Water and wastewater industry checklist for variable speed drives

Recommendations for consultants, contractors and designers

Resilient, reliable and sustainable networks

Resilience is the ability to cope with, and recover from, disruption and to anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future. Resilience lies at the heart of the future water industry.

And yet, advances in variable speed drive (VSD) and motor technology could mean that specifications used by water industry consultants, contractors or designers may be out of date. With pumps being the largest energy consumer within the water industry, it is critical that the selection of VSDs and motors are decided against a clear understanding of just how the technology has evolved.

Challenges presented by cybersecurity, electrical system efficiency, turbidity and harmonics are just some of areas which impact on plant resilience and can be resolved using the latest VSD and motor technology.

This checklist details the key considerations when selecting VSDs for water and wastewater industry applications.

Product specification - variable speed drives (VSDs)

Use this checklist to ensure that a pump, fan or compressor operates at its optimum level.

Physical construction		Check ✓
Drive module, wall-mounted and cabinet-built	• All drives should be available as a module, wall-mounted and cabinet-built to meet space and investment cost needs.	☐
Withdrawable drive module	• Reduces time to maintain or repair/replace modules. Wheeled modules avoid the need for heavy lifting.	☐
Water-cooled drive	• Offers potential to reduce footprint and simplify cooling requirements, offering long-term benefits.	☐
Motor control	• Drives should be capable of accurately controlling all motor types such as synchronous reluctance, permanent magnet or AC induction. Efficient control should be provided by use of direct torque control or vector control.	☐

Ease of use		
Drive control panel (keypad)	• For ease of drive programming, a detachable, multilingual, alphanumeric control panel (keypad) is preferred. • The keypad should include interactive start-up, maintenance and diagnostics support. • It should be capable of copying parameters or settings for backup or for downloading to another drive. • It should be removable, without tools.	☐
Real-time clock and calendar	• Ensure the drive has a real-time clock (including a battery backup) for use during fault logging, with timed functions, etc.	☐
Built-in timers	• Built-in timers allow the drive to be started, stopped and the speed to be changed. • Relay outputs can be operated with timers to control any auxiliary equipment on site. • External timer circuits are no longer required.	☐
Adaptive programming	• This function removes the need for programmable logic controllers (PLCs), timers and other additional equipment, resulting in smaller installations and simpler, more cost-effective system design.	☐

Connectivity		
Serial communications	• Modbus protocol should be built-in as standard. • The drive should have fieldbus adapters for connection of PROFIBUS-DP, PROFINET, Modbus/TCP, EtherNet/IP, Modbus RTU, DeviceNet and CANopen. • Ensure drive can connect to any PLC or HMI system.	☐
Input/Output	• Ensure multiple digital and analogue I/O points are available as standard with expansion capabilities using standard plug-in modules. • Extensive control configuration capabilities, either hardwired or accessible via serial communications network.	☐
Cybersecurity	• Ensure it is possible to integrate the VSD and related accessories into a system that meets IEC 62443 requirements.	☐

Harmonic mitigation		
6-pulse drives	• Standard drive configuration equipped with a choke to reduce harmonic reduction to between 35 to 40 percent THDi (total harmonic distortion). Always check with your supplier as not all include chokes at smaller powers. • Some 6-pulse drives contain patented choke technology capable of delivering 25 percent fewer harmonics at partial loads compared to conventional chokes.	☐
Closed-loop active filter	• Modern filter solution that ensures harmonics are measured and reduced to necessary levels at full or partial loads. Suitable for mains or generator supply. Harmonic content is typically reduced to less than five percent THDi.	
Ultra-low harmonic drive (ULH)	• Modern, compact, all-in-one solution that ensures harmonics are mitigated at source at all loads when connected to either a mains or generator supply. ULH drives produce exceptionally low harmonic content, typically just three percent THDi.	☐

Network flexibility		
Supply voltages	• Ensure the drive provides standard solutions for 200, 400, 500, 690, 3300 and 6600 V. • Standard pre-engineered and tested solutions should be available in modular and cabinet offerings.	☐
Tolerance to network dips	• Drive should have verified tolerance to network interruptions in accordance with Semi F47.	☐

Product specification - variable speed drives (VSDs)

Efficiency		Check ✓
Energy monitor	• Works out energy savings in kWh, MWh, CO_2 emissions and money saved. • Provides graphical visualisation of savings. • Allows verification of energy savings before making investments in capital equipment.	☐
Energy optimisation	• A dynamic control solution that adapts to changes in the motor load and reduces the energy needed to deliver the required torque.	☐
Variable speed cooling fans	• Ensure drives have cooling fans for additional energy saving during partial load situations.	☐

Installation environment		
Coated boards	• Provides up to 3C3 level protection for the printed circuit boards in the drive. This reduces the impact of corrosive atmospheres thereby increasing reliability.	☐
IP21, IP42, IP54 and IP55 protection	• Ingress protection designed to suit the installation environment with no need for a backplate for heatsink cooling.	☐
Integrated 1st environment EMC filters (category C2)	• Ensure the drive has EMC filters suitable for 400 V network (EN61800-3) connection built-in as standard. This saves panel space and avoids additional wiring, earthing and assembly costs required by default.	☐
Flange mounting	• Provides better thermal management in panel installations.	☐

Maintenance information and diagnostics		
System diagnostics	• An onboard diagnostic assistant provides a full fault history, covering voltage, current, DC link level, etc. Each event is date and time stamped, enabling rapid drive diagnostics.	☐
Hours run counters	• Onboard counters keep track of the hours the drive is passing current to the motor and the main cooling fan running hours. Used with the drive's timer function, this can flag maintenance intervals.	☐

Safety		
Safe torque off	• Safe torque off (STO) can be used to stop/prevent the output of the VSD from modulating. This improves safety performance in emergency situations. • STO provides TÜV certified safety to SIL3/2 levels. Can be used to comply with safety PL levels without using an input contactor. • STO can be supplemented with additional drive safety functions such as safely-limited speed, which prevents motors from exceeding a defined speed limit, and safe stop.	☐
Bluetooth keypad	• Enables safe operation of the VSD from outside the arc flash boundary area.	☐
Main switch	• Integrated and visible isolation device to disconnect the drive from the main supply.	☐

Components		
Fans and capacitors	• Ensure there is an operating life of at least six years for fans and nine years for capacitors, based on permanent operation at full load in 40°C ambient temperatures.	☐

Intelligent pump control features

Drive features and benefits		Check ✓
Level control	• Ensures optimal emptying and filling of wastewater and clean water storage tanks by running pumps at the most efficient speed. • Provides default settings for emptying and filling. • Reduces tank maintenance costs. • Controls up to eight pumps, keeping the system operational at all times. • Reduces the need for external controllers or complex level control devices.	☐
Pump cleaning	• Runs pump cleaning procedure, preventing build-up of solids on pump or inlet screens. Removes debris from around pump volute, preventing it from entering the pump and blocking it. • Reduces the possibility of pump blockages. • A regularly used pump cleaning function lowers weekly electricity consumption. • Pump cleaning cycles can be customised to the pump OEM's guidelines.	☐
Intelligent multi-pump control	• Controls flow or pressure of pumps running in parallel. Shares information between connected drives to ensure redundant operation. • Dynamically controls the starting and stopping of multiple pumps to meet demand, balance operation time and reduce surging. • Parameter synchronisation feature ensures multi-pump settings on each VSD in the system are the same, reducing the commissioning time and risk of human error.	☐
Sleep and boost	• Rather than keep pumps running to maintain pressure, this function slightly boosts pressure in the pipeline before shutting pumps down. This allows pumps to sleep for long periods whilst pipe pressure is monitored within limits. • Saves energy by extending sleep time and avoiding having pumps run continuously during low demand periods.	☐
Soft pipe filling	• Protects pipe networks from pressure peaks when starting the pump system. Allows a pipeline to fill smoothly before PID control is activated. • Helps to reduce overpressure and reduces water hammer. • Reduces burst pipes and seal damage during pump start. • Can help improve turbidity control.	☐
Flow calculations	• Reduces the need for external flow meters and is suitable for applications where flow data is not needed for invoicing purposes. • Sensorless flow calculation (power curve) is easily configured and does not require pressure feedback. • Alternatively use pressure transmitters to define the flow by using the pump head curve performance.	☐
Pump protection	• Increases time between maintenance intervals by avoiding mechanical damage. Uses data from pump curves and pressure transmitters to detect any abnormalities. • Reduces failures. • Ensures high plant reliability.	☐
Quick ramps	• Extends the life of a submersible pump by reducing wear of the mechanical parts using ramp sets to accelerate and decelerate the pump. • Protects bearings when a submersible pump is started without water. • Reaches optimal speed to extend pump life. • Ensures operation and prevents unplanned outages.	☐
Pump priority	• Achieves energy savings with optimal pump alternation by running the higher capacity pump when the consumption rate is higher.	☐
Auto changeover	• Increases the mean time between repairs and saves in-service costs by balancing the long-term operating time of all pumps in a parallel pumping system.	☐
Turbidity reduction	• When a pump starts as slowly as possible, it creates the lowest turbidity values for the water being moved or extracted. When combined with the quick ramp and soft pipe fill functions, the drive will protect and run submersible pumps in the most optimal way.	☐
Communications loss backup mode	• Upon a Fieldbus communications loss, the drive can automatically switch to internal PID control. This allows resilient operation of the system and maintains accurate control of the process, rather than using fixed speed backup modes.	☐

Lifetime support

Your VSD supplier should be capable of supporting products throughout their life cycle.

Pre-purchase		Check ✓
Energy assessment	• An energy assessment identifies the motor-driven applications at a customer's site that offer the greatest opportunity to cut energy use. An action plan is then provided to turn those potential savings into actual savings.	☐
Harmonics survey	• Identifies potentially damaging harmonics quickly. A report is then provided that details recommended actions and costs.	☐
Drive selection tools	• Supplier should provide VSD sizing and selection tools to assist with the specification of VSDs.	☐
Harmonic selection tool	• A tool for assessing the harmonic impact of different VSDs should also be provided by the supplier. This provides optimised programs to calculate harmonics.	☐
Applications support	• Ensure supplier has a team of application and service engineers to ensure correct selection and set-up of VSD systems.	☐
Warranty	• Typically up to 60 months from delivery for VSDs.	☐

Installation and commissioning		
Start-up service	• Checks installation, powers up system and configures parameters. Ensures drive start-up is quick and efficient on first run.	☐

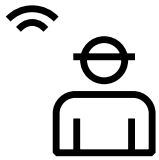
Operation and maintenance		
Asset management support	• A life cycle assessment provides a clear understanding of the drive installed base of a particular facility. A report detailing how assets will evolve over the next six years is produced. This shows the risk profile of the assets and what mitigating actions are recommended.	☐
Preventive maintenance plan	• Preventive maintenance consists of regular inspections and component replacements according to a product-specific maintenance schedule. Onsite preventive maintenance is carried out by certified field service engineers. This gives maximised drive system availability, quality of operation and lifetime, predictable maintenance budgeting and drive lifetime cost management.	☐
Training	• Ensure your supplier provides full technical, service and product training.	☐
Scheduled maintenance	• For a complete fit-and-forget service consider using a supplier who offers scheduled maintenance programs.	☐
Spares	• Ensure spares are readily available locally. Online ordering facilities should provide 24-hour access.	☐
PC tools	• Optimal commissioning and monitoring software that stores VSD parameter sets and operation and maintenance manual documentation. Allows customisation of the VSD, reducing the need for a PLC to control small systems.	☐
Service agreements	• Service agreements should be available to ensure an engineer is available to respond in the event of any unplanned outages.	☐
Withdrawable drive modules	• For high power VSDs consider the need for wheeled drive modules to improve system redundancy and reduce repair time.	☐
Scalable remote services	• ABB Ability™ Remote Assistance provides rapid response and solutions should a problem occur. • ABB Ability™ Condition Monitoring automatically and continuously collects performance data from drives and provides alerts and information to enable the customer to react. • ABB Ability™ Predictive Maintenance optimises VSD maintenance by proposing highly targeted maintenance actions for critical drive applications – before any problems occur.	☐

Upgrade		
Upgrade and retrofit service	• Ensures processes continue to operate with the highest level of efficiency and reliability. • All services, including spare parts, technical support and training, are available for your drive again. • Can be combined with other maintenance tasks to avoid the need for further shutdowns.	☐

Recycling		
Recycling service	• Consider choosing a supplier that offers a recycling scheme for obsolete VSDs. • Modern recycling facilities are able to recycle over 90 percent of a drive's unit by weight. • In most countries ABB is committed to recycling returned material according to ISO 14001.	☐

Technical & commercial considerations

A VSD supplier should be able to offer advice on both technical and commercial considerations.



Energy		Check ✓
IE4 and IE5 motor packages	• Consider synchronous reluctance motors (SynRM) and VSD technology for easy compliance with IE4 efficiency performance levels (and future IE5).	☐
EN 50598	• Introduced in 2014, this standard defines energy efficiency indicators (“IE” and “IES”) for the complete drive module (CDM) and the combination of the CDM and motor to form a power drive system. • Applies to motor-driven equipment from 0.12 to 1,000 kW (100 to 1,000 V). • VSDs must have a minimum efficiency rating of IE2	☐

Supply network		
Circuit breakers	• Protection of low voltage drive inputs by standard MCBs or MCCBs avoids the use of larger and more expensive semiconductor fuses that can be difficult to apply. Tables of suitable circuit breakers should be available from the drive manufacturer.	☐
EN 61000-3-12	• Defines limits for harmonic currents produced by equipment connected to public low voltage systems. • Mandatory for products on a 400 V network. • Ensure your supplier has the necessary expertise on harmonics and is able to advise best practice. • Also, ensure that your chosen drive has a suitable choke that suppresses harmonics effectively across the speed range and not just at full speed.	☐
EMC compliance	• VSDs co-exist with other electric and electronic systems in any installation. A powerful current with a strong electromagnetic field can affect the performance of nearby devices with lower current levels. • Use three-core symmetrical shielded cable. • Use separate external earth (potential equalising) cable between motor and drive. • Route power and control cables separately. • Apply 360° earthing at each end of the cable.	☐

Drive selection		
Medium voltage (MV) and low voltage (LV) drive	• Depending on the specific installation, selection could favour either a LV or MV solution when powers are around 800 kW to 1300 kW. A supplier should be able to assist with the optimum selection. • On larger powers (typically above 1300 kW) MV packages are typically the default offering. • In single low voltage VSD applications (>200kW) with a dedicated MV connection, the solution typically utilises ultra-low harmonic drives. • Ask your supplier to prepare sound technical and commercial arguments for the most cost efficient solution.	☐
Matched drive and motor packages	• Ensures correct dimensioning of the VSD and motor. • Work with a supplier that is able to provide guaranteed package efficiencies.	☐
Fieldbus communications	• Fieldbus offers greater flexibility than point-to-point hardwiring. This improves the volume and speed of information sharing between the drive and other connected devices.	☐
5-level switching	• On MV drives ensure multi-level switching technology is used to ensure optimum output waveform.	☐
Sine filtering	• Sine filtering should be available for ease of retrofitting VSDs into existing direct-on-line (DOL) applications.	☐
Fuse-less designs	• On MV applications consider a fuse-less design. This improves the reliability of the VSD.	☐
Cooling redundancy	• For high power dedicated VSDs (LV and MV) consider the need for cooling fan redundancy.	☐

Installation		
Long cable runs	• Typical applications involve motor cable length up to 150m. Select a VSD with an inbuilt choke to allow for cable runs of 100m or more without additional equipment. The supplier should be able to provide du/dt or sine filters to suit very long cable runs or weak motor insulation applications.	☐

Motor selection		
Motor insulation	• Always ensure the motor insulation is designed for VSD operation without the need for the drive to be fitted with du/dt or sine filters.	☐
Hazardous areas	• For applications sited in hazardous areas, ensure the motor supplier can provide certified ATEX VSD and motor packages.	☐
Slow speed motors	• To reduce VSD rating selection for slow speed motors consider using 690 V (star)/400 V (delta) designed motors supplied with 400 V (star), to improve the overall string efficiency.	☐

Selecting the right motor for your application

Today's water and wastewater applications can be driven by a variety of motor types.

Standard induction motor (IM)	
Advantages	• Well known mechanical sizes; most popular and common motor design. • Efficiency levels are available up to IE4. • Easy to maintain and operate: rewinding is possible and spares are widely available. • Magnet-free: no generated electricity from freewheeling loads. • Hazardous area versions available that meet explosive atmosphere classifications. • Can operate DOL or with a VSD.
Limitations	• Lower efficiency at partial loads. • Smaller power motors are difficult to make high efficiency. • The rotor is a source of I2R losses within the motor, making it hard to achieve very high efficiencies.

Synchronous reluctance motor (SynRM)	
Advantages	• Delivers superior efficiency compared to IMs and the same efficiency as permanent magnet (PM) motors. This contributes to Ecodesign Directive conformity. • SynRMs need a VSD to operate them. This brings all the advantages associated with the drive such as: improved harmonic mitigation, adequate power dip ride through, ability to catch a spinning load, fieldbus connectivity and built-in control features to enhance the application. • Up to 50 percent lighter than IMs. • Cooler running and quieter than other motors, giving longer maintenance intervals and better working environments. • Easy to optimise motor selection to the duty point. • Easy to maintain and operate. Standard motor re-winders can repair a SynRM motor with no more than a "copy wind" approach. • Magnet-free, therefore easier to handle than PM motors and no risk of de-magnetising. • Available in sizes that match IM frames, or smaller, if less space is required e.g., when the motor is mounted inside the duct. • Guaranteed SynRM package efficiencies available from some suppliers.
Limitations	• Requires a VSD to operate. • SynRMs have a higher current requirement than IMs so it may be necessary to use a VSD with a higher power rating (e.g. a 15 kW drive with an 11 kW motor). • Motor runs synchronously but some re-scaling may be needed on BMS/SCADA of a larger drive.

Permanent magnet (PM) motor	
Advantages	• Delivers superior efficiency compared to IMs and similar efficiency as SynRMs. This contributes to Ecodesign Directive conformity. • Suitable for low-speed torque applications with possibility to eliminate gearbox.
Limitations	• Requires a VSD to operate. • PM motors are more expensive than IMs and SynRMs due to rare earth materials. • May generate dangerous back EMF voltages when freewheeling. • More difficult to maintain and operate due to permanent magnets on the rotor. • It is not possible to overspeed PM motors to achieve best efficiency characteristics of the system. • Motor runs synchronously but some re-scaling may be needed on BMS/ SCADA of a larger drive.


ABB

Education and development

ABB offers a wide range of training from Lunch 'n' Learn sessions to hands on, instructor-led skills development courses. A range of e-learning modules is also available.

Target audience
Technicians, electrical engineers, asset managers and those responsible for the upkeep and maintenance of VSDs.

Previous knowledge
There are no prerequisites for this training. However, it would be helpful if the student had a basic understanding of electrical installations and some experience of an industrial environment.

Objectives
To alert engineers and management of the merits of using VSDs to improve process efficiency, reduce energy use and lower carbon dioxide emissions.

Location
The courses can be presented at customer premises or an ABB facility. Online content can be accessed from any web-enabled PC with an up-to-date browser.

Booking
To book training, or for more information, contact your local ABB office.

Lunch 'n' Learn topics	Duration	Reference	Check ✓
Introduction to harmonics	45 mins	WA156	☐
VSD system energy efficiency	30 mins	WA157	☐
Selection and operation rules for borehole and submersible pumps	45 mins	WA158	☐
Best efficiency point pumping	30 mins	WA159	☐
Powerfactor correction using ABB ultra low harmonic drives	30 mins	WA160	☐
Introduction to variable speed drives in water	30 mins	WA161	☐
Using variable speed drives to improve energy efficiency and process control in aeration	45 mins	WA162	☐
Reducing leakage through the use of variable speed drives	45 mins	WA163	☐
ACQ580 hardware and firmware features and benefits	30 mins	WA164	☐
VSD cabinet considerations	30 mins	WA165	☐
Choice considerations between a MV and LV drive solution	30 mins	WA166	☐
An Introduction to IPC (Intelligent Pump Control) software	30 mins	WA170	☐
An Introduction to VSD programming software and remote diagnostics	45 mins	WA174	☐

Skills development courses			
Introduction to ACQ580	3 hours	WA204	☐
Introduction to fieldbus communications	2 hours	WA207	☐
Drives Advantage	1 day	WA219	☐

e-learning courses			
ATEX directives, ABB low voltage AC drives and motors	45 mins	G021e	☐
DriveSize fundamentals	60 mins	G066e	☐
LV AC drives general cabinet engineering principles	60 mins	G089e	☐
Basics of AC drives - process control and various control methods	30 mins	G101e_a	☐
Basics of AC drives - hardware construction	30 mins	G101e_b	☐
Fieldbus basics for ABB drives	15 mins	G107e	☐
Functional safety in ABB drives	40 mins	G111e	☐
Drive composer entry fundamentals	15 mins	G375e	☐
Drive composer pro fundamentals	15 mins	G376e	☐
ACQ580 hardware features	15 mins	G6401e	☐
ACQ580 software features	20 mins	G6402e	☐
ACQ580 startup	15 mins	G6403e	☐

Bespoke training courses available upon request

For more information, please contact your local ABB representative or visit:

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