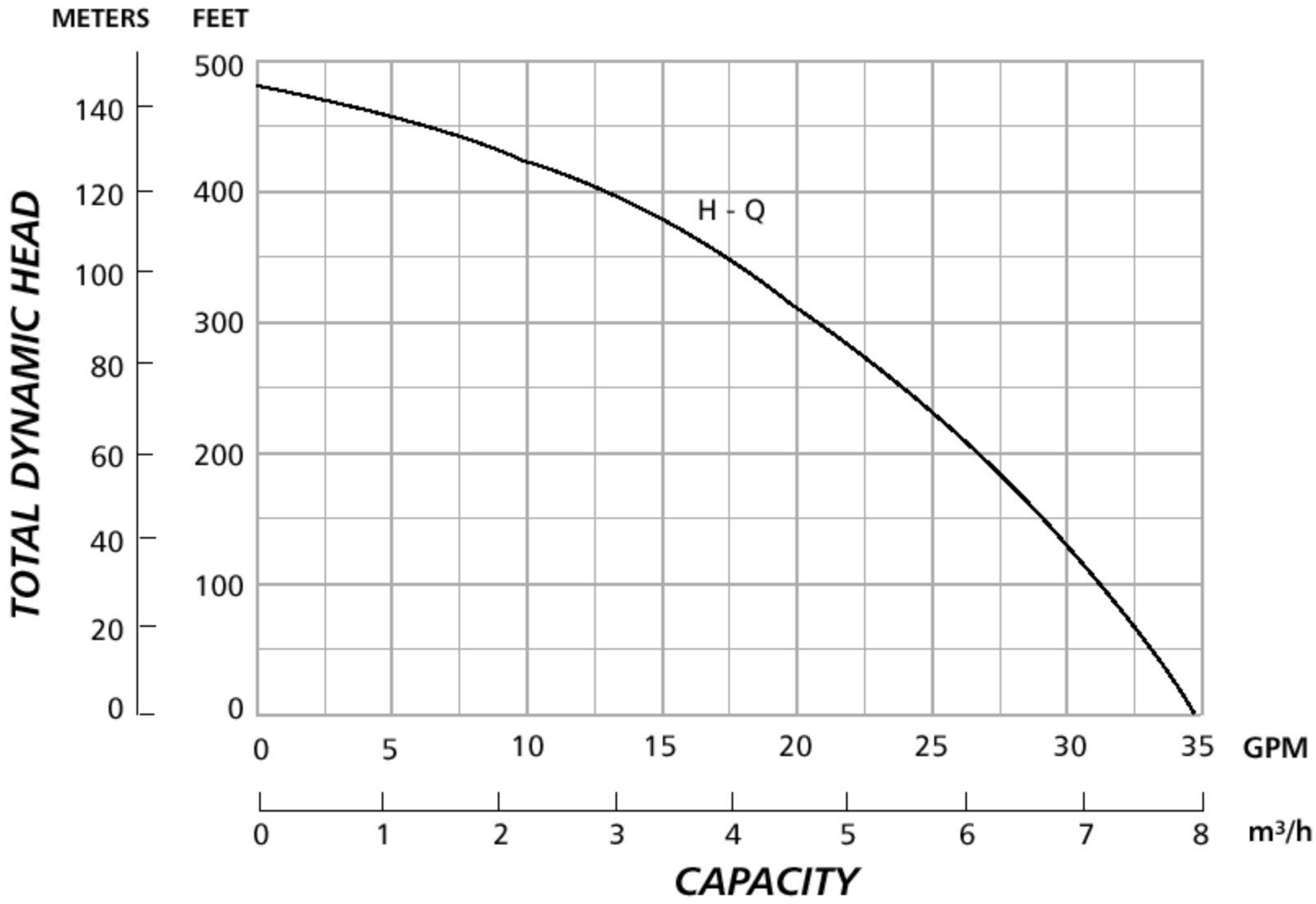
Dec 3, 2008

Outline

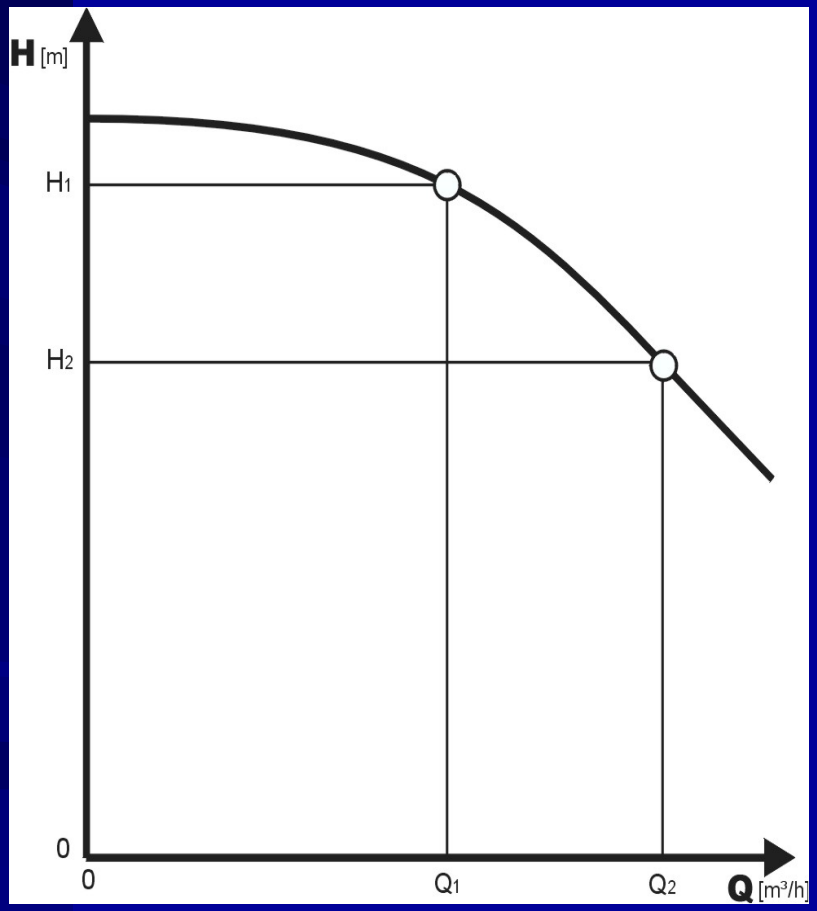
- Pump theory
- Constant pressure
  - Benefits
  - How
- Products
- Installation issues
- FAQ

Centrifugal Pump

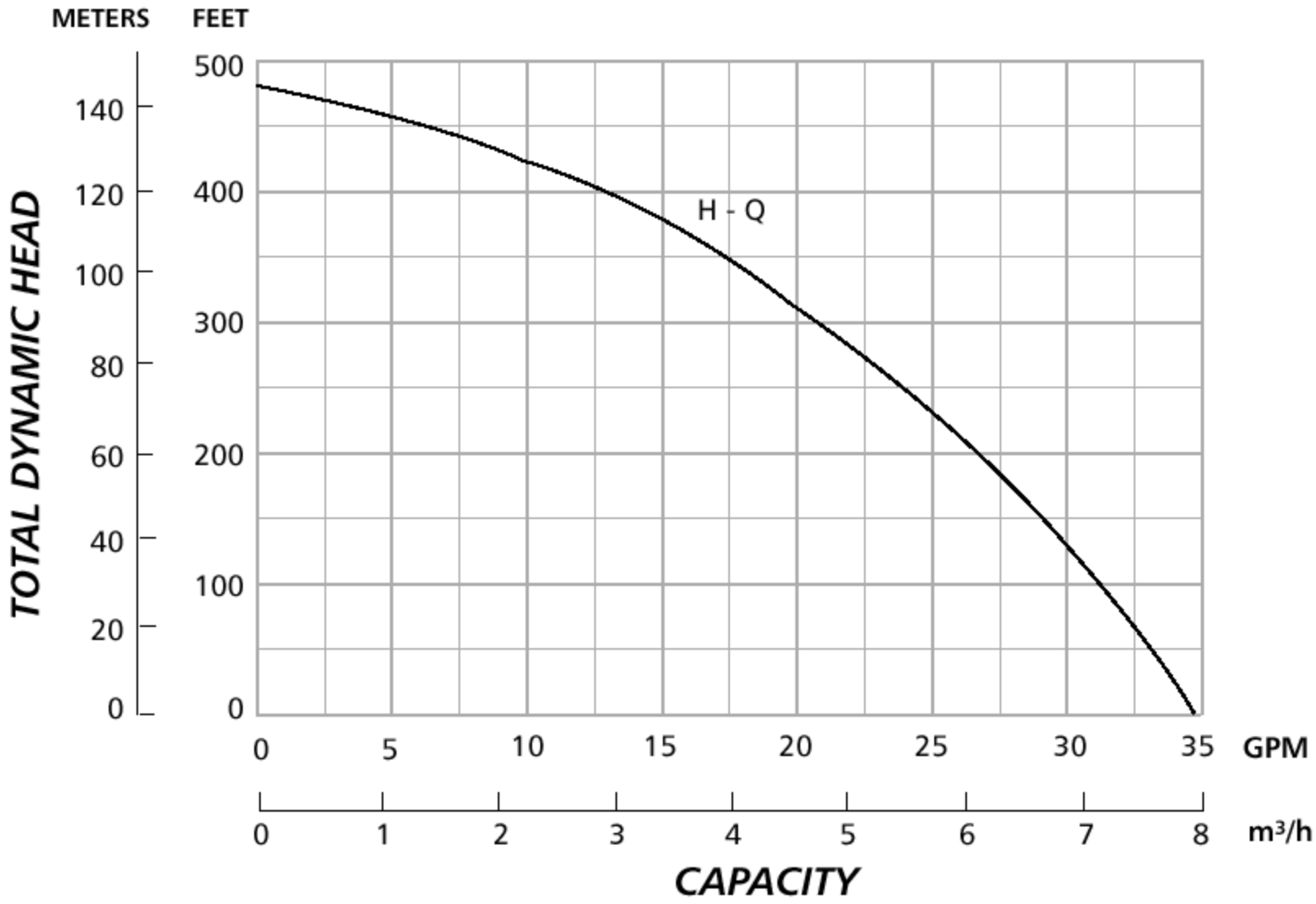



METERS
FEET
TOTAL DYNAMIC HEAD
140
120
100
80
60
40
20
0
500
400
300
200
100
0
H - Q
0
5
10
15
20
25
30
35
GPM
0
1
2
3
4
5
6
7
8
m³/h
CAPACITY

Constant Speed Pump System



- Constant speed curve
  - Normal pump method
  - Pressure and flow change together
- Variable demand produces wasted energy at low flow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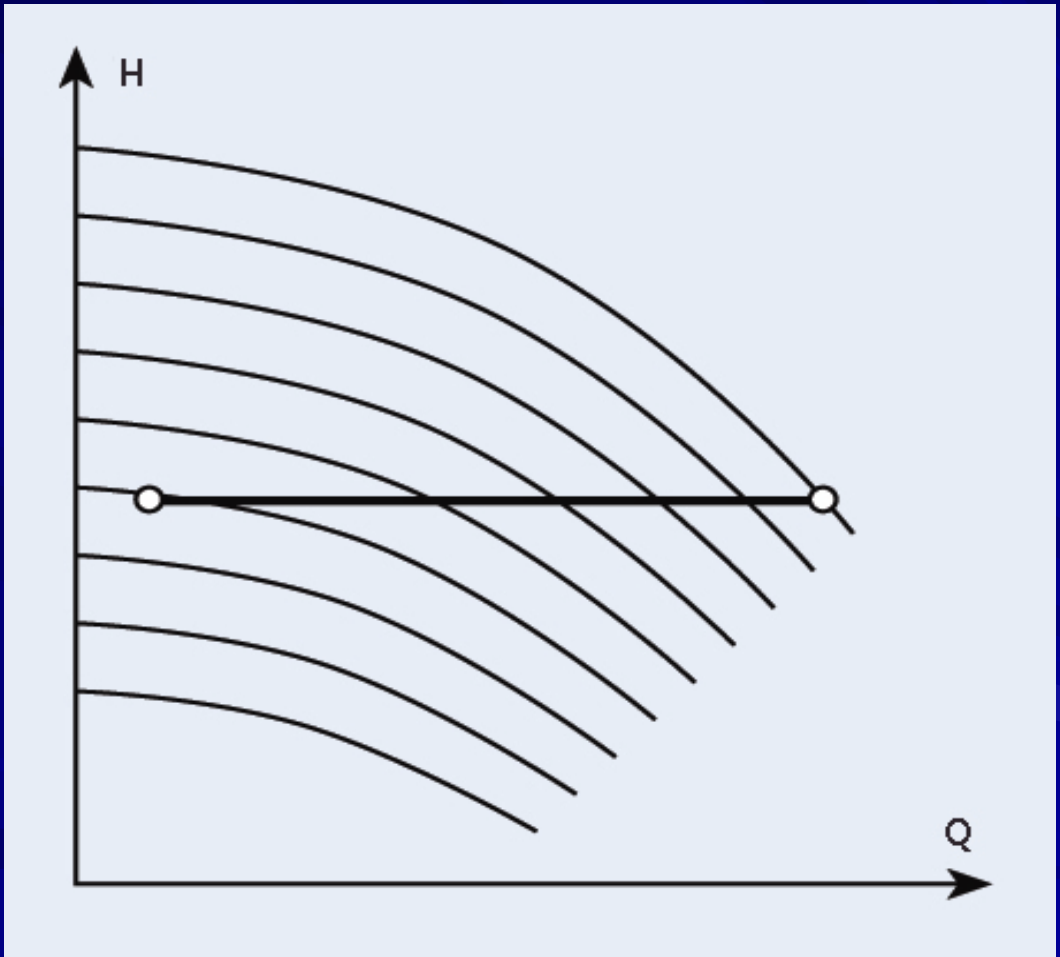
m³/h
CAPACITY

Constant Pressure



Variable Speed Benefits

- Match performance to demand
- Eliminate need to store pressure
- Constant pressure
- Constant flow
- Energy savings
- Reduced voltage starting
- Smaller electric wire in well

Benefits(cont)

- Plastic drop pipe – no starting torque
- Motor protection in controller
- Longer well life
- Phase converter
- Installation easy and fast
- No DIY competition
- More gross margin

Affinity Laws

Relate Performance Changes to Changes in Speed

$$Q_2 = Q_1 \left(\frac{N_2}{N_1}\right)$$

$$H_2 = H_1 \left(\frac{N_2}{N_1}\right)^2$$

$$bhp_2 = bhp_1 \left(\frac{N_2}{N_1}\right)^3$$

Affinity Laws

- Flow - speed
- Head - $(\text{speed})^2$
- Power - $(\text{speed})^3$

Affinity Laws

- Decrease speed 20% (60 Hz to 48Hz)

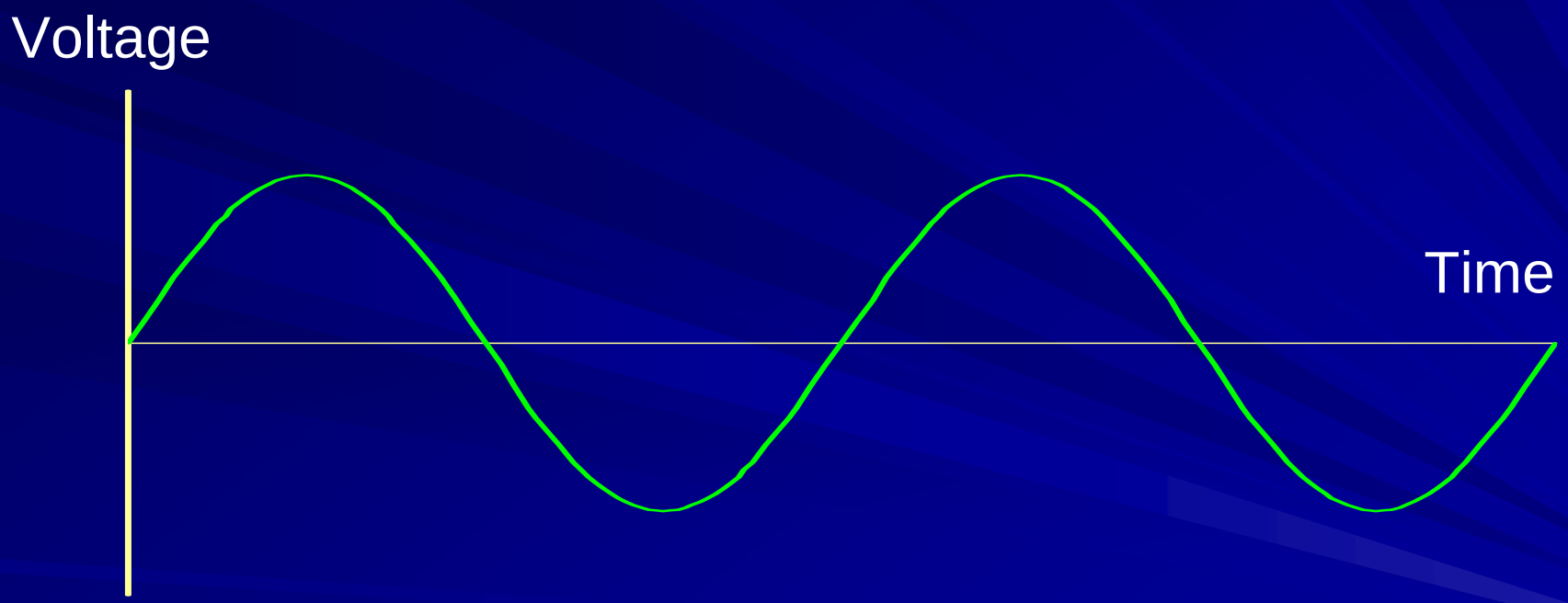
- Flow – 80%
- Head – 64% $(0.8)^2 = 0.64$
- Power – 51% $(0.8)^3 = 0.51$

What is a VFD?

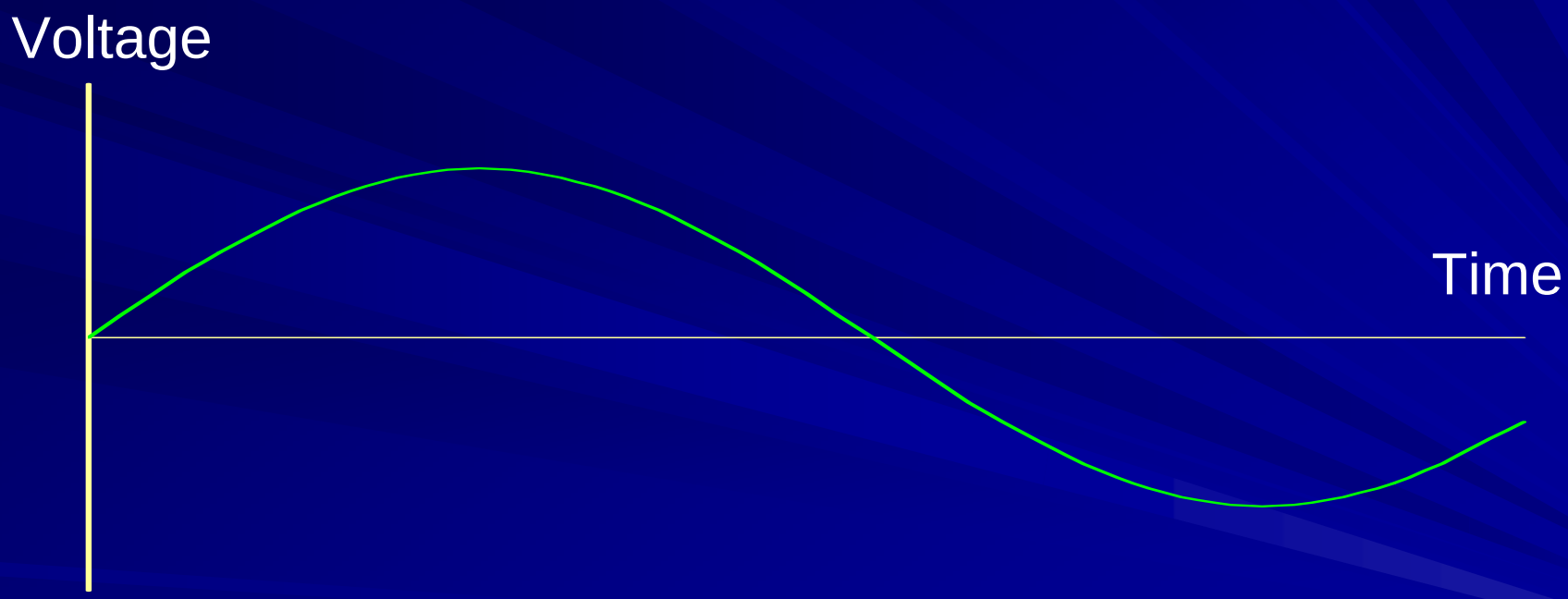
- Variable Frequency Drive

- Varies motor speed by changing the frequency of the voltage to the motor

Standard Motor Speed



Slower Motor Speed



60 Hz Application

$$RPM = frequency \times 60\ sec/min \times \frac{2}{number\ of\ poles} \times (1 - slip)$$

$$RPM = 60 \times 60 \times (2/2) \times .96$$

$$= 3450$$

50 Hz Application

$$RPM = \text{frequency} \times 60 \text{ sec/min} \times \frac{2}{\text{number of poles}} \times (1 - \text{slip})$$

$$RPM = 50 \times 60 \times (2/2) \times .96$$

$$= 2875$$

Constant Pressure Products

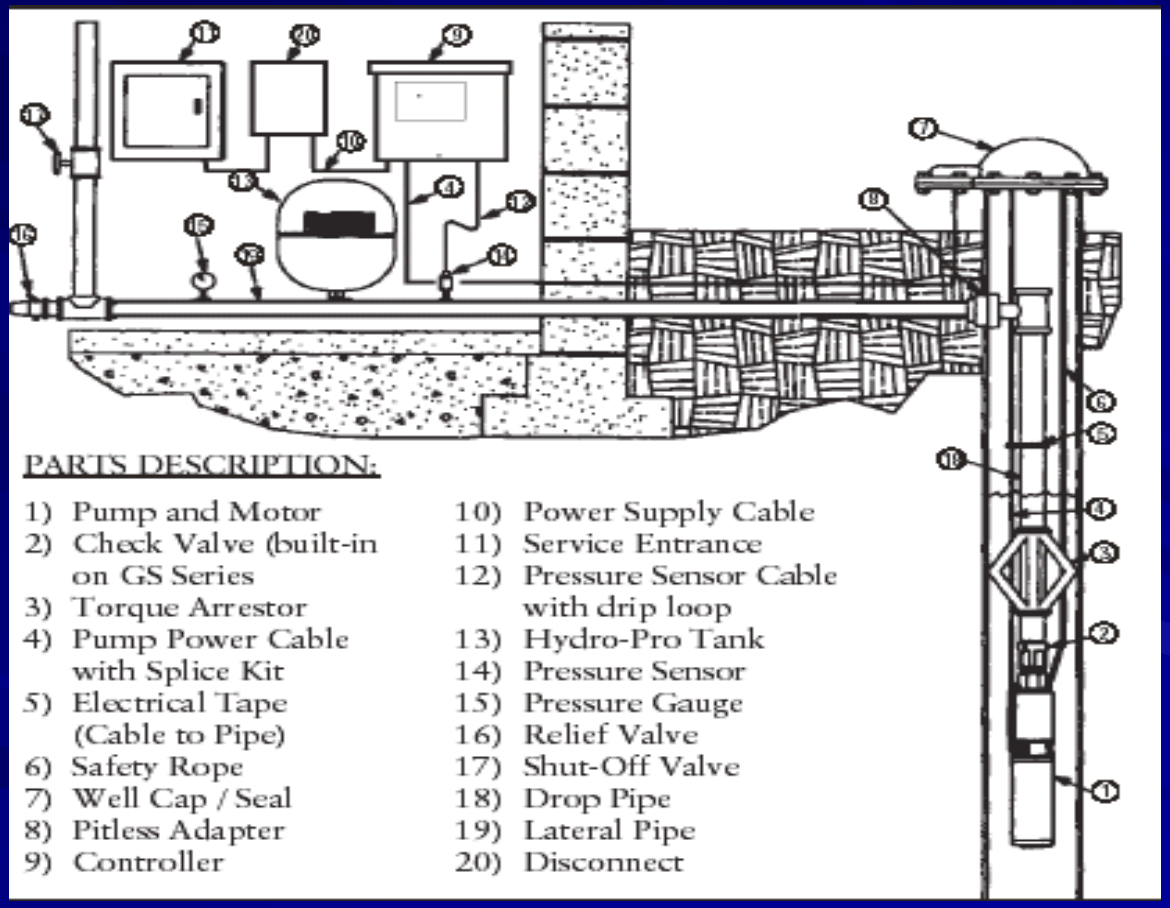
- Balanced Flow
  BF20/30/50
- AquaBoost II
- Aquavar CPC

Balanced Flow

BF20/30/50

- ½ - 2/3/5hp submersibles
- Easy to set pressure
- Simple diagnostics

Typical Installation



PARTS DESCRIPTION:

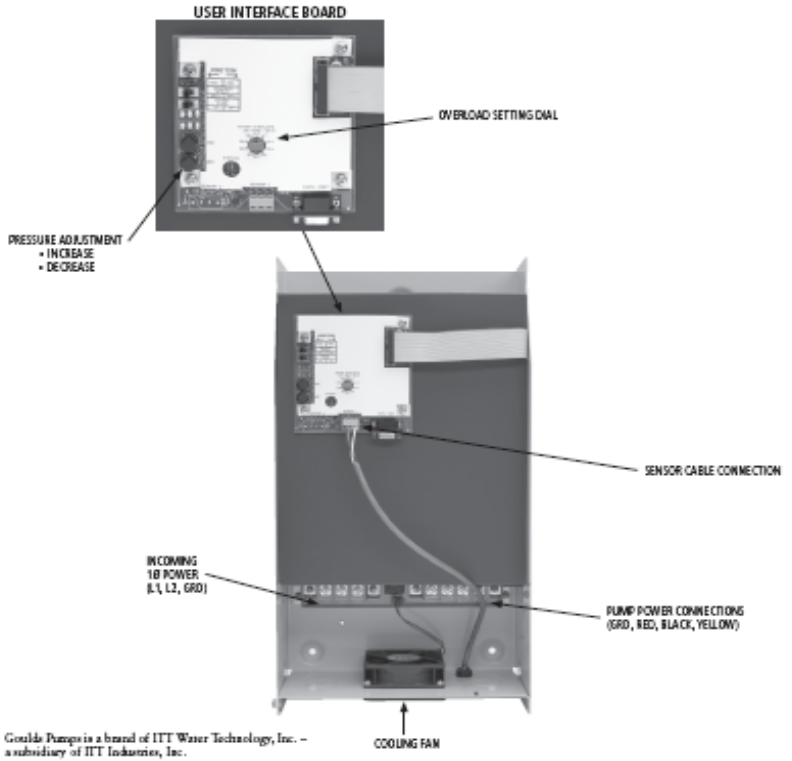
1) Pump and Motor
2) Check Valve (built-in on GS Series
3) Torque Arrestor
4) Pump Power Cable with Splice Kit
5) Electrical Tape (Cable to Pipe)
6) Safety Rope
7) Well Cap / Seal
8) Pitless Adapter
9) Controller
10) Power Supply Cable
11) Service Entrance
12) Pressure Sensor Cable with drip loop
13) Hydro-Pro Tank
14) Pressure Sensor
15) Pressure Gauge
16) Relief Valve
17) Shut-Off Valve
18) Drop Pipe
19) Lateral Pipe
20) Disconnect

BF20/30/50

GOULDS PUMPS

Balanced Flow™ Constant Pressure Controller for 3 HP Submersible Pumps

BF30



www.goulds.com
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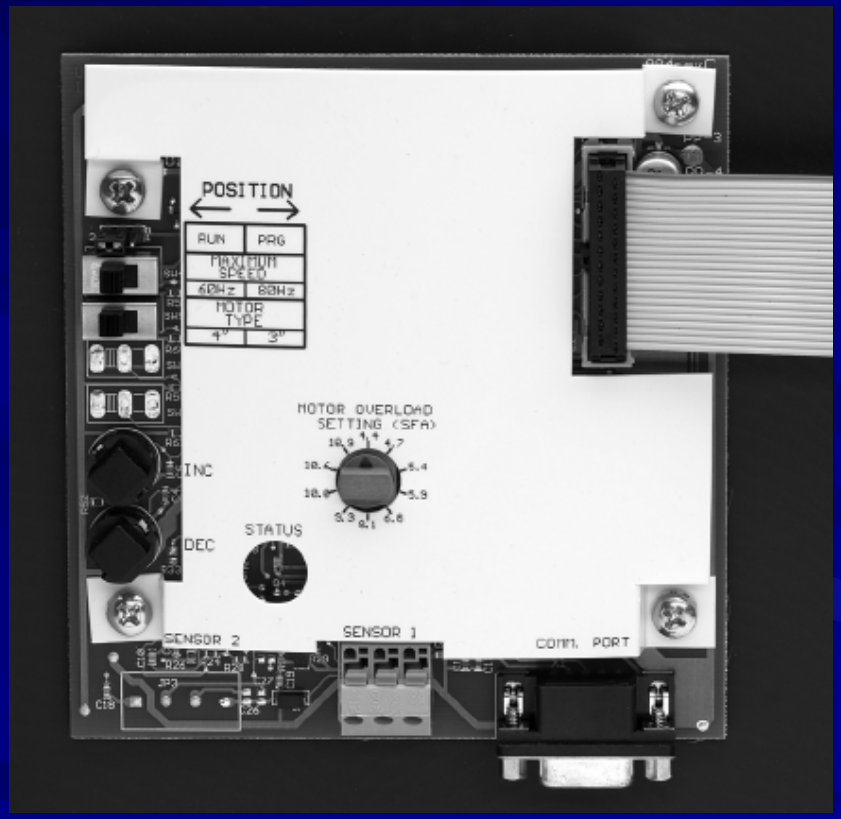
SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

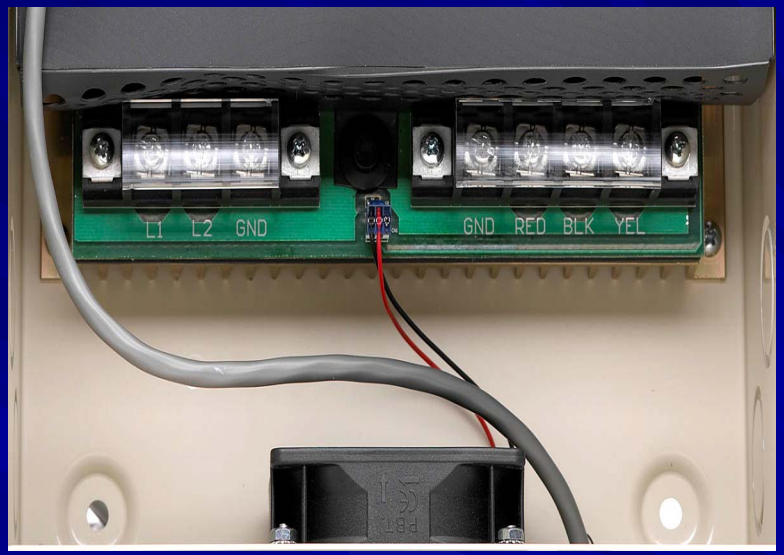
Goulds Pumps
ITT Industries

User Interface

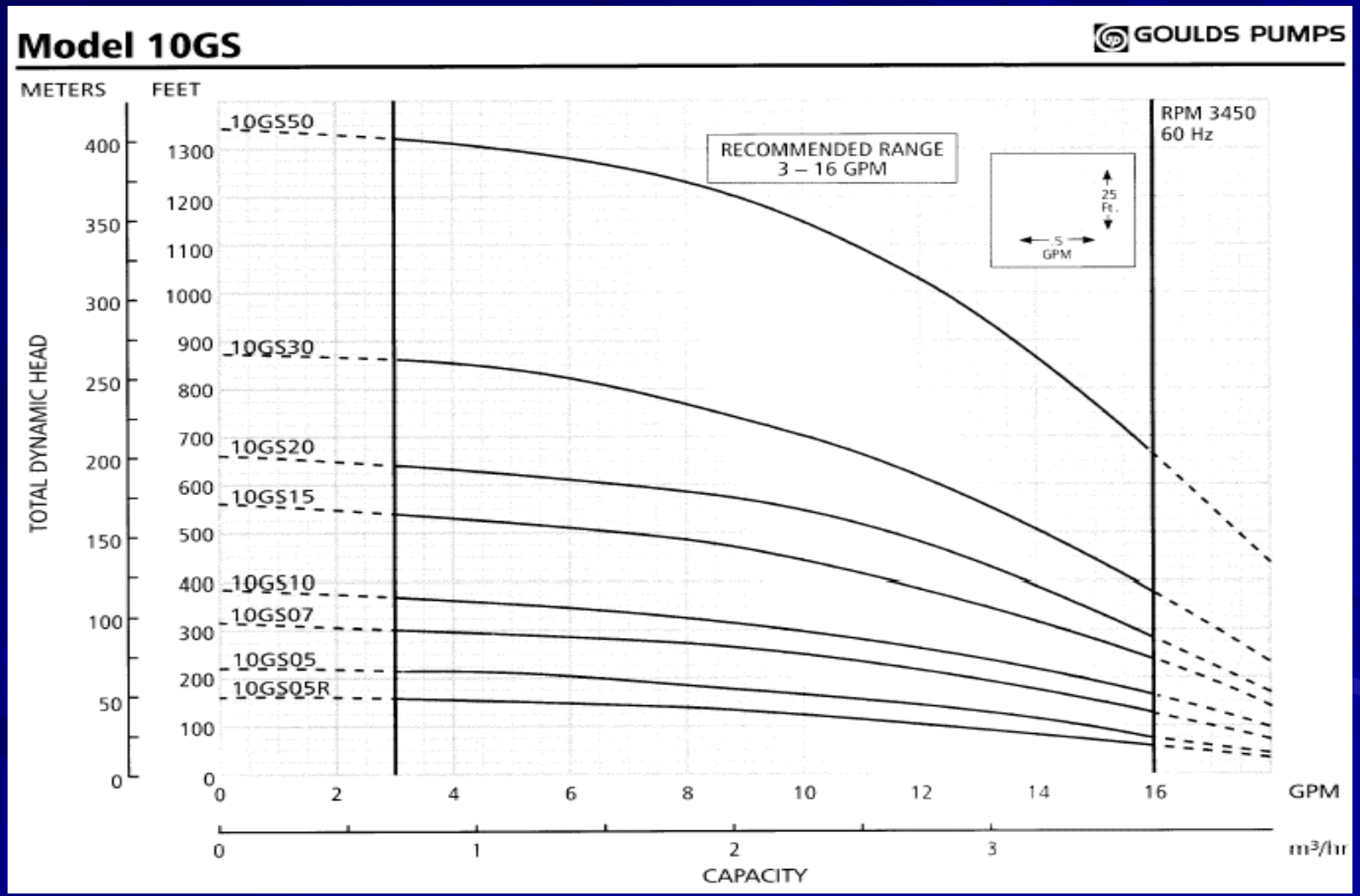


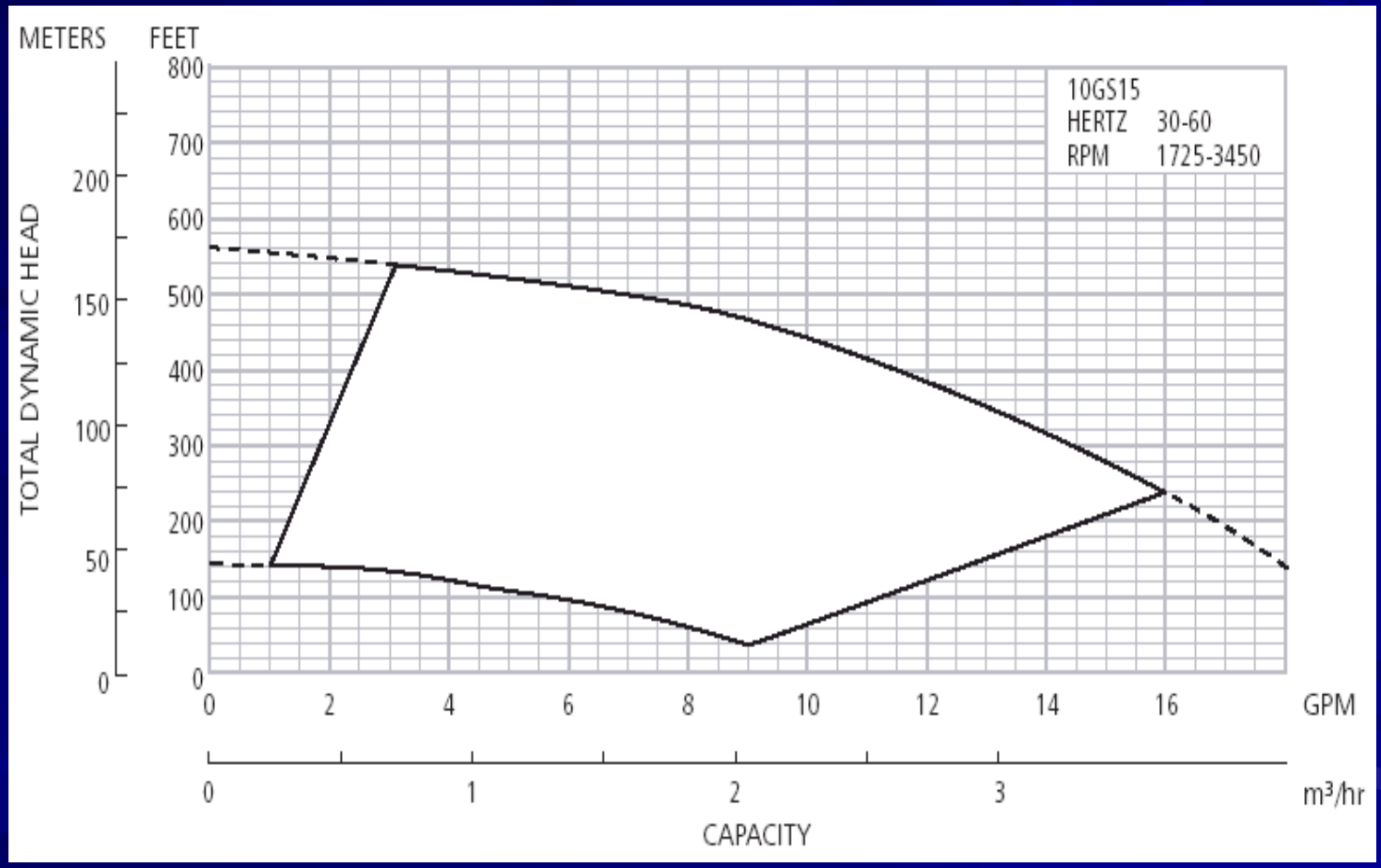
BF20/30/50 Power Wiring

- Input power L1, L2, GND (230volt single phase +/- 15%)
- Motor must be three phase 208 -230 volt
- Drive is a phase converter
- Larger terminal lugs for wire
- Large area for wiring



Pump Selection




METERS
FEET
TOTAL DYNAMIC HEAD
200
150
100
50
0
800
700
600
500
400
300
200
100
0
10GS15
HERTZ 30-60
RPM 1725-3450
0
2
4
6
8
10
12
14
16
GPM
0
1
2
3
m³/hr
CAPACITY

AquaBoost II

- Constant pressure booster system
- Solution for municipal water district customers with low or inconsistent water pressure
- AB II controllers (4.2, 6.9, 10.9 and 16.6 amps) stand-alone or with HMS / MCC pump

AquaBoost II
Model 3&5AB2 Pump Controller

- Extension of current AquaBoost II family
- Designed for surface booster pumps
- Rated for 10.9 amps(3HP) and 16.6 amps(5HP)
- Single phase 208-230volt input
- Variable speed with constant pressure

AquaBoost II

- Plug and play
- Four sizes:
  - Model 1AB2 – 4.2 Amp rating
  - Model 2AB2 – 6.9 Amp rating
  - Model 3AB2 – 10.9 Amp rating
  - Model 5AB2 – 16.6 Amp rating
- Wall mount

AquaBoost II

Packages:

- Consisting of:
  - Pump, controller, transducer, tank, tank tee, pipe plug, pressure gauge
- Three different pumps available:
  - LB pump
  - MCC pump
  - HMS pump

HMS Centrifugal

HMS centrifugal

- Horizontal multistage

3 Models available:

- 1 and 1 ½ HP
- 2,3,4 and 5 stage units
- Flows up to 37 GPM
- Heads up to 225’ TDH

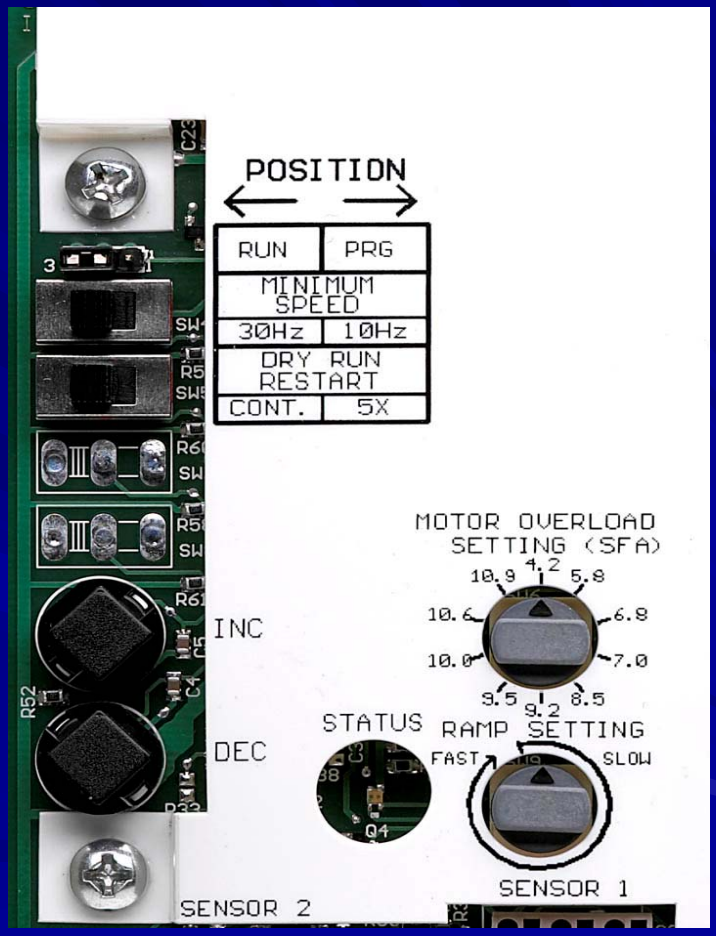
AquaBoost II
Model 3&5AB2 Pump Controller

- Enclosure rated for NEMA 3R outdoor use
- Transducer assembly included (25ft length)
- Filtered fan unit for temps up to 120 F
- Bottom and side knockouts for wiring/conduit
- Painted metal enclosure

AquaBoost II
Model 3&5AB2 Pump Controller

User interface board allows adjustment of:

- Current overload (switch)
- Pressure (buttons)
- Ramp speeds (dial)
- Minimum Frequency (speed)
- Dry run/ low pressure restarts



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Model 3&5AB2 Pump Controller

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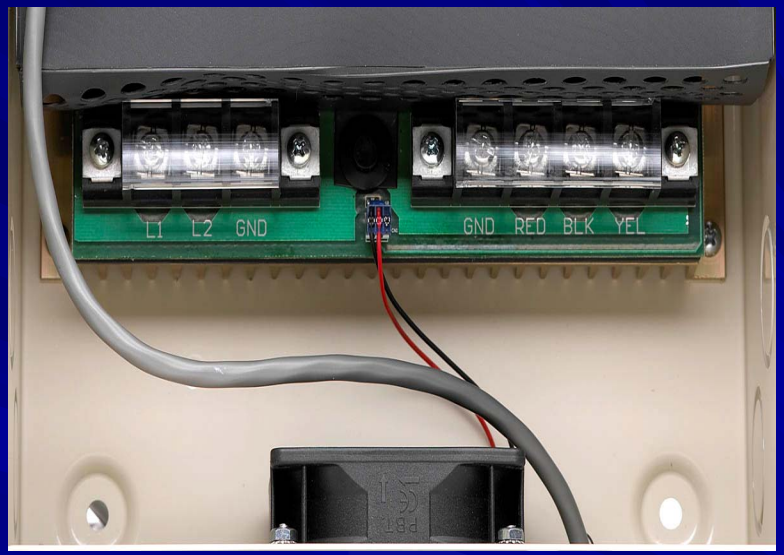


AquaBoost II
Model 3&5AB2 Pump Controller

Diagnostics and protection

- Protects motor or pump from:
  - Overcurrent
  - Short circuit on output
  - Pump/motor bound
  - Low suction/ discharge pressure
  - Ground fault
  - Temperature fault

AquaBoost II Markets

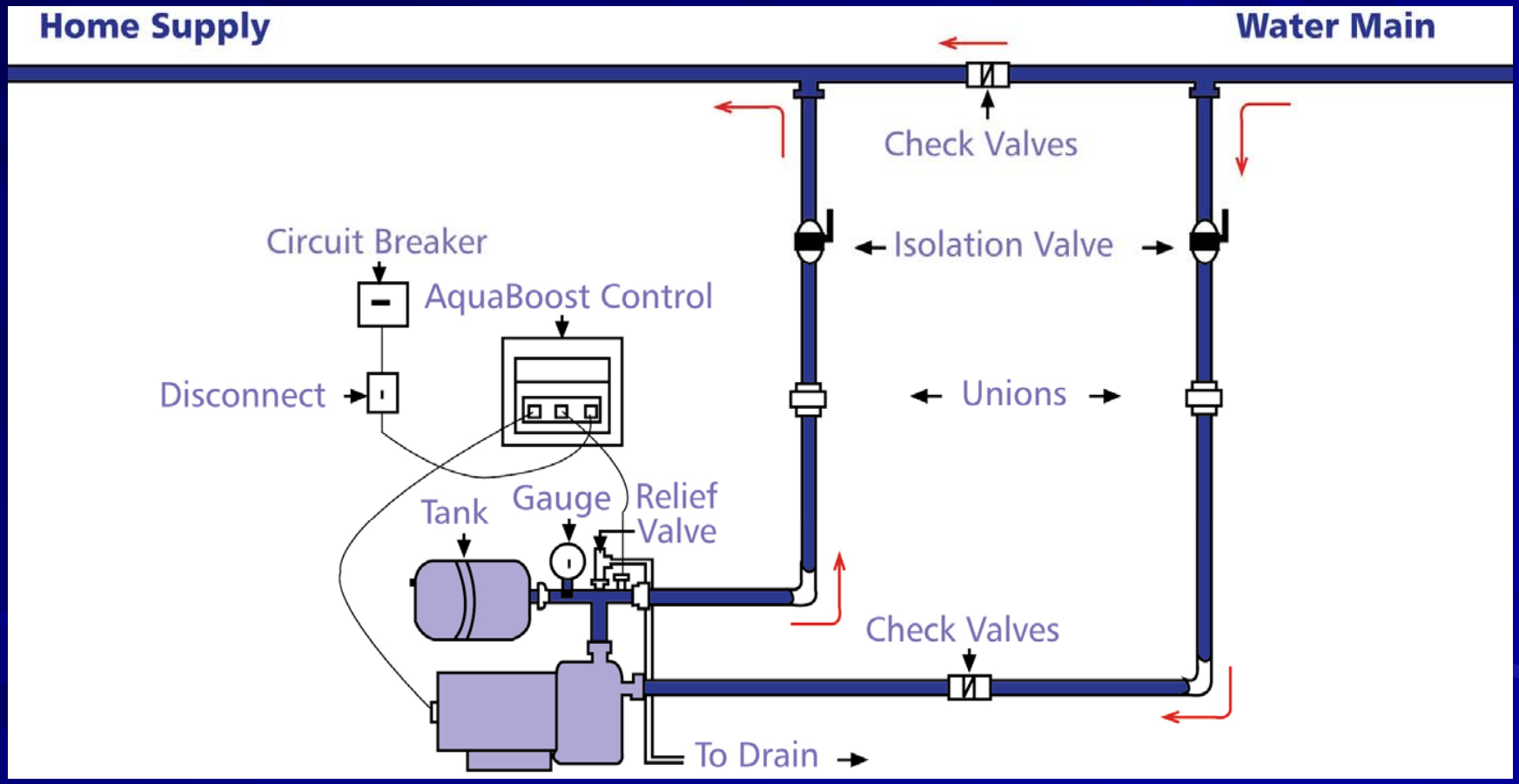
Domestic water boosting “inside the meter”

- New - build homes and retro -fits

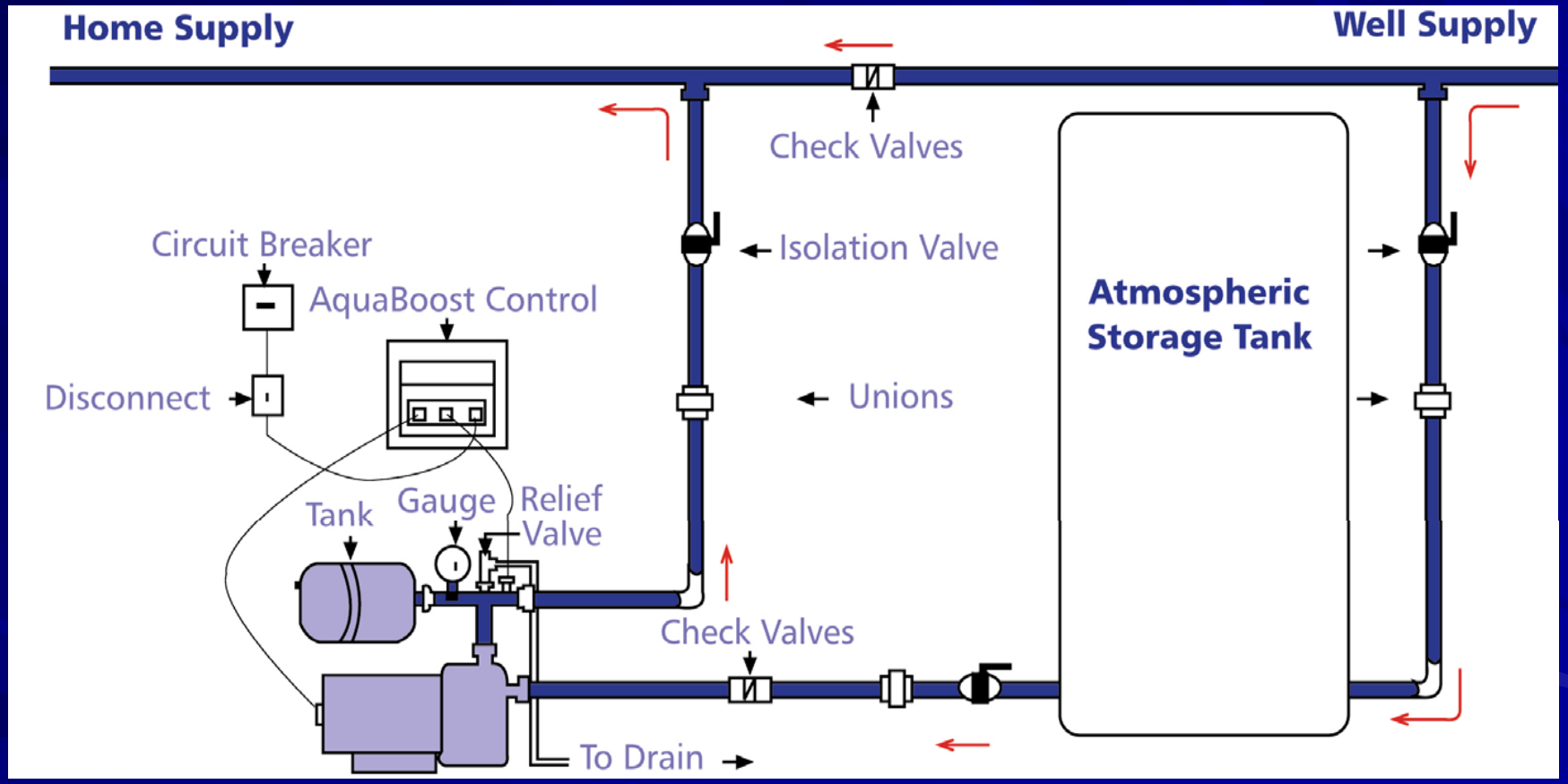
Light commercial

- Restaurants
- Mini-malls

AquaBoost Inline



Low Yielding Well



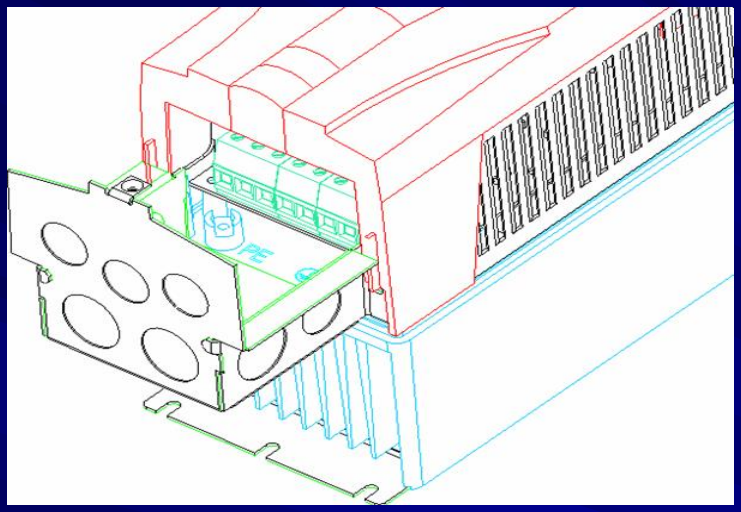
Aquavar Centrifugal Pump Controller (CPC)

- Can be used on any centrifugal type pump (end suction, submersible)
- Available 230 volt 1 thru 100 HP and 460 volt 1 thru 550 HP
- NEMA 1 enclosure (indoor use only) standard, others available upon request

Aquavar CPC Keypad Features

- Control Panel(see IOM page 49)
- “?” key activates on-board parameter descriptions
- Start-up “Wizards” expedite the programming process
- Parameters can be downloaded from the drive to the keypad
- Removable keypad allows the drive to programmed with an extension cable

Aquavar CPC Power Wiring Features



- Removable conduit box provides more room for wiring
- Multiple conduit knockouts allow for wiring vertically or horizontally
- Conduit box can be left off when mounting inside another enclosure or motor control center

Aquavar CPC Hardware Features

- Control wiring easily accessible for transducer, alarms, multi-pump
- Easy to access terminal blocks for RS485, multi-pump connections
- Relay outputs to control up to three slave pumps. 3 programmable relay contacts
- Relay configuration for “Pump run”, “Fault” or “Drive Run”

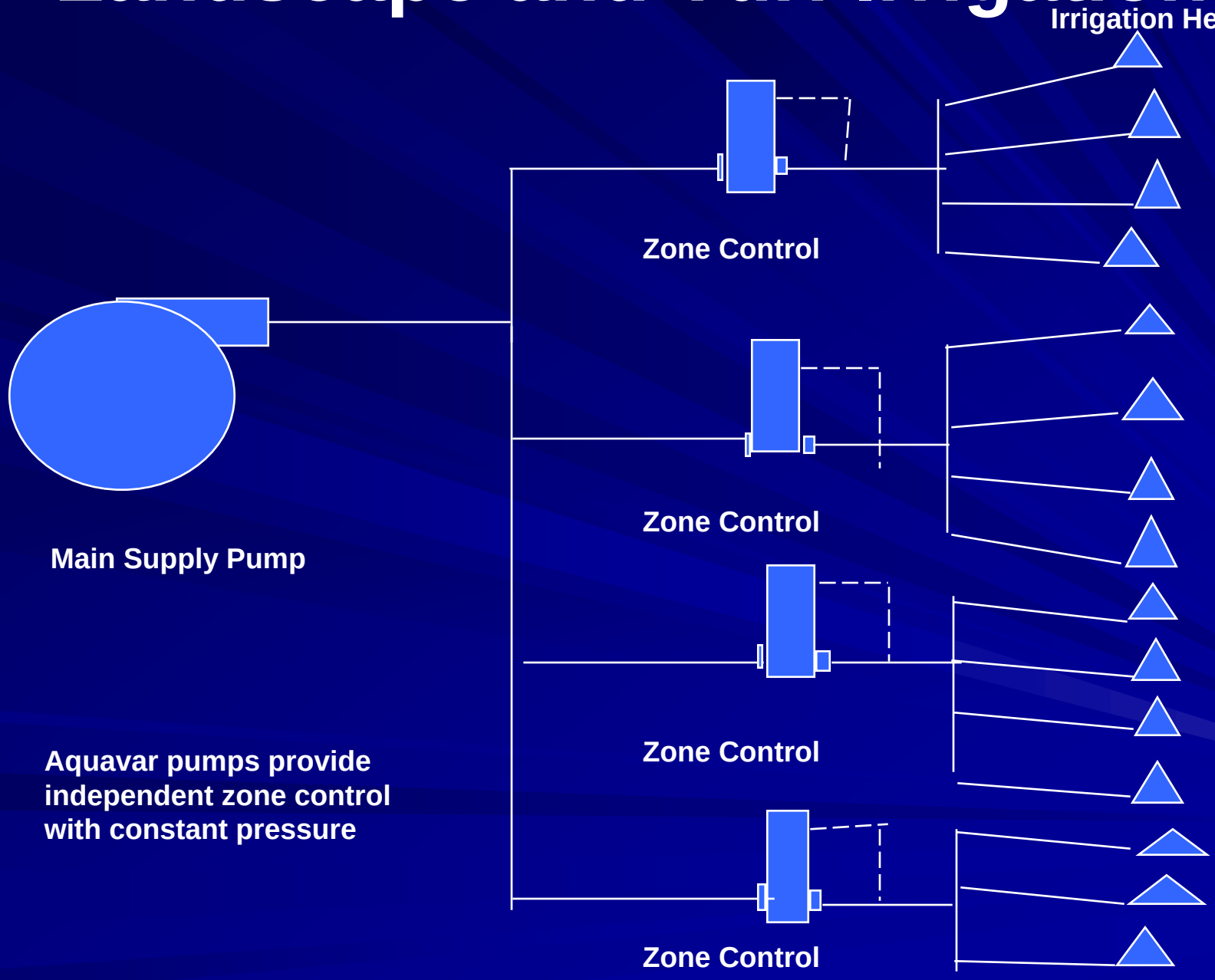
Aquavar CPC Hardware Features

- Transducer and shielded cable included. Texas Instruments 300psi with 30 ft cable
- Available up to 550 HP 380 V -460V (built in fused disconnect 200HP and above)
- Three phase to 100 HP 200 V -240V
- Single Phase to 50 HP 200 V -240V
- Fan will only run when required
- Patented input line choke provides the equivalent of 3% -5% line reactor BUILT IN

AQUAVAR Markets

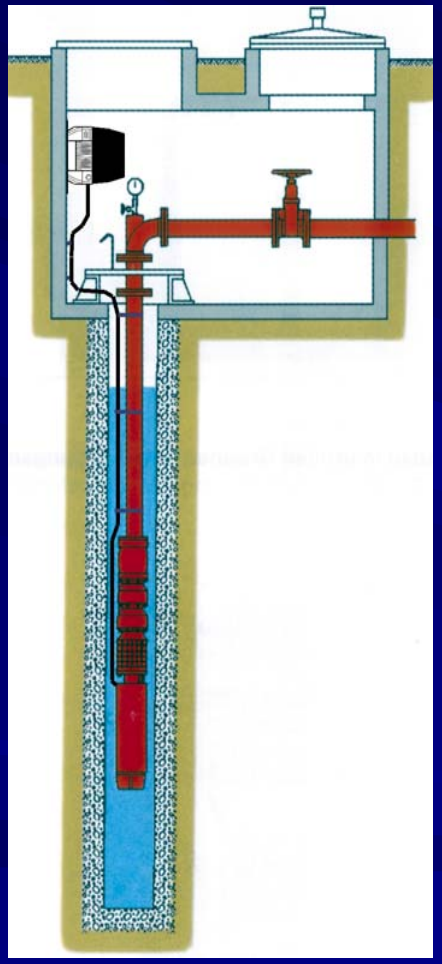
- Irrigation
- Municipal water and waste
- HVAC and building trades
- Industrial
- Residential
- Filtration

Landscape and Turf Irrigation



Aquavar pumps provide independent zone control with constant pressure

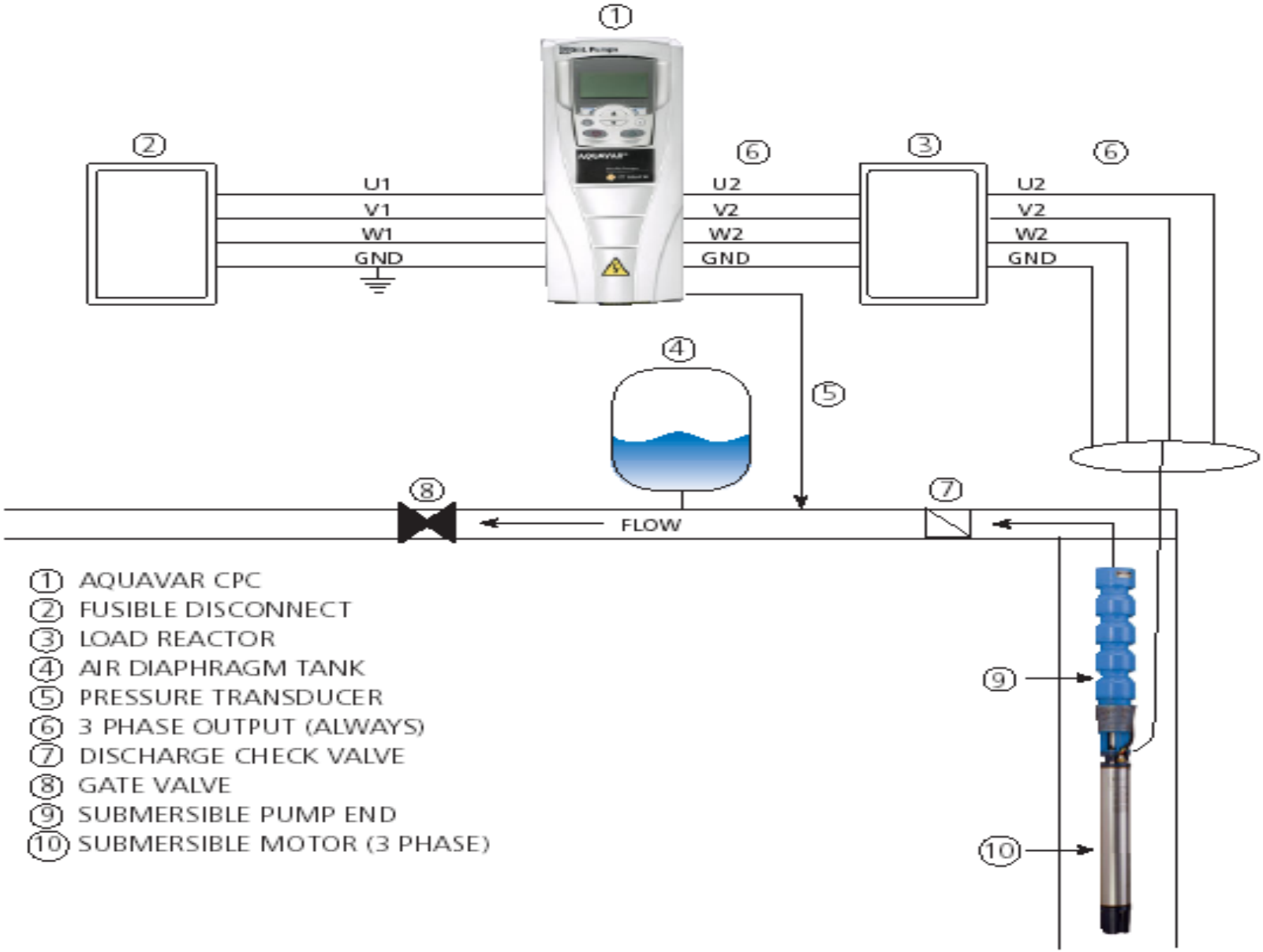
AQUAVAR Submersible Pumps



Control of submersible pump motor speeds

- Submersible well, turbine, effluent or sewage pumps
- Standard to 60 foot depth
- Optional coil (filter) for 1000 foot depth
- Match to motor amp draw not hp
- Minimum frequency setting for submersible motors (bearing lube)

SINGLE PUMP SUBMERSIBLE CONSTANT PRESSURE LAYOUT



① AQUAVAR CPC
② FUSIBLE DISCONNECT
③ LOAD REACTOR
④ AIR DIAPHRAGM TANK
⑤ PRESSURE TRANSDUCER
⑥ 3 PHASE OUTPUT (ALWAYS)
⑦ DISCHARGE CHECK VALVE
⑧ GATE VALVE
⑨ SUBMERSIBLE PUMP END
⑩ SUBMERSIBLE MOTOR (3 PHASE)

AQUAVAR Control Systems

Transducer types available

- Pressure300 psi standard or optional 150 or 500 psi
- Differential pressure
  - Usually used in circulation systems
  - Connects to suction and discharge of pump
  - Measures differential up to 58 psi
- Flow
  - Differential pressure transducer with orifice plate

AQUAVAR Control Systems

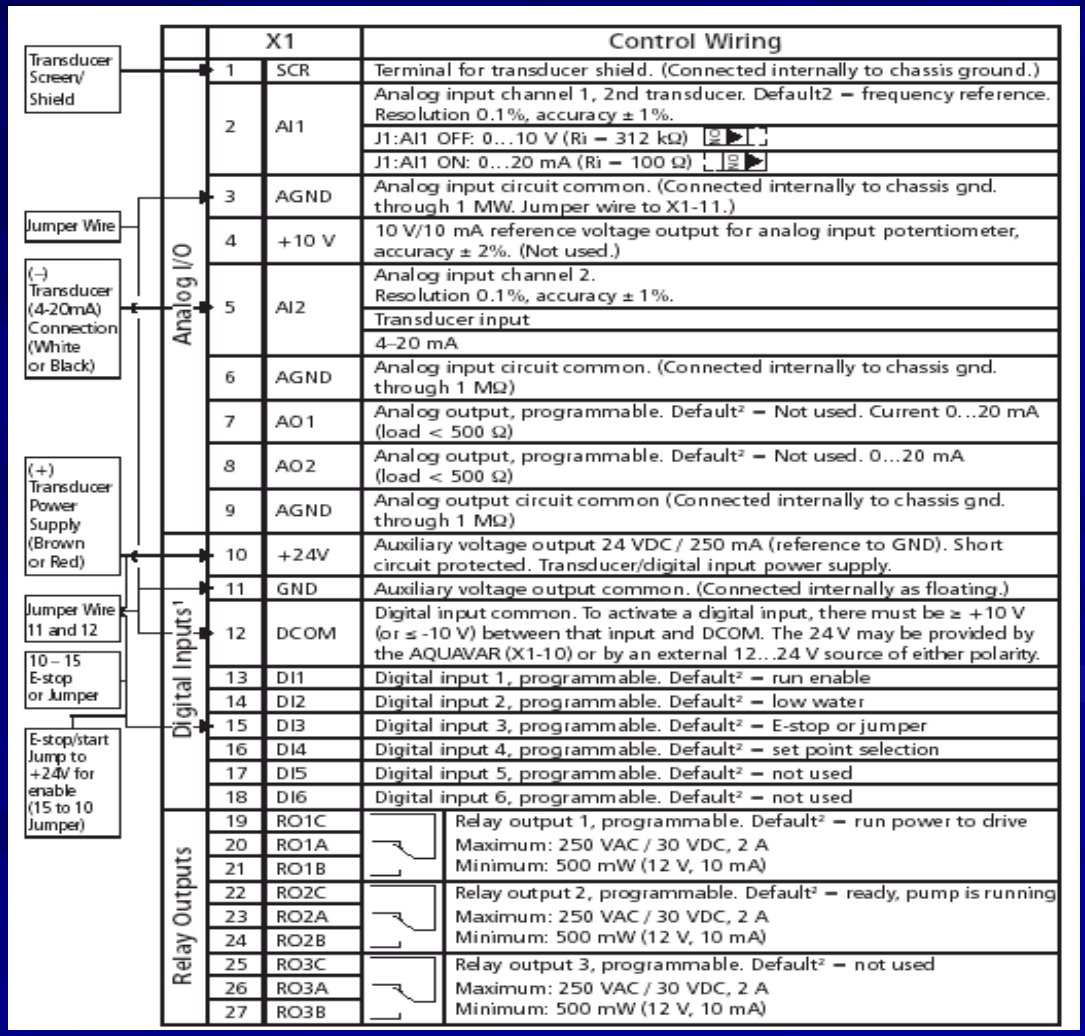
Transducer requirements

- Must be 4-20 mA two wire (0-4V for ABII)
- Must operate with 15V power supply
- Must be shielded cable
- Keep away from high power lines
- Keep cable length to under 1000 feet

Non-pressure applications

- Flow, temperature, air speed, etc.
- Don’t use paddle wheel type for flow

Control Wiring



		X1		Control Wiring
Transducer Screen/ Shield	Analog I/O	1	SCR	Terminal for transducer shield. (Connected internally to chassis ground.)
		2	AI1	Analog input channel 1, 2nd transducer. Default2 = frequency reference. Resolution 0.1%, accuracy ± 1%.
				J1:AI1 OFF: 0...10 V (Ri = 312 kΩ)
				J1:AI1 ON: 0...20 mA (Ri = 100 Ω)
Jumper Wire		3	AGND	Analog input circuit common. (Connected internally to chassis gnd. through 1 MW. Jumper wire to X1-11.)
		4	+10 V	10 V/10 mA reference voltage output for analog input potentiometer, accuracy ± 2%. (Not used.)
(–) Transducer (4-20mA) Connection (White or Black)		5	AI2	Analog input channel 2. Resolution 0.1%, accuracy ± 1%.
				Transducer input
				4–20 mA
		6	AGND	Analog input circuit common. (Connected internally to chassis gnd. through 1 MΩ)
		7	AO1	Analog output, programmable. Default² = Not used. Current 0...20 mA (load < 500 Ω)
		8	AO2	Analog output, programmable. Default² = Not used. 0...20 mA (load < 500 Ω)
(+) Transducer Power Supply (Brown or Red)		9	AGND	Analog output circuit common (Connected internally to chassis gnd. through 1 MΩ)
		10	+24V	Auxiliary voltage output 24 VDC / 250 mA (reference to GND). Short circuit protected. Transducer/digital input power supply.
Jumper Wire 11 and 12	Digital Inputs¹	11	GND	Auxiliary voltage output common. (Connected internally as floating.)
		12	DCOM	Digital input common. To activate a digital input, there must be ≥ +10 V (or ≤ -10 V) between that input and DCOM. The 24 V may be provided by the AQUAVAR (X1-10) or by an external 12...24 V source of either polarity.
10 – 15 E-stop or Jumper		13	DI1	Digital input 1, programmable. Default² = run enable
		14	DI2	Digital input 2, programmable. Default² = low water
E-stop/start Jump to +24V for enable (15 to 10 Jumper)		15	DI3	Digital input 3, programmable. Default² = E-stop or jumper
		16	DI4	Digital input 4, programmable. Default² = set point selection
		17	DI5	Digital input 5, programmable. Default² = not used
		18	DI6	Digital input 6, programmable. Default² = not used
	Relay Outputs	19	RO1C	Relay output 1, programmable. Default² = run power to drive Maximum: 250 VAC / 30 VDC, 2 A Minimum: 500 mW (12 V, 10 mA)
		20	RO1A	
		21	RO1B	
		22	RO2C	Relay output 2, programmable. Default² = ready, pump is running Maximum: 250 VAC / 30 VDC, 2 A Minimum: 500 mW (12 V, 10 mA)
		23	RO2A	
		24	RO2B	
		25	RO3C	Relay output 3, programmable. Default² = not used Maximum: 250 VAC / 30 VDC, 2 A Minimum: 500 mW (12 V, 10 mA)
		26	RO3A	
		27	RO3B	

Installation Issues

- Motor - 3 phase
- Amperage limits
- Wire - low voltage loss
- Enclosure - NEMA rating
- EMI/RFI
- Diagonistics – self
- Tanks
- Minimum frequency

Amperage Limits

- Size VFD by amp load – not HP
- Do not exceed service factor amps
- Found on motor nameplate or manufacturers information

Overload Protection

- Same as standard application
- Quik-trip – 10 sec at 5 times service factor amps
- VFD provides overload protection

Wire Guidelines

- Power leads appropriate size
- Power leads separate conduit
- Sensor lead shielded cable
- Sensor lead away from power leads
- Orientation for correct motor rotation

Wire Size

Service Entrance to Controller

Controller Input	Motor HP	Copper Wire Size 75°C Insulation Exposed to a Maximum of 50°C (122°F) Ambient Temperature ⑥																
		14	12	10	8	6	4	3	2	1	1/0	2/0	3/0	4/0	250	300	350	400	500
230V 1 PH	½	366	583	925	1336	2107	3345	4175	5267	6637	8364								
	¾	279	445	706	1020	1608	2552	3186	4019	5065	6383	8055							
	1	226	360	571	824	1300	2064	2576	3250	4095	5161	6513	8201						
	1½	*	286	455	657	1036	1644	2052	2589	3262	4111	5188	6533	8236	9710				
	2	*	*	331	478	754	1197	1495	1886	2376	2995	3779	4759	5999	7073	8455	9852		
	3	*	*	246	355	561	890	1111	1401	1766	2225	2808	3536	4458	5256	6283	7321	8343	
	5	*	*	*	218	343	545	680	858	1081	1363	1720	2165	2730	3219	3847	4483	5109	6348

Wire Size

Controller to Motor

Controller Output	Motor HP	Copper Wire Size 75°C Insulation Exposed to a Maximum of 50°C (122°F) Ambient Temperature ⑥																	
		14	12	10	8	6	4	3	2	1	1/0	2/0	3/0	4/0	250	300	350	400	500
230V 3 PH	½	905	1442	2290	3306	5213	8276												
	¾	690	1100	1748	2523	3978	6316	7884	9945										
	1	558	890	1413	2040	3216	5106	6375	8041										
	1½	445	709	1126	1625	2562	4068	5078	6406	8072									
	2	324	516	820	1184	1866	2963	3699	4666	5879	7410	9351							
	3	241	384	609	880	1387	2202	2749	3467	4369	5506	6949	8750						
	5	*	235	373	539	849	1348	1683	2123	2675	3372	4255	5358	6755	7964	9520			

Wire Size

Entrance to Controller of 100' and 500' between the Controller and Motor.

- Service Entrance to Controller = 100' of 10 AWG (100/455) = 22 % (455' is from the S.E. to Controller chart)
- Controller to Motor = 500' of 12 AWG (500/709) = 71 % (709' is from the Controller to Motor chart)

Total Drop (must be ≤ 100%) 93 %

Enclosure

- NEMA 4 - weather proof
- NEMA 3R – rain tight
- NEMA 12 - dust proof
- NEMA 1 - indoor

EMI/RFI

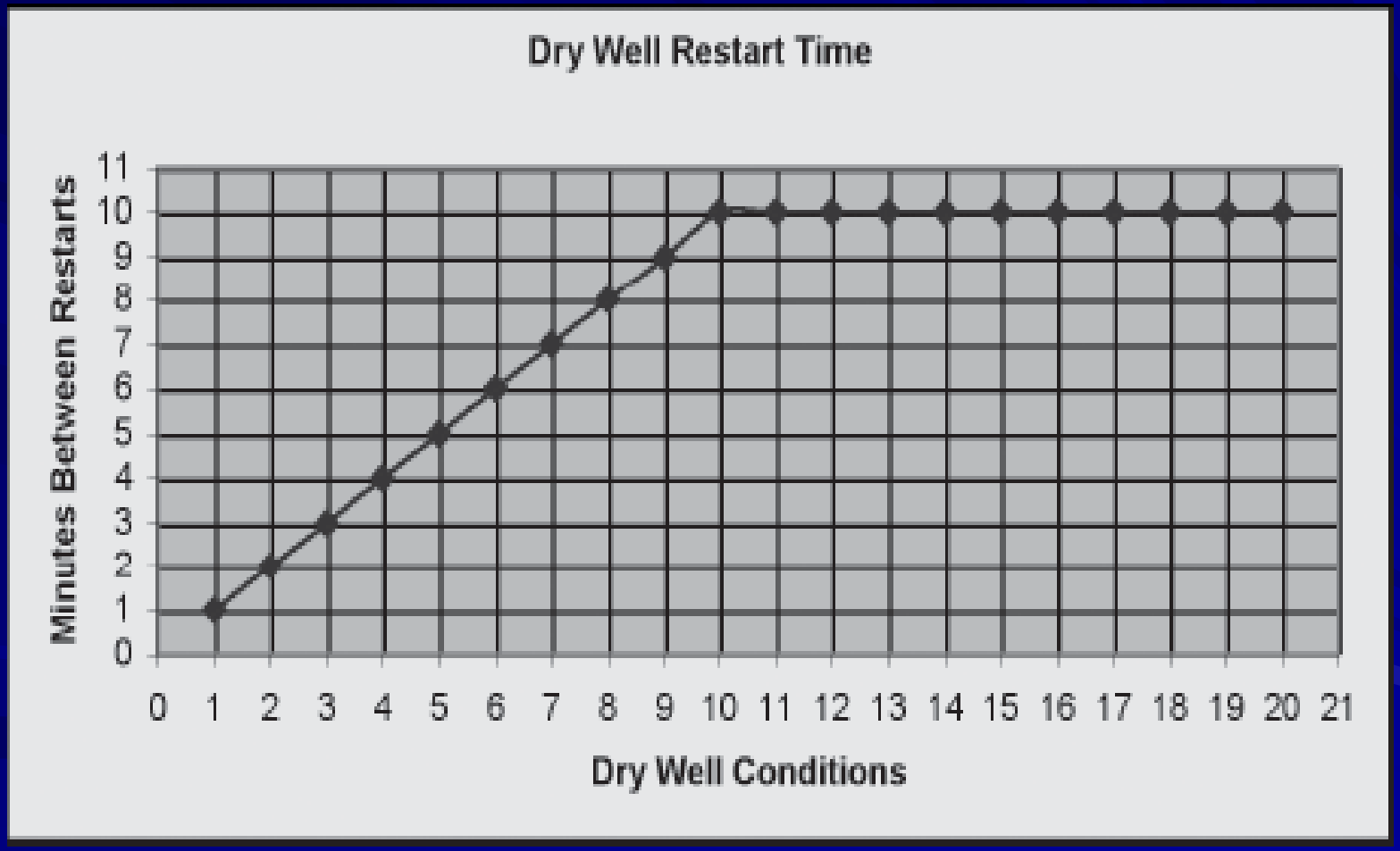
- Electro-magnetic interference
- Radio frequency interference
- Inherent property of VFD
- Does not effect motor
- Long cable runs increase
- Grounding reduces
- Filters-consult VFD manufacturer

Sensor Isolation

BF 20/30/50 Diagnostics

- 2=dry well/low pressure
- 3=pressure sensor fault
- 4=pump bound
- 5=short circuit
- 6=ground fault
- 7=high controller temp
- 8=open power lead

Dry Well


Dry Well Restart Time
Minutes Between Restarts
0
1
2
3
4
5
6
7
8
9
10
11
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Dry Well Conditions

AquaBoost II

Status Code Indicator Light:

Red Light:

- Constant Red – Controller Error
- 1 – No Water
- 2 – Tank Water Logged
- 3 – Pressure Sensor Fault
- 4 – Pump or Motor Bound
- 5 – Short Circuit
- 6 – Ground Fault
- 7 – High Temperature
- 8 – Over Voltage
- 9 – Motor Overload

Tanks

- Bladder type recommended
- Provides a “cushion” or compressibility to the system
- Not used for large drawdown of system
- Size at least 15% of nominal system flow rate, or up to 25% for submersible
- Pre-charge to about 10-15 psi below system pressure
- InWell tank – sensor in well

Minimum Frequency

Submersible motors

- Thrust bearing lubrication: 30 Hz
- Ramp time: 1-4 seconds

Vertical HS or SS

- Motor bearing no issue
- Lubrication of packing or mechanical seal

Frequently Asked Questions

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Does the pump run everytime water is drawn?

Frequently Asked Question

If the pump runs all the time
does it consume more power?

Frequently Asked Question

Can a variable speed controller be used on an existing single speed system?

Frequently Asked Question

If variable speed controller fails, then what?

Frequently Asked Question

Other than constant pressure are there other benefits?

Frequently Asked Question

Can variable speed pump systems be used in low yielding wells?

QUESTIONS ?