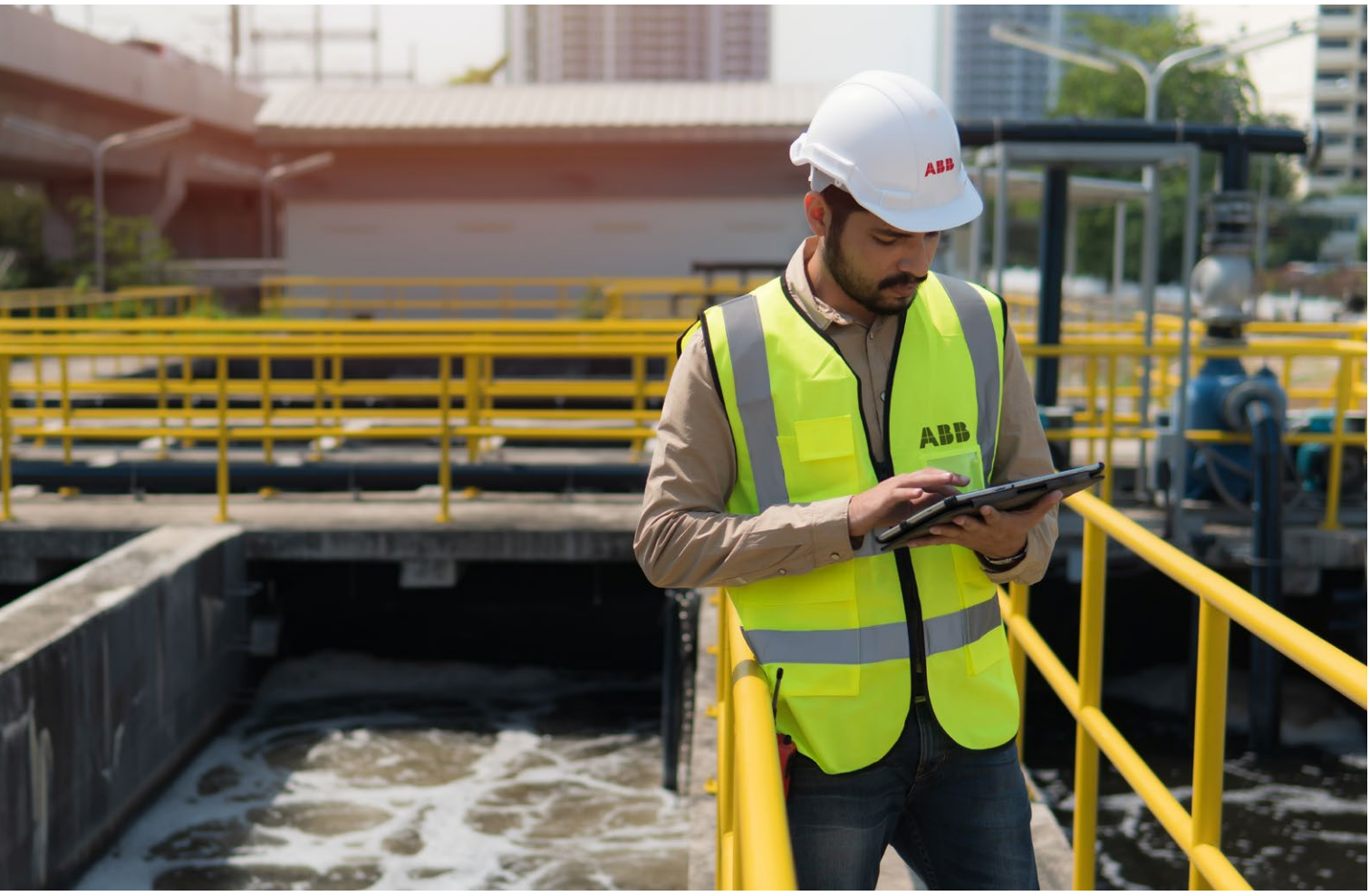
Operations and Maintenance Manager checklist

For Water and Wastewater utilities



Water and wastewater plants Require comprehensive maintenance plans

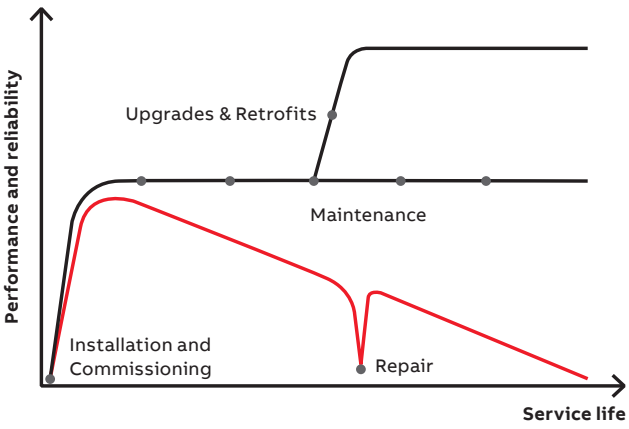
Most Variable Speed/Frequency Drives (VSD/VFDs) are designed to deliver high reliability, however when supported by a comprehensive maintenance strategy, longer operational lifetimes are achievable.

ABB's global experience in the water and wastewater industry has enabled an insight into what causes system failures such as operational conditions like high temperatures. By linking the effects of high temperatures to the aging rate of components, and then being able to combine that with other factors like heavy cyclical loads, allows a depth of knowledge on how the life of a VSD/VFD can be extended further.

Aggressive gases such as hydrogen sulfide, chlorine, or ammonia can damage the electrical circuit boards and mechanical components of VSD/VFDs. Corrosion is also a common issue when VSD/VFDs are installed in high-moisture areas. Therefore, it is important to consider these conditions and take precautions to protect your VSD/VFDs from corrosive gases to ensure their reliable operation and prolong their service life.

This Operations and Maintenance manager checklist aims to go beyond the maintenance lists of a product and offer a valuable insight into our global experience from working within the water and wastewater industry. The checklist will highlight critical contributions made by the maintenance function in achieving business objectives.

Explore daily, weekly, and monthly maintenance schedules for a VSD/VFD on a water or wastewater site, with the commitment of operations and all responsibility roles to ensure compliance with the maintenance program while reducing risks.



The red line is indicative of a decline in performance and reliability if no maintenance plan exists. The black line indicates that a good maintenance plan guarantees performance over service life.

To function properly over the expected service lifetime, VSD/VFDs require regular preventive maintenance. A better understanding of the need for different maintenance (both preventative and predictive) strategies can help reduce unexpected downtime.

Aging components that are poorly, infrequently or never maintained may result in other parts of the VSD/VFD being stressed, which can lead to an increased risk of failure and a decrease in its functional lifetime. Regular predefined preventive maintenance schedules circumvent these tendencies and facilitate service budgeting optimal to the product's true potential.

Guaranteeing the maximum uptime and delaying the cost of replacement are clear business priorities for the water and wastewater industry.

Correctly scheduled maintenance strategies can transform a VSD/VFD's operational capability and extend its life cycle giving you value from your investment and confidence in your operations.

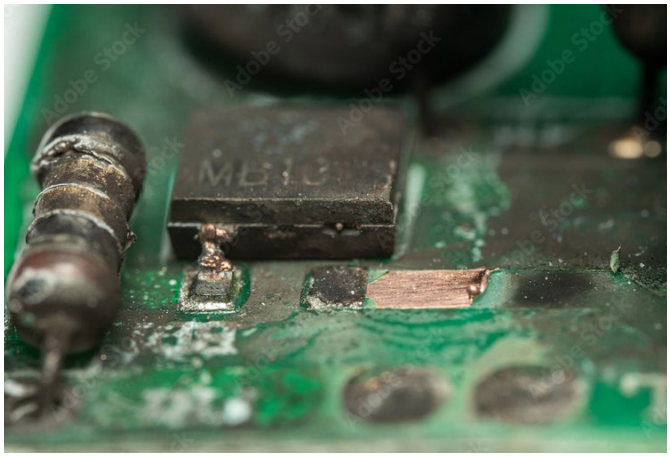
Managing asset life-cycle is key to ensuring that your processes run without interruptions

Comprehensive solutions
Helping you to maintain operational resilience

ABB VSD/VFDs are designed for the highest reliability and their maintenance guidelines and solutions ensure long lifetime. Serviceability is built into ABB VSD/VFDs to ensure our customer commitment for continued operations.

Many water and wastewater companies can be stuck in a reactive maintenance cycle. Without planning and scheduling, maintenance can be ineffective at best and non-existent at worst, often resulting in a loss of throughput, including break-downs.

Teams of maintenance workers can spend hours waiting on equipment to arrive. With critical spares not being readily available, delays, overtime costs, exhausted workers and ineffective utilization occur. Key indicators of a reactive maintenance approach are projects overrunning the planned shutdown times and a growing back-log of scheduled activities, mainly consisting of component replacements.



An asset's life cycle typically includes five stages: planning, procurement or acquisition, operation and maintenance, and disposal or archive. By implementing asset lifecycle management, water companies can reduce costs, increase productivity, and ensure the smooth operation of their treatment processes.

ABB Drives Solutions include:

Operational excellence

Is uptime your priority?

Example services include:
- Installation and Commissioning
- Spare Parts
- Preventive Maintenance
- Reconditioning
- ABB Drive Care agreement
- Drive Exchange

Rapid response

Is rapid response a key consideration?

Example services include:
- On-site Repair
- Response time agreements
- Training

Life cycle management

Need to extend your assets' lifetime?

Example services include:
- Life Cycle assessment
- Upgrades, Retrofits and Modernization
- Replacement, Disposal and Recycling

Performance improvement

Is performance most critical to your operation?

Example services include:
- ABB Tailored Solutions and Services
- Energy Appraisal
- Extended warranty

Three different perspectives

Purchasing decisions aren't always made by just one person, and this is the same with operation decisions within a water or wastewater plant. Understanding the gains of the different stakeholders in the decision-making process allows all goals to be met.

Production control and resilience

"Water security is everything to me."

Operations Manager

Know where to look...
At every stage of the water and wastewater treatment process, there are opportunities for improvement in operations and maintenance, production control, process efficiency and network resilience..

... and how to unlock production resilience

Operations and maintenance personnel continually strive, with a constrained budget, to overcome challenges that can interrupt normal operations. Maintaining equipment, power quality disturbances, emergency generator instability, aging infrastructure, and process control inefficiencies all play a part.

"If there is a risk in the equipment that is operating my plant, I want to know about it and have a strategy in place to prevent it from failing."

... whilst maintaining network resilience

- Provide credible, impartial analysis of existing maintenance strategies, and identify improvements that can prevent unplanned interruptions
- Highlight process efficiencies gains and change maintenance approaches.

Good maintenance practices can prevent plants exceeding effluent or license/permit limits, leading to fines or even plant shutdowns.
"I service my car every year, not because I want it to last longer than 10 years, but because I need a vehicle that will reliably get me to work every day – I should have the same confidence in my process assets."

Productivity and resilience

"We must avoid supply interruptions and deliver high customer outcomes."

Plant Manager

Build in resilience...
Water and wastewater plants need to run without interruption and in the most efficient and environmentally conscious way. Ensuring the reliability of plant assets is the best way to reduce supply interruptions, lower environmental impact and keep your business efficient and effective.

... with flexible motor-driven solutions

VFD/VSDs have the ability to detect and prevent problems in the applications. Due to the electrical and mechanical connection, they can detect problems like no flow and/or pump blockages and prevent system failures in advance such as seal failure or cavitation damage.

You depend on utility power being available at all times or having backup generators take over in an instant when there is an emergency. In an ideal world, the utility power is 'clean' and compliant recognized standards. However, there are many common and often hidden issues 'dirty' power causes when harmonics are present on your voltage and current waveforms.

Using an ultra-low harmonic (ULH) VSD/VFD reduces the losses in the mains supply, improves the mains power quality and reduces the risk of disturbance of other equipment connected to the mains.

Reliability and maintenance

"We must be able to predict issues before they become problematic."

Maintenance Manager

Lower operational overheads...
Wastewater pumps suffer a higher wear rate because of grit, rags, debris and other solids. Managing these issues extends the life of the assets and saves energy by avoiding pumping against partial blockages.

... by utilizing smart drive functionality

Temperature, load, under/overvoltage protection and warning features help anticipate breakdowns.

A real-time clock allows timed tracing of faults, so you know what has happened and when.

ABB Ability™ Condition Monitoring services support remote pumping stations by delivering accurate, real-time information about VSD/VFD and motors, ensuring equipment is available, reliable and maintainable.

Having a system that knows what's starting to go wrong before it does, just by feeling the vibration, temperature, etc. in the application is key. It's easier to sleep at night knowing you have all green lights across all your VSD/VFDs across all your plants. Knowing that you will be notified the first instant a motor or drive is moving off trend is very valuable.

Seven steps to keep your water and wastewater operations running uninterrupted

1. Check power quality, harmonics, and generator operation
2. Take care of aging infrastructure
3. Review equipment installation, environment and protection
4. Fix outdated installation practices
5. Stop spills, bursts and water hammer
6. Protect your pumps from cavitation damage
7. Extend system lifetime by improving process efficiency

1. CHECK POWER QUALITY, HARMONIC DISTORTION, AND GENERATOR OPERATIONS

Poor power quality can negatively impact your operations and you may not see the evidence until it's too late.

- Most electrical equipment that uses solid state devices, including older VSD/VFD types, causes increased voltage and current harmonic distortion and other side effects.
  - For example, transformers and motors can suddenly overheat, sensitive electronic equipment can operate erratically or fail, metering equipment can show false readings, breakers can randomly trip, generators can become unstable, and fuses can blow, potentially leading to multiple issues from water quality to increased capex.
- Modern VSD/VFD technologies, such as ABB's Ultra Low Harmonic (ULH) drives mitigate harmonic disturbances, produce exceptionally low harmonic content, and can be retrofitted into water applications, ensuring compliance with harmonic standards.

2. TAKE CARE OF AGING INFRASTRUCTURE

Identify how aging infrastructure increases your costs.

- When serviced and maintained properly, supply and treatment systems have a natural life expectancy of 20-25 years for some pumps, pipes, motors, and other mechanical systems.
- Unmaintained power electronics, like VSD/VFDs and other solid-state devices, can have a much shorter service life of 10 to 15 years.
- Heat, moisture, corrosion, and obsolete components all contribute to reducing the useful life of these devices.
- When older and obsolete technologies continue to run beyond the expected lifetime, the risk of breakdown or total failure increases.

3. REVIEW EQUIPMENT INSTALLATION, ENVIRONMENT AND PROTECTION

How to protect and extend your VSD/VFD's lifetime.

- Water and wastewater treatment processes utilize extremely corrosive liquids and gases during filtration, disinfection, and odor control.
- The hostile environments, temperature swings and humidity levels in which VSD/VFDs are commonly installed cause equipment to suffer from damage, degradation, and premature failure.
- Prolonged exposure to these negative effects significantly decreases equipment life and can exponentially affect the cost of repair.

4. FIX OUTDATED INSTALLATION PRACTICES

Prevent trips and interruptions caused by improper installation of VSD/VFDs.

- The importance of correct VSD/VFD installation cannot be overemphasized, unfortunately, it's sometimes overlooked (for example enclosure protection class, EMC, Harmonic filtering and cable types etc.).
- If VSD/VFDs in your plant regularly trip and stop, it could be because of poor installation practices or intermittent power quality events that are detected by the VSD/VFD.
  - Most modern VSD/VFDs protect themselves and trip off-line when they detect abnormal conditions, such as earth faults and high VFD/VSD temperatures etc.

5. STOP SPILLS, BURSTS AND WATER HAMMER

Prevent its impact on pressurized systems, pipes, pumps, and valves.

- Shock waves are caused when there is a rapid change of water flow, which often occurs when valves are slammed closed or pumps accelerate rapidly.
- Water hammer can be extremely hard when pumps are started and stopped on the aging infrastructure in many municipalities.
  - It can cause leaks at multiple points in the system, cracked pipes, and water-main breaks, which can be hard to find and are very expensive to repair.
  - Additionally, the leaks can result in environmental spill issues and license/permit non-compliance.

6. PROTECT YOUR PUMPS FROM CAVITATION DAMAGE

Cavitation is one of the most troublesome issues that can occur in pumping systems.

- Cavitation is a big challenge for the water and wastewater industry because of the large number and scale of pumps used.
- The damaging effects of cavitation increase the risk of downtime and inevitably result in high maintenance costs.
- These costs go beyond the frequent replacement of the pump itself – sending a maintenance team with heavy lifting equipment to a remote pumping site, often at short notice, can cost several times the cost of the pump itself.

7. EXTEND SYSTEM LIFETIME BY IMPROVING PROCESS EFFICIENCY

Poor process efficiency can increase energy and chemical costs, while stressing equipment.

- Water and wastewater plants need to run without interruption and in the most efficient and environmentally conscious way. Regulatory compliance is the primary mission, and municipalities cannot jeopardize water quality standards or service levels.
- Lifecycle of pumps can be dramatically reduced when moving off the Best Efficiency Point (BEP) so it's important to review pumping systems to ensure they are running efficiently.
- Process optimization and energy savings opportunities are available within both water and wastewater plants regardless of treatment or flow capacity.

Critical assets in Water

Well planned and executed maintenance approaches are critical at a water treatment facility as poor maintenance can result in increased costs, serious damage to systems and financial losses. Common problems in water treatment can range from scaling or membrane fouling to instrumentation failure and/or mechanical failure. A robust maintenance approach can allow the site to stay at its best condition for longer.

1 GROUNDWATER ABSTRACTION/EXTRACTION

If you rely on a borehole water supply, then keeping it maintained is extremely important. With regular maintenance check-ups, you not only extend the working life of the borehole but also maintain its efficiency and yield.
Any time you open a well cap, you create the opportunity for bacteria and foreign objects to get into the water supply.
Inspect all parts of your borehole regularly, including the catchment area, to make sure there is no interference or damage.
Ideally, the water should be tested for bacteria, nitrates/nitrites and any contaminants of local concern. Other typical additional tests are those for iron, manganese, water hardness, sulfides, and other water constituents.
Water testing should also be carried out any time there is a change in the taste, odor, or appearance of the borehole water, or if a problem occurs such as a broken well cap or a new contamination source.

Site knowledge required to keep your process running smoothly:

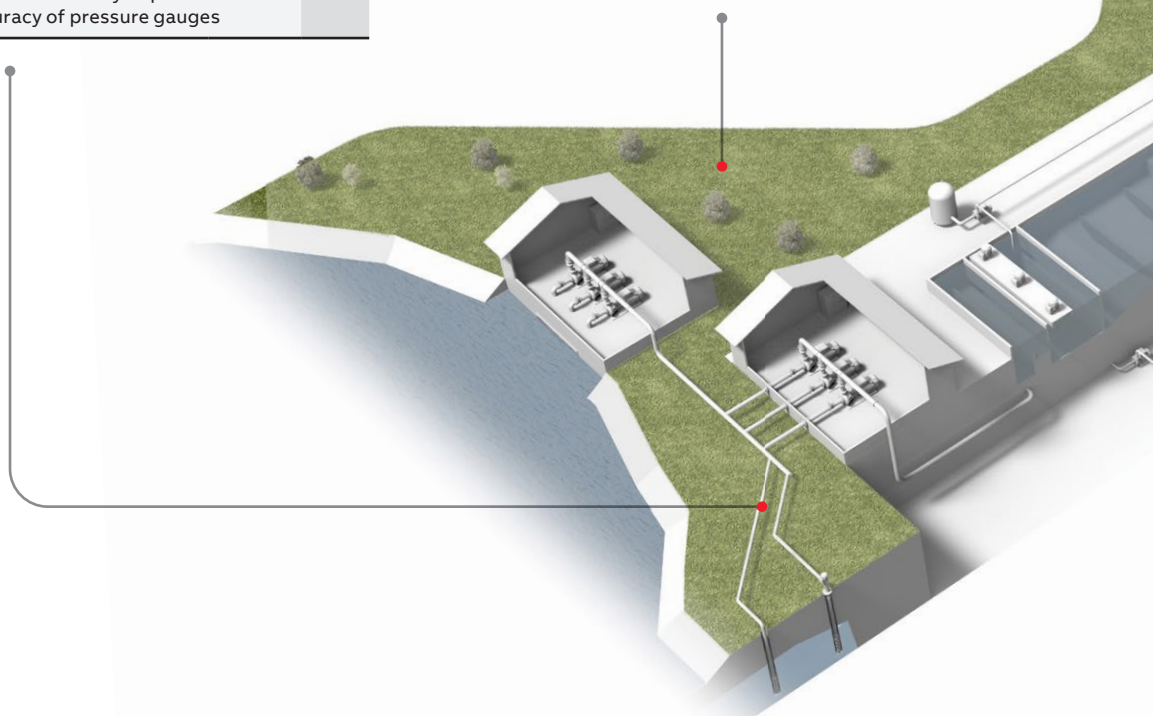
		Check ✓
Pump	• Average daily design flow • Maximum daily flow • Peak hour flow • Peak instantaneous flow	☐
Checks	• Conduct a complete system check and visual inspection of pipework and components • Verify connections are in place and no wires have been frayed or cut • Examine the functionality of pressure tank and the accuracy of pressure gauges	☐

2 RIVER ABSTRACTION

This process relies on hydraulic systems such as a weirs, boulder traps, gravel traps and pumps, motors and VSD/VFDs. All require regular attention and maintenance approaches to match their critical nature. Pump abstraction stations on rivers are susceptible to coarse sediment which can damage the pumps and cause sedimentation at the intakes. The site will have to ensure that floating debris doesn't block the pump intakes but also ensure that during low flow periods the pump is sufficiently submerged.

Site knowledge required to keep your process running smoothly:

		Check ✓
Pump	• Average daily design flow • Maximum daily flow • Peak hour flow • Peak instantaneous flow	☐
Flow	• Abstraction constraints – River flow levels requiring abstraction to cease (or reduce) if the river flow falls below this threshold	☐
Environmental	• Location and knowledge of sensitive species nearby • Information on other river users or protected rights nearby	☐



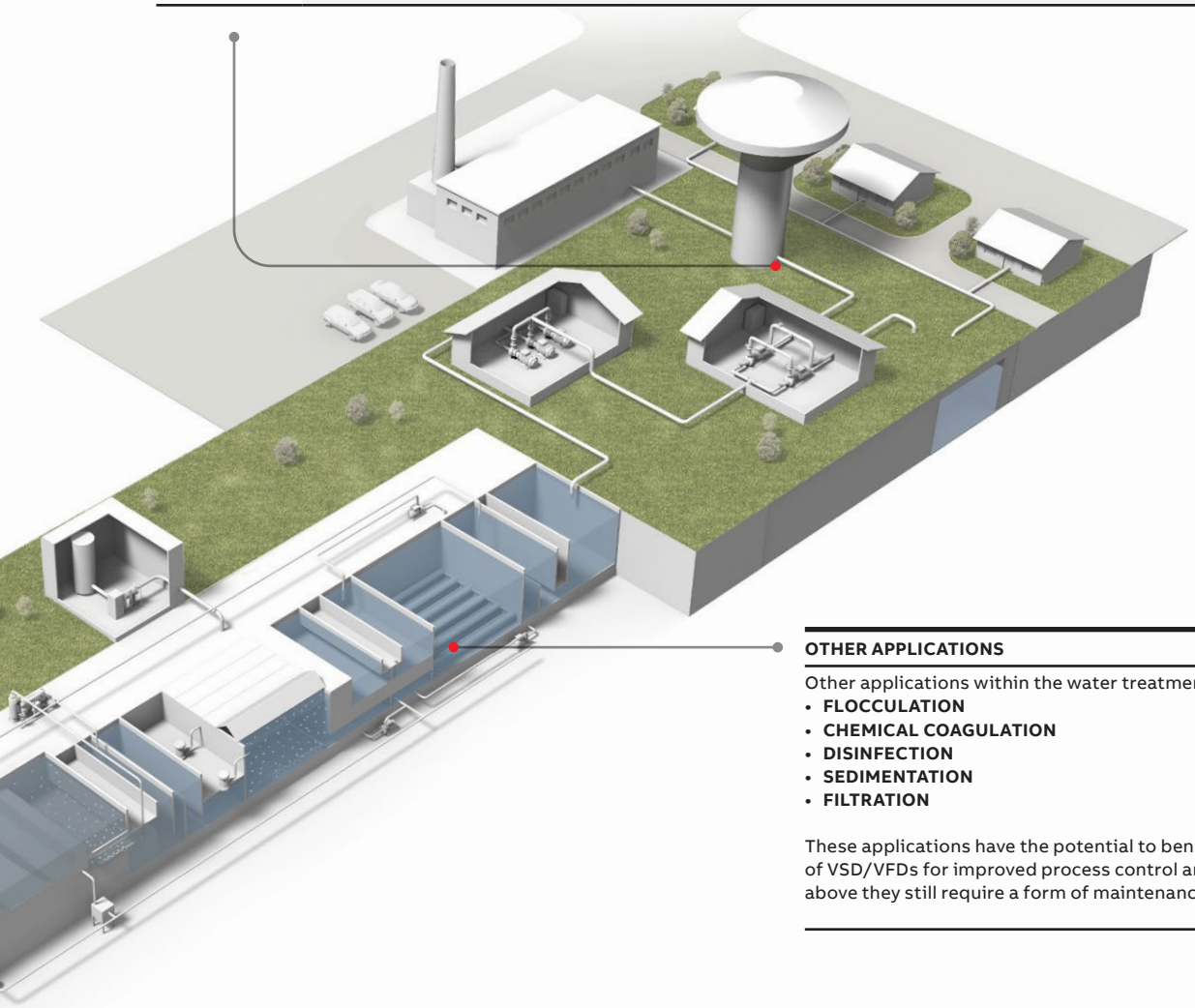
3 DISTRIBUTION NETWORK

Check ✓

A distribution network is the system of pipes, pumps and tanks that store and convey water following treatment to consumers' taps and faucets. The arrangement of distribution systems can be extremely variable, both in terms of their complexity and physical construction either due to age or geography, and can range from simple single length pipe runs to larger more complex systems that are difficult to trace. As such, the number of potential or actual hazards present in any distribution system can be numerous, diverse and variable. Maintenance of such a network can have a direct bearing on water quality if the system is not managed and/or maintained according to its layout and design.

Site knowledge required to keep your process running smoothly:

Pumps	• Average daily design flow • Maximum daily flow • Peak hour flow • Peak instantaneous flow • Record well pump running times and pump cycle starts	☐
Map	• Current finished water distribution system • Inventory list of property, service lines, equipment, tools and instruments; include manufacturer, model, serial number, and condition • Locations of spare parts (including pumps and backup power source) and vendor contact	☐
Location checks	• Sampling and monitoring records • Check water meter readings and record water production • Check chemical solution tanks and record amounts used • Check and record water levels in storage tanks • Check and record chlorine residual at the point of application • Check and record fluoride concentration in the distribution system • Check instrumentation for proper signal input/output	☐
Flow	• Flow-meters provide data on either entering or leaving water and notification of hidden leaks	☐



OTHER APPLICATIONS

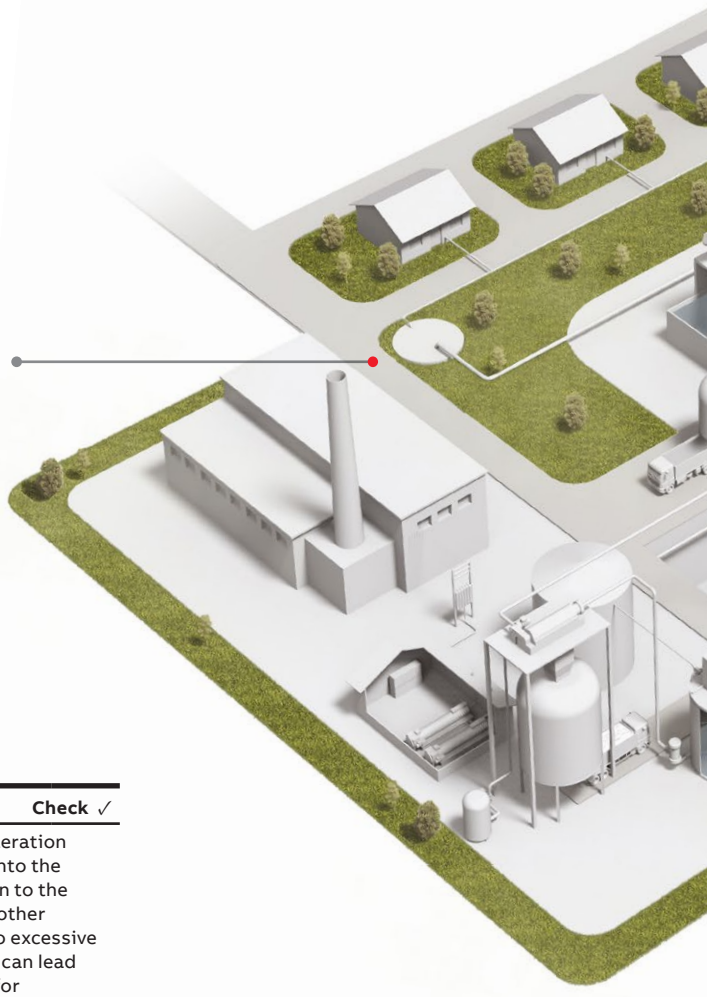
Other applications within the water treatment process include:

- **FLOCCULATION**
- **CHEMICAL COAGULATION**
- **DISINFECTION**
- **SEDIMENTATION**
- **FILTRATION**

These applications have the potential to benefit from the application of VSD/VFDs for improved process control and although not listed above they still require a form of maintenance.

Critical assets in Wastewater

In every stage of wastewater treatment there are threats to the resilience of a VSD/VFD, for example Hydrogen sulfide (H2S). H2S is a gas found in wastewater collection systems particularly ones with low flow-through velocities. Under anaerobic (septic) wastewater conditions, sulfides cannot be oxidized, and they combine with hydrogen to produce hydrogen sulfide gas. Although corrosion is most severe where the acid collects, it can be traced to VSD/VFD printed circuit boards (PCBs) and it will affect the PCBs if the PCBs are not conformally coated.



1 WET WELL / LIFT STATION

Check ✓

Typical maintenance issues at a wet well/ lift station can include blocked and clogged pumps leading to equipment failure and production downtime. Often design implications of oversized or undersized pumps, combined with limited working and expansion space, means unforeseen problems like flooding or odor problems make this an ideal area for a planned maintenance approach.

Site knowledge required to keep your process running smoothly:

Flow	• Average daily design flow • Maximum daily flow • Peak hour flow • Peak instantaneous flow • Domestic flow, industrial flow and commercial flow	☐
Characteristics	• Wastewater characterization (for nutrient removal systems)	☐
Pumps	• Type of pump, manufacturer and number of units • Number and location of pumping stations • Wet well dimensions and volumes • Level control system	☐

2 AERATION

Check ✓

The effects of poor maintenance with an aeration basin can lead to decreased aeration efficiency possibly due to sludge build up. This can impede the flow of oxygen into the wastewater, making the bubbles smaller and less capable of transferring oxygen to the water column. Sludge buildup on the diffusers also decreases their lifespan. Another consequence of poor maintenance is an increased back-pressure, which leads to excessive wear and tear on the blowers. In the worst-case scenario, a lack of maintenance can lead to breakdown emergencies. These situations may call for emergency overtime for employees and lead to high plant productivity losses and emergency repair costs.

Site knowledge required to keep your process running smoothly:

Pumps	• RAS (return activated sludge) withdrawal mechanism • RAS pump capacity • WAS (waste activated sludge) / scum pump capacity	☐
Tank	• Type of process and number of units • Tank dimensions and volume • Detention time • Tank pressure test history	☐
Capacity	• Blowers – HP/kW and capacity • Mechanical aerators – HP/ kW, oxygen transfer rate • Mechanical mixers – HP/ kW	☐

3 CLARIFIER

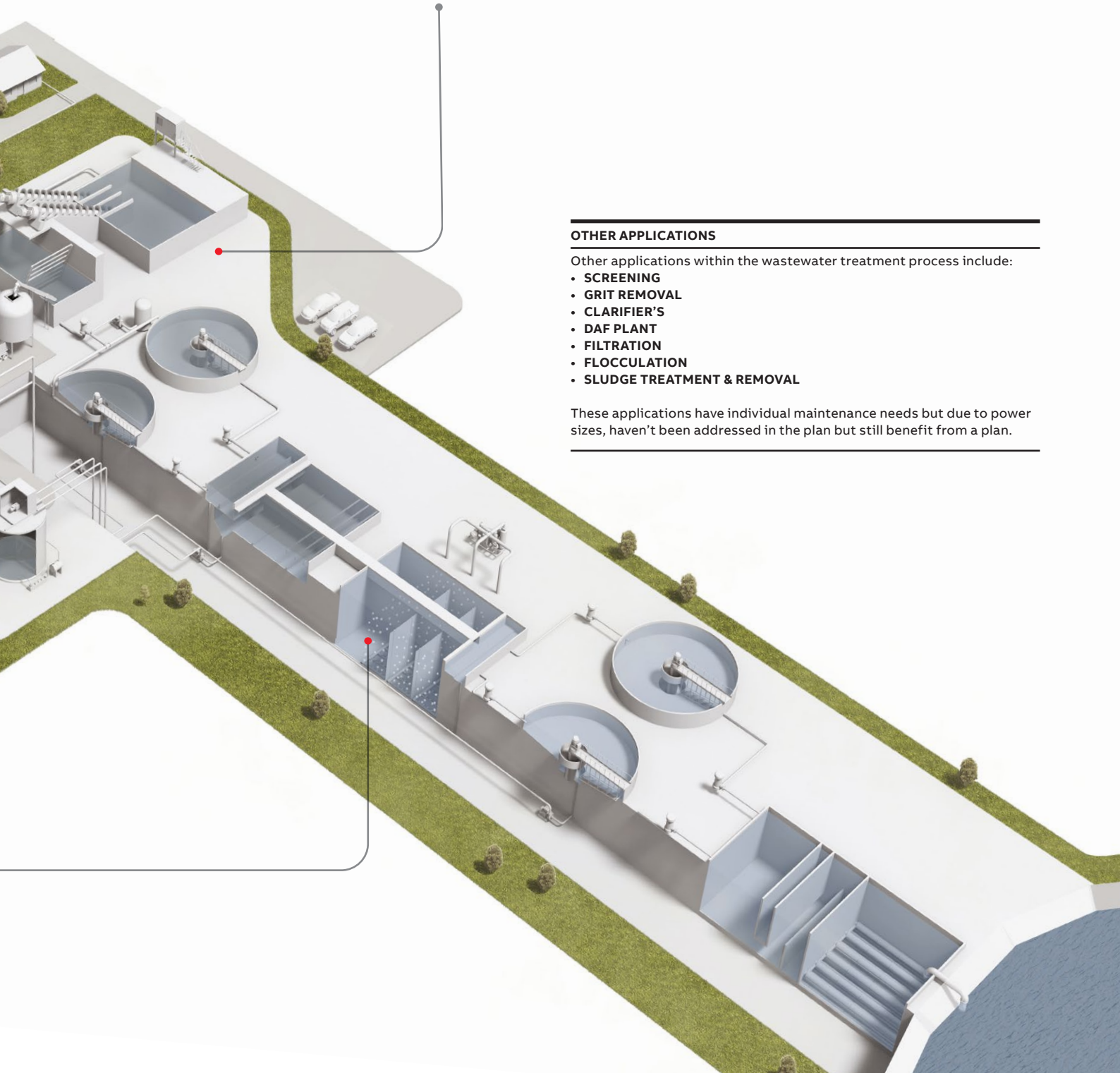
Check ✓

Settlement and clarifier tanks are by their nature susceptible to three main issues: corrosion, erosion and chemical exposure. Maintenance steps to reduce the impact of these issues can start by controlling their operation. VSD/VFDs can control the flow speed from inlet pipes to low, minimizing the amount of turbulence and disruption of the settled and coagulated solids. However, effective operation still cannot completely eliminate these problems and maintenance is required.

Whether these problems arise in the form of deteriorated concrete; eroded and corroded metal, or failed expansion joints, the appropriate solutions must be able to withstand the operating conditions and demonstrate long-term resistance to the aforementioned effects.

Site knowledge required to keep your process running smoothly:

Tank	• Tank dimensions and volume • Detention times	☐
Pump	• Sludge pump capacity, range of flow • Scum pump capacity, range of flow	☐
Flow	• Design surface overflow rate @ ADF (Average Daily Flow) and peak hour flow • Design weir overflow rate @ ADF and peak hour flow	☐
RAS Pump	• RAS withdrawal mechanism • RAS pump capacity, range of flow and flow measurement	☐



OTHER APPLICATIONS

Other applications within the wastewater treatment process include:

- **SCREENING**
- **GRIT REMOVAL**
- **CLARIFIER'S**
- **DAF PLANT**
- **FILTRATION**
- **FLOCCULATION**
- **SLUDGE TREATMENT & REMOVAL**

These applications have individual maintenance needs but due to power sizes, haven't been addressed in the plan but still benefit from a plan.

Fix on Failure?

A Fix on Failure or Corrective Maintenance strategy is based on the theory of restoring the function of a asset after an allowed failure. It is based on the assumption that the failure is acceptable due to it having a low risk economically with no significant impact on safety and the environment.

1 SPARES

Spares and staff on hand are a critical element of success to a "Fix on Failure" maintenance approach. Depending on the availability and locality of the asset that needs to be repaired/replaced, this approach is often used for applications that pose no safety risks and have a minimal effect on production and environment.

ABB Solutions
By involving ABB and our local VSD/VFD partners to provide life cycle service assessments that are based on both VSD/VFD and application knowledge enhanced reliability, the efficiency and predictability of ABB VSD/VFDs, many risks to a "Fix on Failure" approach can be minimised.

2 SAFETY

The "Fix on Failure" maintenance approach doesn't mean ignoring safety elements and good work practices. Understanding that power connections can loosen with repeated heating and cooling cycles and then in turn lead to VSD/VFD faults and failures is critical.

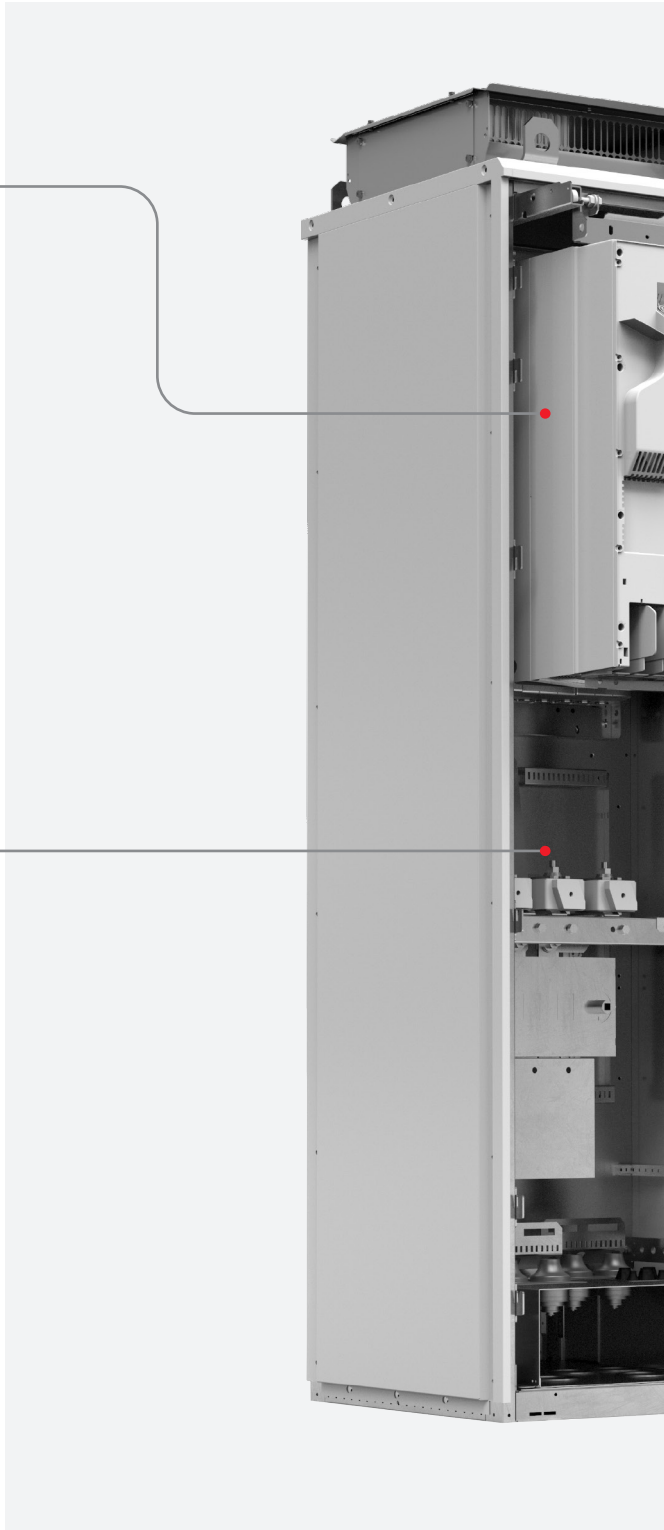
Cabinet mounted VSD/VFDs will require lockout/tag-out isolation procedures according to local rules and regulations to protect personnel and they should form the basis for any "Fix on Failure" procedures.

Even when turned off, a VSD/VFD can retain energy within the capacitors and can cause electrocution unless hardware manual recommendations are followed.

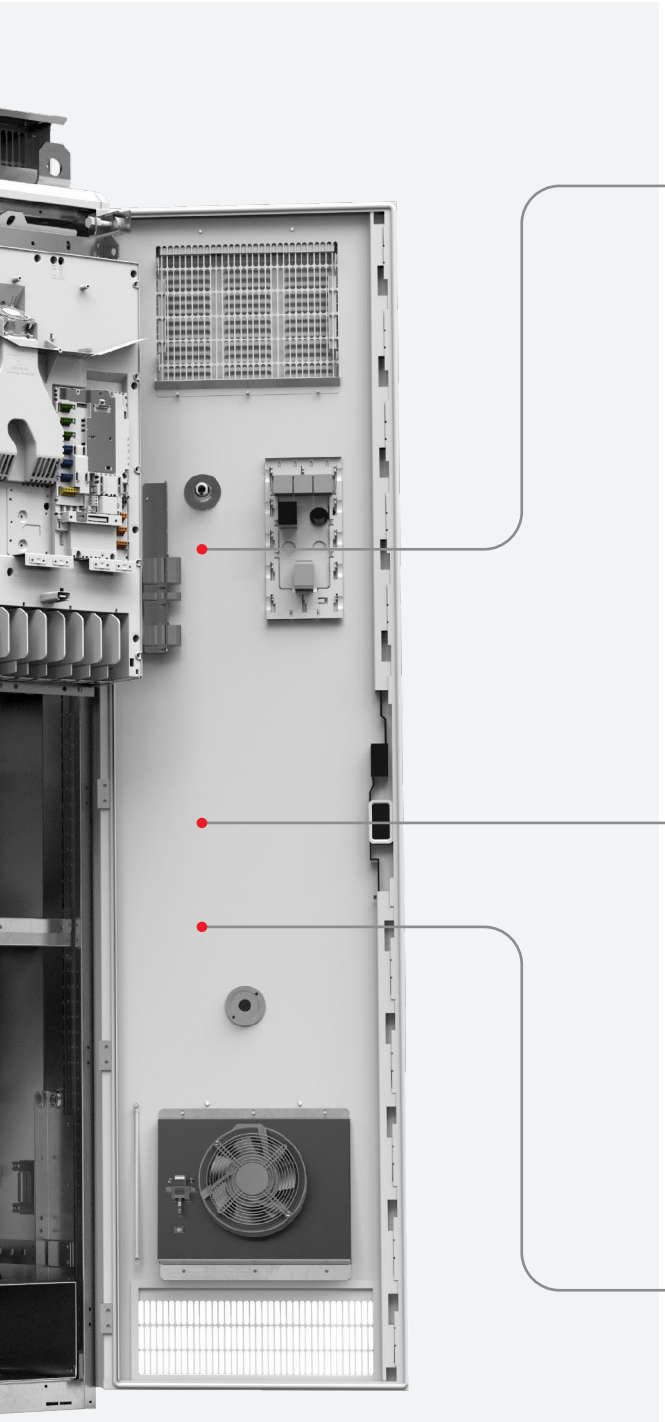
ABB Solutions
Local electrical safety rules and regulations (such as OSHA electrical and NFPA-70E arc flash in the US) are highly relevant when working on a VSD/VFD. Following the VSD/VFD manufacturer's safety guidelines, wearing the correct personal protection equipment (PPE) and always following lock out/tag out procedures will provide the start of good site practice with VSD/VFDs.

Detailed further inspections can also help to verify that all power connections meet the torque specifications of the VSD/VFDs. A trained maintenance professional may also use a thermal imaging camera to check the power wiring for hot spots and correct accordingly.

Safe Torque Off (STO) is a safety function available in ABB VSD/FDVFDs, which brings a motor's torque to zero, ensuring a safe and controlled stop. It is designed to meet safety standards and prevent unexpected start-ups, thereby enhancing the safety of personnel and equipment. STO is a fundamental safety function for drive-based functional safety, and it helps in reducing panel costs by eliminating the need for certain components such as contactors and panel wiring.



A common low maintenance strategy in the water industry due to most applications having redundant assets (duty/standby/assist), it works on the knowledge that assets are allowed to operate until they fail, at which point reactive maintenance is performed. However, a plan is required to be in place ahead of the failure, so that the asset can be fixed without potential major production and distribution issues.



3 TRAINING/QUALIFICATION

Consistent high temperatures or rapid heating/cooling cycles, can lead to permanent damage to your VSD/VFD's components. The hotter a VSD/VFD operates the shorter its useful life will be. Through dedicated VSD/VFD training an understanding can be built on the impact of dirty filters and the restriction of airflow.

ABB Solutions
Incorporating simple measures such as cleaning or replacing filters on a basis schedule with a visual inspection of the complete installed base will help to avoid heat stress on VSD/VFDs and could be combined to look for condensation, corrosion, dust, and foreign objects in the wrong places. All of this will help to reduce dust build-ups in fans and cooling plates/heatsinks (passive heat exchanger that transfers the heat generated by the VSD/VFD). Learning how and what to look for can be provided through a series of ABB VSD/VFD training courses.

4 REVIEW ASSET FAILURE IMPACT

Assigning critical ratings to assets based on their potential risks, such as economic, safety, and production impacts, is a key part of failure impact analysis.

Criticality analysis considers factors like VSD/VFD failure modes and their effects. Assets with a high probability of causing injury or severe operational interruption or license/permit issues if they fail are prioritized within this maintenance strategy, ensuring operational success.

ABB Solutions
ABB and its VSD/VFD partners can help in a criticality assessment, from explaining the different options for failure modes within an ABB VSD/VFD to providing mean time between failure analysis.

5 COMMISSIONING/START-UP

A professionally commissioned product ensures process reliability, safe operation and reduced unplanned downtime, using manufacturer/qualified expertise to review installation. Certified engineers adjust the VSD/VFD parameters to meet the precise demands of the application. Safety issues related to the application are taken into account. All start-up information with parameters are delivered to the customer and saved in a database.

ABB Solutions
ABB and its global network of approved partners provides trouble-free start-up and commissioning conducted by a network of factory-trained experts.

Preventative maintenance

Maintenance on your electrical equipment starts before powering them. VSD/VFDs can be found within a lot of water and wastewater applications for process control and/or energy saving. They can also be fitted for the reduction of maintenance, but they too have their own maintenance requirements.

1 VISUAL INSPECTION

Visual inspections looking for condensation, corrosion, dust, and foreign objects are the first step in preventative maintenance. A blocked heatsink or fan obstructions can prevent the VSD/VFDs from running cool and can lead to both short-term and long-term issues.

The VSD/VFD's heatsink fins can pick up dust from the cooling air, leading to over-temperature warnings and faults if the heatsink is not cleaned. So a visual inspection must include panel/enclosure inspection of air filters looking for dust build-up, gaskets and checking for deterioration.

ABB Solutions
Review maintenance intervals for fan replacement in average operation conditions. In addition, the ABB VSD/VFDs have a fan on-time counter which indicates the running time of the cooling fan. (Remember to reset any fan hours counter after a fan replacement).

The main VSD/VFD fans can be speed controlled, with the speed of the fan matching the VSD/VFD's cooling needs. This can increase the life span of the fan and potentially lead to some energy savings. When the VSD/VFD is stopped, the main fan runs at a low speed until the VSD/VFD cools down. Replacement fans are available from ABB. Use only specified spare parts.

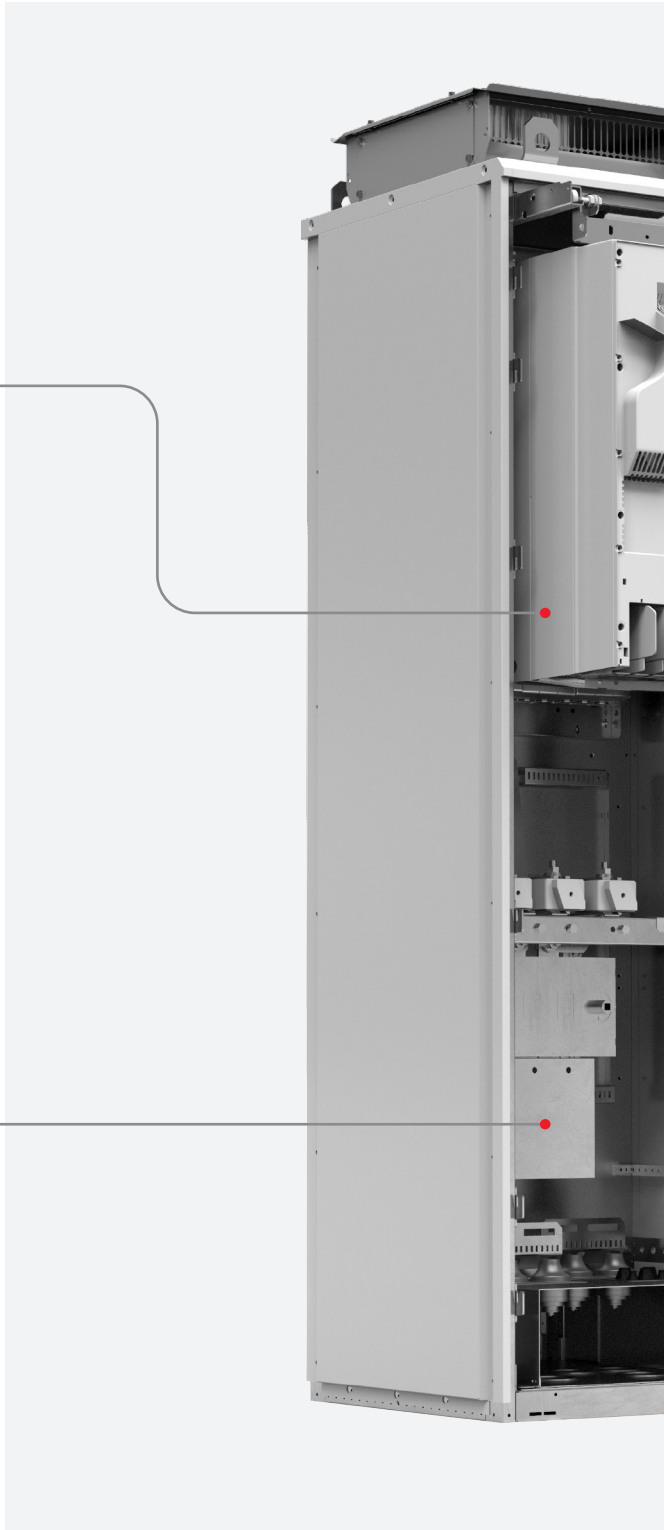
When cleaning the heatsink, use a vacuum cleaner with antistatic hose and nozzle. Using a normal vacuum cleaner creates static discharges which can damage circuit boards.

3 CHECKING POWER CONNECTIONS

Loose power connections can cause overheating and can lead to equipment failure and/or malfunction. Checking all terminals, bus bar, and motor terminal box connections (securely tightening to specified torque, if loose) must be a step in any preventative maintenance approach alongside replacing any parts or wiring that is damaged from overheating.

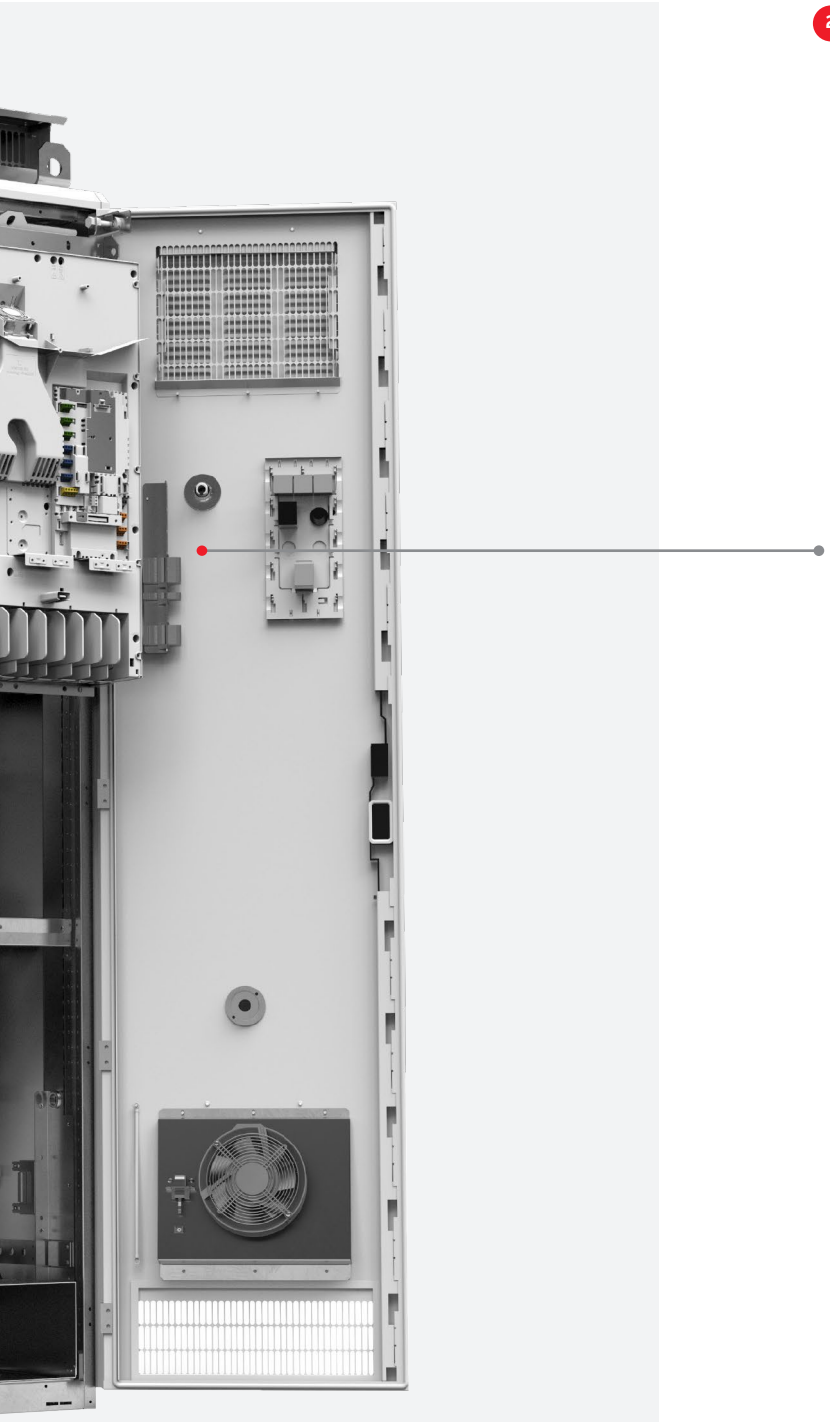
ABB Recommendations
Extreme caution is required when checking a VSD/VFD as the motor cable terminals of the VSD/VFD are at dangerous voltages when the input power is on, regardless of whether the motor is running or not. External wiring can supply dangerous voltages to the terminals of relay outputs.

Do not power up the VSD/VFD more than five times in ten minutes. Frequent power-ups can damage the charging circuit of the capacitors. Refer to the VSD/VFD troubleshooting guide for more information.



VSD/VFD preventive maintenance checks can involve as few as three steps:

- Visual inspection
- Verifying component life and reforming capacitors
- Checking power connections



2 VERIFYING COMPONENT LIFE AND "REFORMING" CAPACITORS

VSD/VFDs typically contain large DC capacitors as part of their construction. These capacitors are used as an energy source and for smoothing the DC voltage after the supply is rectified and converted into the "DC Bus".

The lifetime of an electrolytic capacitor is highly dependent on the application conditions and is affected by both electrical factors (voltage, ripple current and charging/discharging) and environmental factors (temperature, humidity, atmospheric pressure and vibrations).

In many applications, the lifetime of a VSD/VFD is directly linked to the lifetime of the electrolytic capacitors inside. Capacitor failure is usually followed by damage to the VSD/ VFD and an input cable fuse failure, or a fault trip.

If a VSD/VFD is stored, unpowered, for a period of months (typically 12 months and above but always check with vendor), the DC capacitors need to be "reformed" or slowly powered to operating voltage to ensure service lifetime.

ABB Solutions
As the lifespan of a VSD/VFD depends on the operating time, loading, and ambient temperature, their life can be prolonged by lowering the ambient temperature.

Contact ABB if capacitor failure is suspected as ABB authorised replacements and Service Engineers are available.

For information on reforming the capacitors, see Converter module capacitor reforming instructions (3BFE64059629 [English]).

Predictive maintenance

Digital technologies are designed to improve the performance, reliability and efficiency of all components within the powertrain: from VSD/VFDs and motors, to pumps, couplings & gearboxes and bearings. Data from your powertrain can be aggregated, stored and further accessed via the computing cloud. The ability to analyze this data reveals information on the status and condition of your equipment so that you can intelligently maintain and manage the performance of your powertrain.

Using the capabilities of ABB Ability™ digital technology, and creating a digital powertrain with a range of products and services such as ABB Smart Sensors, monitoring tools and an interactive portal, ABB's global network of Remote Expertise Centres (REC) staffed by asset experts, monitor customer data, analyse it and provide periodic reports to show equipment health and advise you on long term trends which could impact operations.

1 POWERTRAIN ANALYSIS

Intelligent analysis of the condition of your powertrain's components enables you to reduce downtime, be smart about maintenance scheduling and increase efficiency.

Data gathered from the VSD/VFD's inbuilt sensors and loggers together with that collected from ABB Ability™ Smart Sensors fitted to motors, bearings and pumps, can be aggregated, stored and further accessed via the computing cloud.

PUMP PROTECTION DATA	VSD/VFD	PUMP
Cavitation detection	×	×
Dry run detection	×	×
Max/min pressure detection	×	×
Flow detection	×	×
Pump clean detection	×	×

2 TURNING DATA INTO VALUABLE INFORMATION

The ability to gather and analyze data can reveal information on the status and condition of your equipment so that you can schedule service activities more effectively.

Reliability managers can quickly look at the need for upcoming maintenance, and gain an important insight to accomplish the goals of their maintenance strategies.

ABB SMART SENSOR CONDITION MONITORING PARAMETERS	VSD/VFD	FAN BLOWER	MOTOR	PUMP
Energy consumption	×			
Power	×		×	
Speed	×		×	
Torque	×		×	
Current	×		×	
Control board temperature	×			
Run time counters	×		×	×
Fan on time		×		
Ambient temperature	×	×	×	×
Annual aging statistics		×	×	

3 SAVE TIME AND MONEY ON MAINTENANCE

Data from the powertrain can be gathered and assessed, revealing information that helps you schedule maintenance intelligently and lower operating costs.

Predictive maintenance combines various sensor readings (condition monitoring), sometimes external data sources and performs powerful analytics on thousands of logged events/data (e.g., simulation, statistical analysis).

It can be enhanced further adding prescriptions to support the mitigation actions.

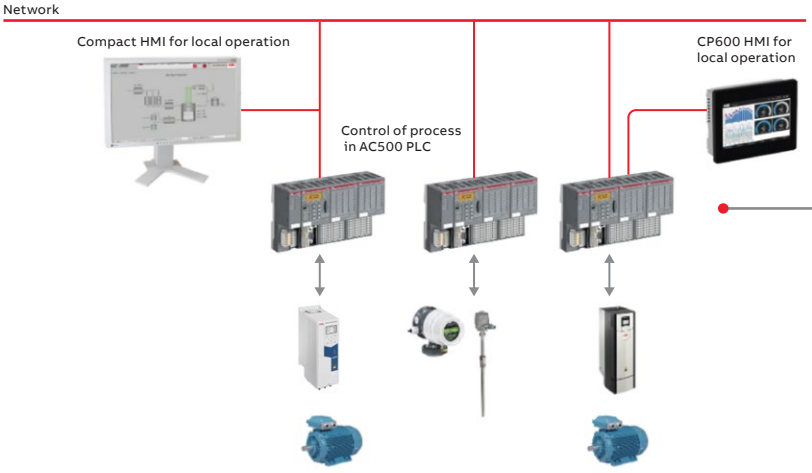
ABB SMART SENSOR POWERTRAIN HEALTH MONITORING PARAMETERS	VSD/VFD	BEARING	PUMP
Overall vibration	×	×	×
Skin temperature	×	×	×
Misalignment	×		×
Bearing condition	×	×	×
Mechanical imbalance		×	
Looseness (excessive movement in bearings)			×
Impeller problem			×

4 PROVIDES PEACE OF MIND

Automated reports and alerts allow you to monitor the performance of your powertrain remotely and even predict when components will need replacement depending on their specific environment.

See the health of your equipment in real time, and see what has an impact on the lifespan of your equipment on a daily basis

ABB SMART SENSOR MONITORING PARAMETERS	MOTOR	BEARING	PUMP
Vibration (radial)	×		×
Vibration (tangential)	×		×
Vibration (axial)	×		×
Speed	×		×
Operating time	×		×
Number of starts	×		×
Pump status			×
No. of starts between measurements	×		×
Motor supply frequency	×		
Output power	×		
Re-greasing advice	×		
Kurtosis (frequency curves)		×	
Skewness		×	
Formfactor		×	



5 INTEGRATE CONTROL SYSTEMS FOR HOLISTIC PICTURE

Condition monitoring systems (CMS), such as the AC500 PLC platform's FM502 module, help you to improve your operations resulting in greater efficiency and higher reliability while minimizing service and operating costs.

Dedicated stand-alone or control integrated CMS solutions with multiple Information technology and site connectivity options allow you to widen condition monitoring and fast protection (vibration, current, voltage, speed/encoder) and at the same time connect to SCADA and/or RTU systems.

The 7-step checklist

Use this checklist to ensure that your plant operates at its optimum level.

1. CHECK POWER QUALITY, HARMONICS AND GENERATORS		Check ✓
Installed loads	• List your largest installed non-linear loads at each facility/utility power connection: - VSD/VFDs (6-pulse) - VSD/VFDs (12 or 18-pulse) - Lighting (LED or fluorescent) - Power supplies, UPS batteries and computer/server equipment.	☐
Measure power quality and effects of poor utility supply	• Does poor power quality interrupt your operations? • Dips and swells – are you experiencing voltages higher or lower than the expected value? • Unbalanced phases – is there a variance between each phase current/voltage? • Transients – are electrical loads switching and causing effects such as lighting to flicker? • Harmonics – are you measuring voltage and current harmonic distortion?	☐
Utility billing	• Are you being penalized by your power utility for adversely affecting the supply grid?	☐
Process efficiency	• Do you have problems with pressure/flow/dosing process feedback measurements suffering from interference?	☐
Investigate failures that have no confirmed failure mode	• Overheating motors which are operating within their specified Volts/Amps/Hz limits. • Transformers overheating and failing. • Sensitive equipment operating erratically or failing. • Circuit breakers randomly tripping. • Fuses blowing for no reason.	☐
Review generator operation when running on standby power	• Are your generators running reliably at all times? - Check stable operation – are they struggling to maintain voltage? - Are they randomly tripping and interrupting operations? - Do they struggle with leading power factor when running?	☐
Estimate harmonic distortion	• ABB's VSD/VFD experts can help estimate harmonics created by existing VSD/VFD loads and make recommendations on mitigation and upgrades that will maintain pump/blower operations even if power quality is disturbed. • Upgrading to ABB's Ultra-Low Harmonic (ULH) technology will maintain IEEE519 at the VSD/VFD terminals with no external hardware.	☐
Plan mitigation	• Engage your ABB VSD/VFD expert to help plan technology upgrades and solutions that will prevent costly interruptions to supply and treatment.	☐

Causes of harmonic distortion

Harmonics are caused by non-linear loads. Non-linear loads do not draw current sinusoidally from the utility. Examples of non-linear loads include VSD/VFDs, EC motors, LED lighting, photocopiers, computers, uninterruptible power supplies, televisions, and the majority of electronics that include a power supply. The most significant causes of harmonics in the utilities are typically non-linear, three-phase power, and the higher the power, the bigger the harmonic currents in the network will be.

The most popular VSD/VFD design works by taking a three-phase AC line input voltage and rectifying the voltage through diodes. This turns the voltage into a smooth DC voltage across a bank of capacitors. The VSD/VFD then converts the DC back into an AC waveform for the motor in order to control the speed or torque and direction of the motor. The non-linear current is created by the three-phase AC-to-DC rectification.

Some of the problems that may be encountered are:

- Premature failure and reduced lifespan of devices often occurs when overheating due to harmonics is present, such as:
  - Overheating of transformers, cables, circuit breakers and fuses
  - Overheating of motors that are powered directly across the line
  - Nuisance trips of breakers and fuses due to the added heat and harmonic loading
- Unstable operation of backup generators
- Unstable operation of sensitive electronics that require a pure sinusoidal AC waveform
- Flickering lights Incorrect recording by devices that use the 50/60 Hz supply frequency for timing/counting etc.

Mitigation with Active Front End VSD/VFDs

In active front end (AFE) VSD/VFDs the rectifier consists of insulated gate bipolar transistor (IGBT) devices instead of diodes meaning the input terminal voltage and current can be controlled, mitigating the problems caused by harmonics and adding resilience to utility power voltage dips, sags and imbalances.

ABB ACQ580 AFE VSD/VFDs, also known as ULH (ultra-low harmonic) drives, have a current distortion between 3 percent and 5 percent. This compares to levels of 45 percent or higher for a standard diode front end VSD/VFD.

There is a water main*) break every two minutes and an estimated 6 billion gallons of treated water lost each day in the U.S. alone, enough to fill over 9,000 swimming pools.

[2021 Infrastructure report card https://infrastructurereportcard.org/] *) Includes pipes, pumps or other distribution network assets.

2. TAKE CARE OF AGING INFRASTRUCTURE		Check ✓
Review service life	• Audit the installation and service life of your assets - these are often varied depending upon type: - Pumps, pipes, motors and mechanical systems are typically 20-25 years; - Transformers, power distribution, switchgear is similar 20-25 years; - Power electronics, such as VSD/VFDs and other solid-state devices are shorter at 10-15 years.	☐
Reduce damage from water and pressure peaks	• Protect pumps, valves and pipes from pressure surges and peaks that cause older assets to break, burst or spill by applying ramped starts and stops and pressure/flow control, using VSD/VFDs.	☐
Protect pumps, valves and pipes	• Monitor pump performance to ensure it does not jam, run dry or over pressurize the network. • Apply ABB ACQ580 VSD/VFDs to your pump and blowers to leverage water specific functions designed to protect assets and extend usable service life. • Use built in diagnostic and trip logs to detect and mitigate motor, pump and blower performance conditions that may shorten expected service life.	☐
Protect transformers, power distribution, switchgear	• Check electrical equipment condition and history of trips and faults. • Ensure you are following manufacturers' recommended maintenance actions and timescales. • Monitor your power quality to make sure you are not being affected by hidden harmonics, transients, sags or dips in supply voltage.	☐
Protect VSD/VFD health	• Ensure VSD/VFDs are maintained to manufacturers' recommended service schedules. • Check cooling fan hours run, and heatsink condition. • Carefully clean any external cooling channels and enclosure filters. • Ensure operating temperature and humidity/condensation do not exceed specification. • Use built in diagnostic and trip logs to detect and mitigate conditions that may shorten expected service life.	☐
Audit VSD/VFD installed base	• Check when each VSD/VFD asset was installed and commissioned. • Review recommended spare/replacement parts lists to ensure uptime should a failure occur.	☐
Replaced outdated VSD/VFD technology	• Applying newer ABB VSD/VFD technologies to systems with aging infrastructure can reduce the costs of maintaining those failing systems. • Advancements in VSD/VFD internal health monitoring along with improved resilience to external environmental and utility power issues can greatly improve system reliability. • ABB's VSD/VFD migration programs leverage industry and application experts who can assess risk and help you identify and upgrade to new technology.	☐

Aging infrastructure can be a huge problem for water companies, municipalities and cities. Burst pipes, mechanical failures, water and wastewater leaks and spills, and electrical failures can all adversely affect water treatment processes, increasing costs and causing service interruptions.

Pumps, pipes, motors, and other mechanical systems typically have a service life of 20 to 25 years. Electrical equipment, like transformers, power distribution gear, motor control centers, and electrical wiring also have a long service life. Power electronics, like VSD/ VFDs and other solid-state devices, have a much shorter service life, typically 10 to 15 years.

Fitting VSDs/VFDs mitigate stress on an aging pump system infrastructure. In many water companies, where the piping system is old and decaying, a full voltage start of the pumps direct across the line could cause damage to pipes, pumps and motors, and increase expenditures required to maintain the system.

Applying newer ABB VSD/VFD technologies to systems with aging VSD/VFDs and controls can reduce the costs of maintaining those failing systems. Advancements in VSD/VFD internal health monitoring along with improved resilience to external environmental and utility power issues can greatly improve system reliability.

ABB leverages industry and application experts who can assess risk and help you identify and upgrade to new technology. This can often be done within the existing footprint of the currently installed equipment. Added features built into ABB's ACQ580 VSD/VFD can ensure your processes will be more resilient and efficient than before, protecting your infrastructure and saving money for future reinvestment into your processes.

3. REVIEW INSTALLATION, ENVIRONMENT AND PROTECTION		Check ✓
Safety	• Ensure that all power is removed and breakers/switches locked and tagged by qualified personnel before inspecting equipment. • Follow all local electrical safety and arc-flash protection legal requirements.	☐
Electrical distribution	• Ensure all electrical panels, enclosures and distribution boxes have the correct installation class for the environmental conditions (chemicals, water, etc.). • Check all protection devices are intact, where fitted. • Clean thoroughly, vacuum and perform full visual inspection of all LV switchboards. • Inspect control wiring, relays, power supply units, timers, etc. where applicable. • Inspect all panels for evidence of paint work damage and signs of corrosion.	☐
Cables & Wiring	• Rewiring old drives that have been used in a wastewater plant is typically not an easy task. • Ensure you have a good electrical connection if there is corrosion and material stuck to the terminals or oxidation. • Consider adding a communication module to an existing drive as an alternative. • Check and torque electrical connections to specified levels. • Visually inspect for signs of overheating or deterioration and corrosion.	☐
Electrical and electronic controls, VSD/VFDs	• Check the installation class for VSD/VFDs and controls: - IP20/21 or NEMA Type 1 for inside a protected enclosure; - IP54/55 or NEMA Tye 12 for wall-mounted units that require protection from dust/water; - IP66 or NEMA Type 4X for wall-mounted units located in outdoor locations exposed to harsh heat and water exposure conditions; - Ensure that VSD/VFDs are designed to meet C4 chemical protection standards if corrosive chemicals and/or gases are present (IEC/EN 60721-3-3:2019 and ISO 9223). • Redundant systems: - In the main redundancy is built into lot of the systems, but how often do you check if the redundancy setup actually works; - Does the generators start when the mains cut out, does the next pump start if the first fails or is blocked. What happens if the PLC communication is broken does it what is expected... - You might have all the systems, and perhaps the did work 2 years ago, but do they still work? (I know that a test today cannot say it will work tomorrow, but it is more likely if you test regularly). • Check for loose input power and output cables. • Clean control boards thoroughly, vacuum (using an antistatic hose and nozzle) and perform full visual inspection for overheating or deterioration and corrosion. • Inspect cooling heatsinks, remove dust and debris, and check cooling fan operation. • Replace cooling fans at manufacturer recommended intervals.	☐
Motors	• Ensure correct installation class for the environmental conditions (chemicals, water, etc.). • Clean motors that are affected by dust, solids other or debris – especially clearing cooling fins and check forced cooling fan for operation. • Check bearings for play and perform lubricating at recommended intervals with recommended grease only – replace if past manufacture recommended lifetime. • Check for loose motor cable connections, mounting, bolts shaft alignment etc.	☐
Environment	• Make sure you protect electronics with the correct electrical enclosures, environmentally controlled electrical rooms, conduit seals, and conformal coating (chemical and gas resistant) printed circuit boards. • Review ISO standard 9223:2012(EN) and ensure equipment meets C4 standards if installed in corrosive environments.	☐

Equipment condition

Visual inspections looking for condensation, corrosion, dust, and foreign objects are the first step in preventative maintenance.

Starting with the distribution/MCC panels, identifying problems and remediating early will reduce the chance of interruptions and damage. Loose cable(s) or corroded terminals can lead to overheating and failure.

Blocked heatsinks or fan obstructions can prevent VSD/VFDs from running cool and can lead to both short-term and long-term issues. The VSD/VFD's heatsink fins can pick up dust from the cooling air, leading to over-temperature warnings and faults if the heatsink is not cleaned.

So a visual inspection for the panel/enclosure must include inspection of air filters looking for dust build-up, and gaskets checking for deterioration.

Environment

The construction materials and process equipment that are used with treatment facilities must be able to withstand a wide range of extreme conditions. Water and wastewater treatment processes exhibit extremely corrosive liquids and gases during filtration, disinfection, and odor control with extreme temperatures, water ingress and high humidity.

The hostile environments in which these systems are commonly installed cause equipment to suffer from damage, degradation, and premature failure.

All of these things can create the need for expensive repairs and increase the risk of costly interruptions to key processes.

Prolonging these negative effects significantly decreases equipment life and can exponentially affect the cost of repair/replacement.

4. FIX OUTDATED INSTALLATION PRACTICES		Check ✓
Cooling requirements	• Check existing cooling provision, ambient temperature (through all seasons) and permissible temperature ranges for installed electrical equipment (a typical maximum is +40C/104F, but can vary depending on age and condition of equipment). • Verify airflow requirements for equipment. • Add extra forced cooling or air conditioning (for enclosures/panels). • Check solar heat loading for externally mounted equipment and fit shields if necessary. • Check motor cooling requirements, if running at reduced speed with VSD/VFDs, additional cooling may be required.	☐
Environmental conditions	• Make sure the installation class of installed equipment matches the humidity/temperature/chemical protection requirements. • If motors are susceptible to condensation, use motor heaters to make sure water does not form in windings (modern VSD/VFDs include this as a feature that does not require costly physical heaters that often require new motors).	☐
Power cabling and protection	• Review protection devices for electrical equipment, VSD/VFDs and motors and ensure they are the correct type/class and rating. • Make sure cable sizes and installation recommendations are followed to prevent nuisance tripping, damage or interference. • Review earthing/grounding and neutral connection of installations/motors and follow recommended practices (electrical equipment often includes components that must be configured for transformer/neutral connections etc.). • Make sure all equipment adheres to EMI/EMC regulations by following installation guidelines, modernizing filters and replacing incorrectly installed cables etc.	☐
Motors and motor cables	• Review motor cable length with control method manufacturer recommendation, making them as short as possible. • Extremely long cables may require additional filtering on VSD/VFD outputs to prevent tripping and/or cable and motor damage. • Review power cabling used for VSD/VFD. VSD/VFD cables that are not screened or not designed for higher voltages and switching frequencies can fail prematurely, or cause trips and interruptions to processes. • Check that motors are rated for VSD/VFD duty. Motors that are not designed for high peak to peak voltages may fail prematurely and require additional filtering to prevent this from happening. • Motor bearing protection – incorrectly grounded motors and cables can suffer from bearing erosion due to common mode voltages grounding via bearings. Ensure that grounded motor bearing are used, where possible, or add common mode chokes or filters to VSD/VFD output.	☐
Signal and control cables	• Make sure all control cables are routed away from power and motor cabling to prevent interference and potential failures in control systems. • Where analog or communications signals are used, ensure they are shielded or use the recommended cable specification for the signal type. • Use EMI/EMC filters where there is evidence of electrical interference in control systems.	☐

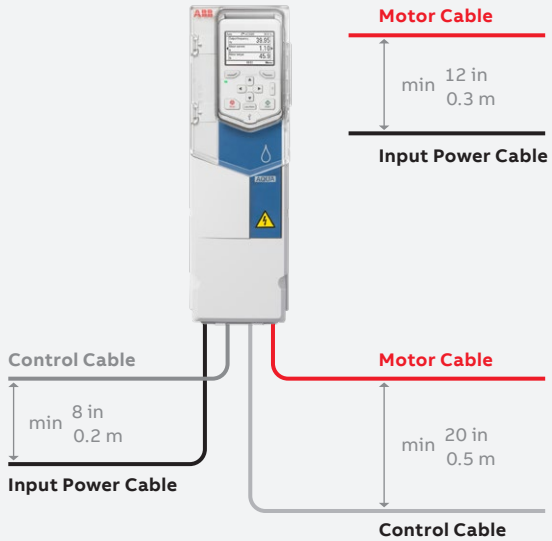
Prevent trips and interruptions caused by improper installations of VSD/VFDs

The importance of correct VSD/VFD installation cannot be overemphasized and yet unfortunately, it's sometimes overlooked. Most VSD/VFDs protect themselves and the trip off-line when they detect abnormal electrical conditions and high internal VSD/VFD temperatures.

If VSD/VFDs that control process flow, such as dissolved oxygen (DO), or wet well levels in your plant trip and become inoperative, it is likely because of poor installation practices or intermittent power quality events that are detected by the VSD/VFD.

In addition, motors windings and bearings can be affected and prematurely fail as a result of poor cabling, wiring, and grounding practices. Installations requiring long motor cables and non-VSD/VFD rated insulation-class motors may require additional external devices for successful operation.

Electrical connections, grounding, motor cable type and length, supply voltage, protective devices, and much more need to be taken into consideration to adhere to local guidelines and electrical standards/codes.



Variable Frequency Drive power and control cabling best practices – separation
Ensure installation is in accordance with national and regional codes, refer to installation manuals for additional cabling and conduit best practices.

—

ABB offers a specific application of its Drive System Consulting service, called Failure Mode and Effects Analysis (FMEA). FMEA is a specific method to measure and evaluate the robustness of a drive system, design, or process for potential failure mechanisms.

5. STOP SPILLS, BURSTS AND WATER HAMMER		Check ✓
Check your flow	• Use data from meters and flow measurement devices to discover potential leaks if you are experiencing water hammer. • If your application cannot easily be modernized with flow meters, consider installing a VSD/VFD with in-built software flow measurement and compare design specification with performance.	☐
Look for water hammer and related failures	• Audit your network: - Review maintenance and failure logs to find out where water hammer has been identified; - Note the scope, cost, and frequency of repairs, leaks or spills; - Focus on these areas first then approach the rest of your network where hammer may be occurring but has not been identified yet.	☐
Model networks	• Model and simulate additions or changes to networks to ensure that the possibility of water hammer is not unexpected. • Consider specifying VSD/VFDs to control pressure and mitigate modeled problems before the network is commissioned.	☐
Monitoring	• Implement real-time monitoring systems so pressure fluctuations in the distribution network trigger alarms when pressure variations exceed safe limits. • VSD/VFDs with in-built pressure protections are a low cost effective solution, and can be connected to SCADA/RTU to feed back alarms or instantaneous pressure reading.	☐
Review pump starting method	• Direct-on-line (DOL) or across-the-line starters create peaks in pressure as the starting torque ramps the pump up to speed quickly, causing pressure transients that risk water hammer (see Fig. 1). • Soft-starters improve the situation but can still cause peaks if not suited to the application. • VSD/VFDs can control the acceleration ramp time of the pump to prevent peaks, and can utilize pressure transducer feedback to ensure pressure is controlled accurately mitigating the risk of water hammer (see Fig. 2).	☐
Review pump stopping method	• DOL starters do not control motor/pump slow down, risking water hammer as the pressure drops and water flows back to fill air in pipes. • Non return/check valves and arrestors valves help mitigate but water hammer or pressure transients are still possible. • VSD/VFDs can control the deceleration ramp time of the pump to reduce pressure and flow in a controlled manager to prevent hammer from occurring.	☐
Control pressure with VSD/VFD	• VSD/VFDs can be used to accurately control pressure and flow, preventing transients. • The controls can also monitor and warn before issues cause interruptions. • Typical benefits of VSD/VFD monitoring: - Motor overload protection to detect bursts; - Undercurrent monitoring to detect blocked pipes or low flow; - Instantaneous over-current protection to prevent damage due to debris or damage from objects or failed assets; - Resonance control feature that allows the VSD/VFD to skip resonance in the pump that can cause pressure surges or instability.	☐
Pump protections in VSD/VFD	• Custom water and pump features in the ABB ACQ580 VSD/VFD can further enhance analysis of potential problems with assets: - Anti-cavitation function slows down the pump speed or stops the pump when damaging cavitation occurs; - Dry run protection prevents the pump from running dry; - Pressure protections help to protect the pump and the system in case of a blockage or rupture in the pipeline; - Pump cleaning keeps the impeller of the pump clean by running a sequence of aggressive ramps between configurable pump speeds.	☐

Like any other natural resource, water must be managed responsibly. One area where water is clearly wasted is “nonrevenue” water, which is lost due to leaks in pipes and joints before it reaches the user. So, you have wasted money and time to process a product that will never generate any revenue.

Water loss can be due to slow, long-term leaks or sudden large-scale breaks. They can occur in water pipes, joints, fittings and overflow service reservoirs. And the causes can vary widely: pressure fluctuations, corrosion, root penetration, thermal expansion and contraction, erosion, and changes in soil characteristics can all result in water loss. For most people, breaks in large water mains are perhaps the most obvious example of water loss, but even small leaks that go undetected can result in the loss of thousands of liters/gallons of water over time.

The impact of non-revenue water can be huge. Each liter/gallon lost must be replaced with an additional liter/gallon, requiring extra costs for processing, energy, labor, chemicals, etc. With leakage losses for some municipal water networks estimated as high as 40% of their total water flow, the resulting inefficiencies can have a massive dual-effect impact on operating margins in terms of higher costs and lower revenues.

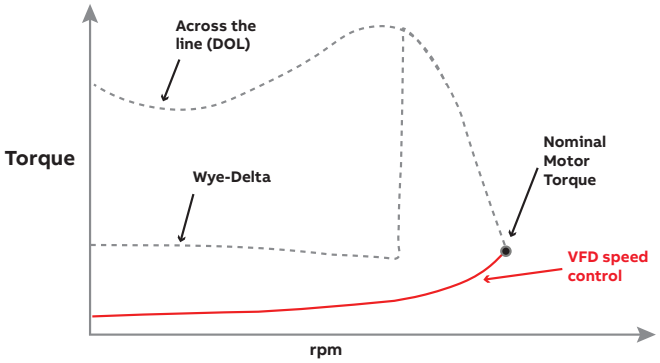
Additionally, water leaks can negatively influence the environment by eroding soil, creating sink holes, and damaging roads. Similarly, wastewater can back-up into basements, contaminate streams, lakes, and oceans, and result in expensive environmental cleanup and perhaps massive fines.

Our Trusted Advisor will investigate your leakage problems and, based on the findings and their expert opinion, suggest ways to mitigate leaks and lower your costs.

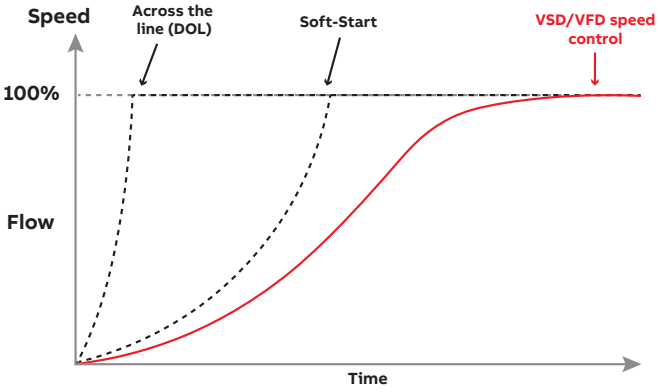
—

Up to 50% savings in maintenance costs by using VSD/VFDs to reduce water leakage from hammer and infrastructure damage.

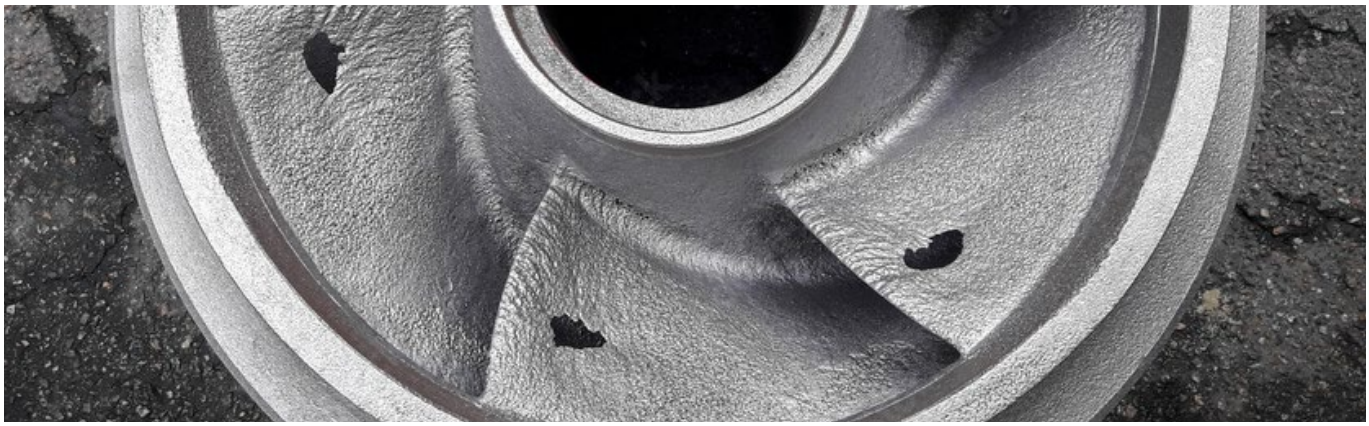
new.abb.com/drives/trusted-advisor/find-water-leaks



—
Figure 1
Traditional motor starting methods can cause peaks in motor torque and pressure transients, that do not occur when using VSD/VFDs.



—
Figure 2
Controlling flow using a VSD/VFD allows you to avoid the fast ramps and transients often associated with traditional motor starting methods.



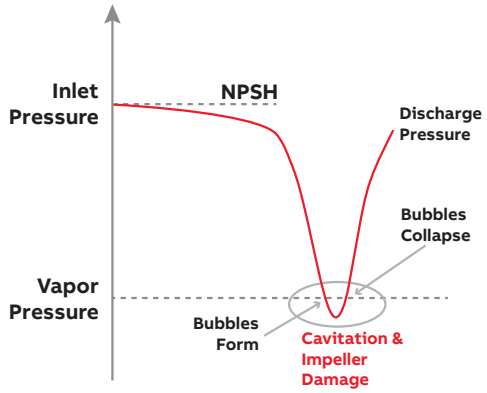
6. PROTECT YOUR PUMPS FROM CAVITATION DAMAGE		Check ✓
Look for the effects of cavitation	• Noise: Are your pumps noisy? Listen for crackling, bubbling sounds, or the impression that something is rattling around the pump impeller. • Note if there has been a reported decrease in pressure or flow with no changes in your process. • Vibration and seal damage: cavitation can cause vibration issues that can then result in damage to seals or bearing where leaks sometimes occur. • Impeller damage or failure: look for pitting on the impeller caused by bubble implosions. • Power consumption change: - Loss of efficiency in a damaged impeller can show itself by an increase in power required to maintain flow/pressure in a closed loop system; - But the power will drop in open loop running fixed speed due to lower efficiency.	☐
Look for the causes	• Net Positive Suction Head cavitation – if the pressure at the pump inlet falls below the vapor pressure of the water being pumped, cavitation can occur. • Turbulence and vortexes – if pipes, elbows and fittings are too small for the system, they may introduce turbulence that can cause cavitation. • Other problems than can affect pump performance: - Outlet restrictions – if valves or other obstructions prevent pumping, water can recirculate within the impeller and cause high pressures that damage seals; - Air in the system – faulty pipes, elbows or other fittings on the inlet to the pump can draw in air and further reduce the efficiency of the system.	☐
Preventative measures	• Review pump curves against operational conditions to ensure they are within design parameters. • Fit booster pumps if inlet pressure cannot be maintained. • Evaluate pipework and elbows to ensure restrictions and bends are minimized. • Use the VSD/VFD speed control instead of valves and restrictions to control pressure/flow. • Maintain infrastructure to ensure no air is drawn into pump network.	☐
VSD/VFD cavitation detection and control (Anti-cavitation)	• The ACQ580 VSD/VFD monitors the motor torque ripple and requires no costly external sensors to detect the start of cavitation. • When detected, the pump speed is automatically reduced to prevent ongoing cavitation. • Depending on user preferences, the VSD/VFD can attempt to return to set speed, warn that cavitation has occurred, or stop should the problem become continuous.	☐
Other detection methods	• Listen to your pumps – fit specialist external equipment and sensors to detect the noise made by cavitating bubbles. • Fit external vibration sensors to detect collapsing bubbles and the effect on the impeller.	☐

Cavitation is a destructive force that seriously affects pump operation and lifespan. Insufficient Net Positive Suction Head in the pump inlet causes air bubbles due to local changes in the liquid pressure inside the pump and turns the liquid into vapor.

The subsequent rapid implosions and shock waves can cause serious mechanical damage to the pump's impellers and seals. Pump performance and efficiency also decreases leading to higher costs and eventually to pump failure.

Cavitation is a major challenge for the water and wastewater industry, increasing the risk of downtime and inevitably results in high maintenance costs and lower pumping efficiency.

These costs go beyond the replacement of the pump itself. Sending a maintenance team with heavy lifting equipment to a remote pumping site, often at short notice, can cost several times the cost of the pump itself.



The ability to detect cavitation as it's happening can prevent Interruptions and costly damage.

7. EXTEND SYSTEM LIFETIME BY IMPROVING PROCESS EFFICIENCY		Check ✓
Pressure control	• Where water networks are pressurized to ensure customers receive a sufficient flow of water, if the pressure gets too high due to water hammer, pipes can become damaged, causing leaks or bursts. Pressure can be optimized to minimize damage to pipes while ensuring customer demand is met with the control of a VSD/VFD. • A drop in pressure could mean that there is a leak in the network. • In-line pressure sensors transmit back to a central system for analysis and allow for changes in the network pressure in real time.	☐
Flow measurement	• Flow-meters provide data on either entering or leaving water sometimes localized within a district metered area (DMA) enabling identification of leaks and providing data that can be used for process improvements with VSD/VFDs. • Measuring the minimum night flow (MNF) allows better insights into leakage rates with DMA and allows identification of hidden leaks.	☐
Energy Efficiency	• Optimization of water network pump operation has the potential for operational and energy cost savings reductions alongside the reduction in hammer and pressure surges. • Improvements can be made in several ways. Optimizing automation systems, applying VSD/VFDs to control pressure and flow to demand, improving equipment efficiency, and applying precise control can all have an impact. • ABB can evaluate your facility to help you identify where and how you can achieve the best return on investment. These evaluations use your application data and energy costs to calculate payback. • Often the top applications for payback can offer a return on investment (ROI) as short as 24 months. Improving processes and incorporating VSD/VFDs can often give you the most dramatic process improvements and energy savings.	☐
Asset optimization	• Producing the best possible outcome from a treatment process involves exploiting the accurate, real-time data provided by in-line instrumentation. • Look for system solutions that offer maximum flexibility for the nature of the process, the work environment, and the people who need to monitor and interact with it.	
Asset Management	• Once control systems are fine-tuned to optimize process efficiency, it pays to focus attention on higher-level analytics to derive maximum value from plant infrastructure. • This means monitoring and managing equipment for long, trouble-free performance life, a high ROI and lowest total cost of ownership (TCO).	☐
Effective Chemical Use	• Software for distributed control and asset management can react to the slightest changes in water chemistries, as well as project future trends in equipment life, to guide optimal decisionmaking for overall best control and operating efficiency.	☐

—

There are several technologies available that can help water and wastewater plants improve their process and energy efficiency. The most notable of which are VSD/VFDs for savings and control and upgrading motors to more efficient models.

Process changes with data linked to the VSD/VFD control
Protecting the environment and conserving water resources is a global responsibility. In many regions, water shortages have led to a need to control and report the amount of water lost through distribution. Smart flow-meters placed in the network provide utilities with high-resolution data that can be analyzed to give information about the location and approximate severity of leaks.

This enables appropriate actions from operators such as reducing flow and pressure. Through a full automation approach, two big advantages can be gained over conventional techniques. First, real-time analysis can lead to early warnings and predications often meaning that leaks are fixed more quickly, minimizing disruption to customers. Second, manually surveying networks and listening for leaks involves a high labour cost that can be eliminated.

Global support available locally
At your service

Over **140** years of servicing our customers

Service in more than **70** countries

Over **1,200** field service engineers

~ 50 service workshops

~ 600 service partners

—

Whether it's the extension of the life cycle of a product or enhanced powertrain performance, energy efficiency or maximizing success through digitalization, our local teams of experts are here to provide a tailored, holistic approach. Tell us what a successful future looks like for you and we will work in partnership to achieve your vision.

solutions.abb/motionservices

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.

Previous knowledge
There are no prerequisites for these training topics. However, it would be helpful if the student had a basic understanding of water industry applications.

Objectives
To alert operations managers of the merits of maintaining the VSDs/VFDs that improve their process efficiency, protect their assets, 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 served using online conferencing software.

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

Bespoke training courses
Contact your local ABB office for any training opportunities tailored to your custom needs.

Lunch 'n' Learn topics	Duration	Reference	Check ✓
Drives Basics – Theory	15 mins	EN154	☐
Pumps Basics – Theory	15 mins	EN155	☐
Best Efficiency Point Pumping	20 mins	EN156	☐
Wastewater – Wet Wells – Understanding the application	20 mins	EN157	☐
Wastewater – Headworks – Understanding the application	20 mins	EN158	☐
Wastewater – Aeration – Understanding the application through energy case studies	20 mins	EN159	☐
Clean water – River Abstraction – Understanding the application through energy case studies	20 mins	EN160	☐
Clean water – Groundwater abstraction – Understanding the application through energy case studies	20 mins	EN161	☐
Clean water – Distribution network – Understanding the application through energy case studies	20 mins	EN162	☐
Clean water – Reservoir – Understanding the application through energy case studies	20 mins	EN163	☐

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

new.abb.com/drives
new.abb.com/drives/segments/water-and-wastewater
new.abb.com/motors-generators
new.abb.com/service/motion

Learn more from the Drives website.

Learn more from the Drives and PLCs for water and wastewater website.

Learn more from the ACQ580 drives for water and wastewater website.

Learn more from the Motors and Generators website.

3AXD50001175665 REV A 26.8.2024