xylem
Let's Solve Water

Installation, Operation, and Maintenance Manual

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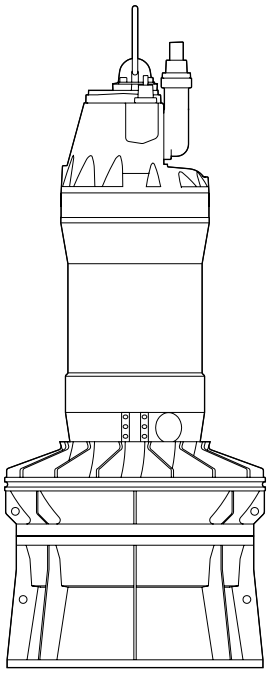


E7556

FLYGT
a xylem brand

Table of Contents

1 Introduction and Safety

1.1 Introduction

Purpose of the manual

The purpose of this manual is to provide the necessary information for working with the unit. Read this manual carefully before starting work.

Read and keep the manual

Save this manual for future reference, and keep it readily available at the location of the unit.

Intended use

WARNING:

Operating, installing, or maintaining the unit in any way that is not covered in this manual could cause death, serious personal injury, or damage to the equipment and the surroundings. This includes any modification to the equipment or use of parts not provided by Xylem. If there is a question regarding the intended use of the equipment, please contact a Xylem representative before proceeding.

Other manuals

See also the safety requirements and information in the original manufacturer's manuals for any other equipment furnished separately for use in this system.

1.2 Safety terminology and symbols

About safety messages

It is extremely important that you read, understand, and follow the safety messages and regulations carefully before handling the product. They are published to help prevent these hazards:

- Personal accidents and health problems
- Damage to the product and its surroundings
- Product malfunction

Hazard levels

Hazard level	Indication
 **DANGER:**	A hazardous situation which, if not avoided, will result in death or serious injury
 **WARNING:**	A hazardous situation which, if not avoided, could result in death or serious injury
 **CAUTION:**	A hazardous situation which, if not avoided, could result in minor or moderate injury
NOTICE:	Notices are used when there is a risk of equipment damage or decreased performance, but not personal injury.

Special symbols

Some hazard categories have specific symbols, as shown in the following table.

Electrical hazard	Magnetic fields hazard
 Electrical Hazard:	 CAUTION:

1.3 User safety

All regulations, codes, and health and safety directives must be observed.

The site

- Observe lockout/tagout procedures before starting work on the product, such as transportation, installation, maintenance, or service.
- Pay attention to the risks presented by gas and vapors in the work area.
- Always be aware of the area surrounding the equipment, and any hazards posed by the site or nearby equipment.

Qualified personnel

This product must be installed, operated, and maintained by qualified personnel only.

Protective equipment and safety devices

- Use personal protective equipment as needed. Examples of personal protective equipment include, but are not limited to, hard hats, safety goggles, protective gloves and shoes, and breathing equipment.
- Make sure that all safety features on the product are functioning and in use at all times when the unit is being operated.

1.4 Wash the skin and eyes

Follow these procedures for chemicals or hazardous fluids that have come into contact with your eyes or your skin:

Condition	Action
Chemicals or hazardous fluids in eyes	1. Hold your eyelids apart forcibly with your fingers. 2. Rinse the eyes with eyewash or running water for at least 15 minutes. 3. Seek medical attention.
Chemicals or hazardous fluids on skin	1. Remove contaminated clothing. 2. Wash the skin with soap and water for at least 1 minute. 3. Seek medical attention, if necessary.

1.5 Protecting the environment

Emissions and waste disposal

Observe the local regulations and codes regarding:

- Reporting of emissions to the appropriate authorities
- Sorting, recycling and disposal of solid or liquid waste
- Clean-up of spills

Exceptional sites

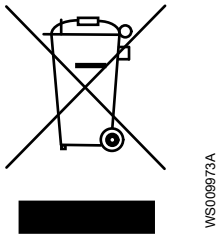
CAUTION: Radiation Hazard

Do NOT send the product to Xylem if it has been exposed to nuclear radiation, unless Xylem has been informed and appropriate actions have been agreed upon.

1.6 End of life product disposal

Handle and dispose of all waste in compliance with local laws and regulations.

Correct disposal of this product — WEEE Directive on waste electrical and electronic equipment



This marking on the product, accessories or literature indicates that the product should not be disposed of with other waste at the end of its working life.

To prevent possible harm to the environment or human health from uncontrolled waste disposal, please separate these items from other types of waste and recycle them responsibly to promote the sustainable reuse of material resources.

Waste from electrical and electronic equipment can be returned to the producer or distributor.

1.7 Spare parts

CAUTION:

Only use the manufacturer’s original spare parts to replace any worn or faulty components. The use of unsuitable spare parts may cause malfunctions, damage, and injuries as well as void the warranty.

1.8 Warranty

For information about warranty, see the sales contract.

2 Transportation and Storage

2.1 Examine the delivery

2.1.1 Examine the package

1. Examine the package for damaged or missing items upon delivery.
2. Record any damaged or missing items on the receipt and freight bill.
3. If anything is out of order, then file a claim with the shipping company.

   If the product has been picked up at a distributor, make a claim directly to the distributor.

2.1.2 Examine the unit

1. Remove packing materials from the product.

   Dispose of all packing materials in accordance with local regulations.
2. To determine whether any parts have been damaged or are missing, examine the product.
3. If applicable, unfasten the product by removing any screws, bolts, or straps.

   Use care around nails and straps.
4. If there is any issue, then contact a sales representative.

2.2 Transportation guidelines

2.2.1 Precautions

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.

Delivery units

The hydroturbine is delivered from the factory in one or two units, depending upon configuration.

Unit	Transportation unit	Delivery position
Hydroturbine without gearbox	Complete hydroturbine: assembled generator unit and turbine unit	Horizontal
Hydroturbine with gearbox	Turbine unit and gearbox	Vertical
	Generator unit	Horizontal

Make sure that the unit cannot roll or fall over and injure people or damage property.

Hydroturbines without gearbox

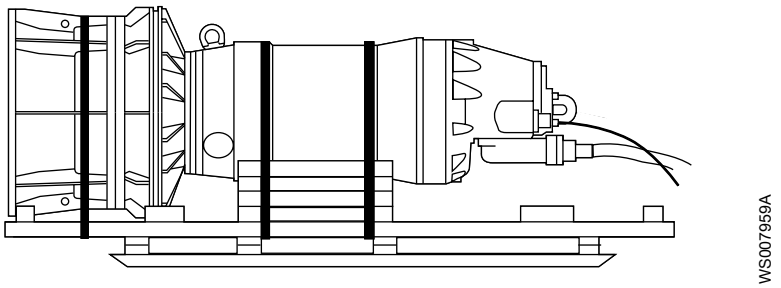


Figure 1: Direct-driven hydroturbine (generic unit shown)

Hydroturbines with gearbox

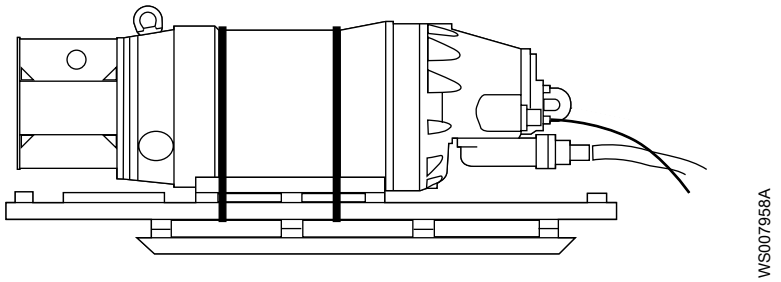


Figure 2: Generator unit (generic unit shown)

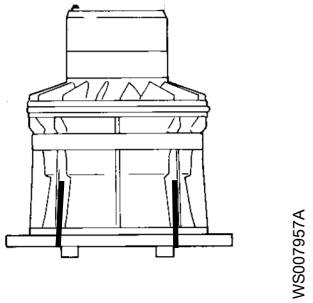


Figure 3: Turbine unit and gearbox

2.3 Lifting

Always inspect the lifting equipment and tackle before starting any work.

WARNING: Crush Hazard

Always lift the unit by its designated lifting points.
Use suitable lifting equipment and ensure that the product is properly harnessed.
Wear personal protective equipment.
Stay clear of cables and suspended loads.

NOTICE:

Never lift the unit by its cables or hose.

Lifting equipment

Lifting equipment is always required to handle the unit. The lifting equipment must fulfill the following requirements:

- The minimum height between the lifting hook and the floor must be sufficient to lift the unit. Contact a Xylem representative for more information.
- The lifting equipment must be able to hoist the unit straight up and down, preferably without the need for resetting the lifting hook.
- The lifting equipment must be correctly anchored and in good condition.
- The lifting equipment must support the weight of the entire assembly. Only authorized personnel may use the lifting equipment.
- Two sets of lifting equipment must be used to lift the unit for repair work.
- The lifting equipment must be dimensioned to lift the unit with any remaining pumped media in it.
- The lifting equipment must not be oversized.

CAUTION: Crush Hazard

Improperly-dimensioned lifting equipment can lead to injury. A site-specific risk analysis must be done.

2.3.1 Lifting link placement for vertical lifting

Use the following lifting link configurations to lift the unit in the vertical position.

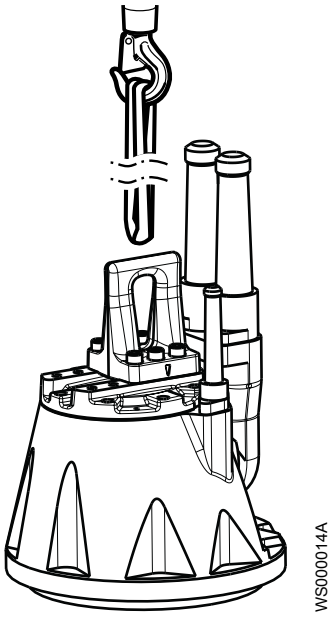


Figure 4: Generators 905–998

For 905–998 generators, the lifting link must be positioned so that the complete unit hangs forward with an incline of 0–2° in relation to the vertical axis.

2.4 Lift the direct-driven hydroturbine and remove the transport pallet

WARNING: Crush Hazard

Always lift the unit by its designated lifting points.
Use suitable lifting equipment and ensure that the product is properly harnessed.
Wear personal protective equipment.
Stay clear of cables and suspended loads.

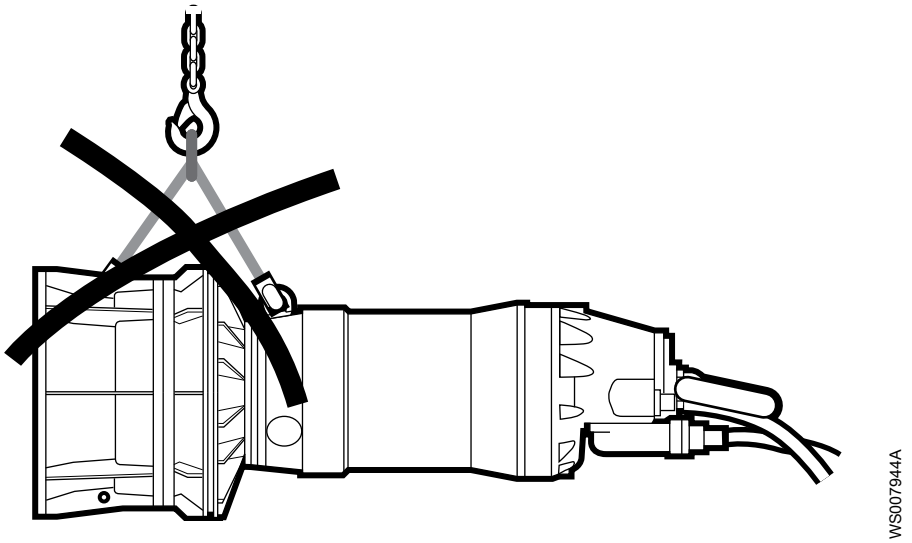


Figure 5: Never lift the assembled unit by the holes in the turbine unit

NOTICE:

When handling the unit to and from horizontal position, the unit should always be lifted by the lifting link. Use a suitable lifting sling/strap.

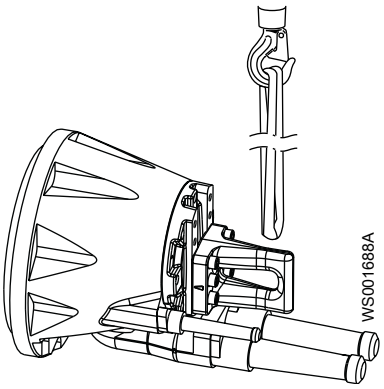


Figure 6: The lifting link

2.4.1 Lift the hydroturbine with double-hook equipment (recommended)

The figures in this section illustrate a generic unit.

1. Fasten a suitable lifting sling/strap to the lifting handle on the top of the generator unit.

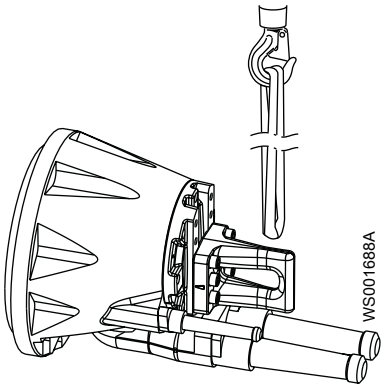
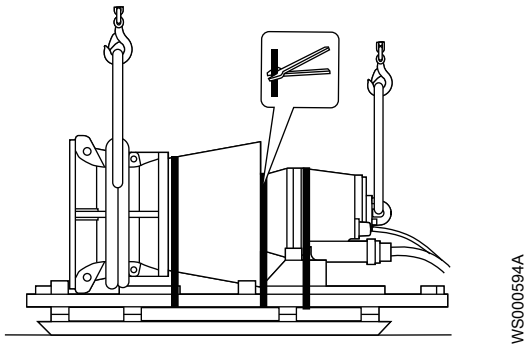


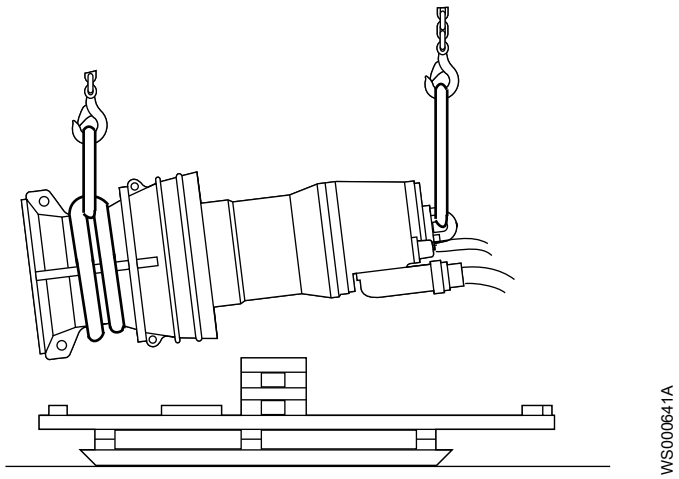
Figure 7: The lifting handle

2. Fasten a sling around the turbine unit.

3. Remove the straps securing the unit to the transport pallet.



4. Lift the unit.



5. Place the unit upright on a rigid horizontal surface so that it cannot fall over.

2.4.2 Lift the hydroturbine with single-hook equipment

The figures in this section illustrate a generic unit.

1. Fasten a suitable lifting sling/strap to the lifting handle on the top of the generator unit.

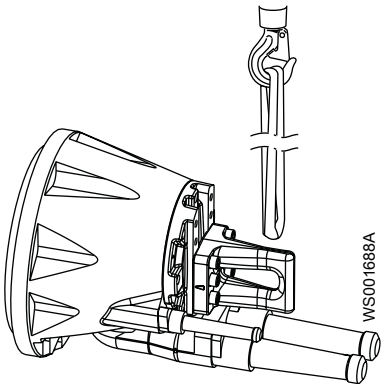


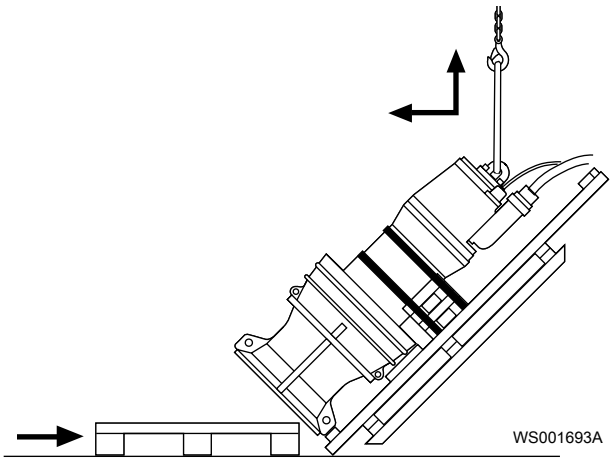
Figure 8: The lifting handle

2. Raise the unit approximately halfway to its upright position.

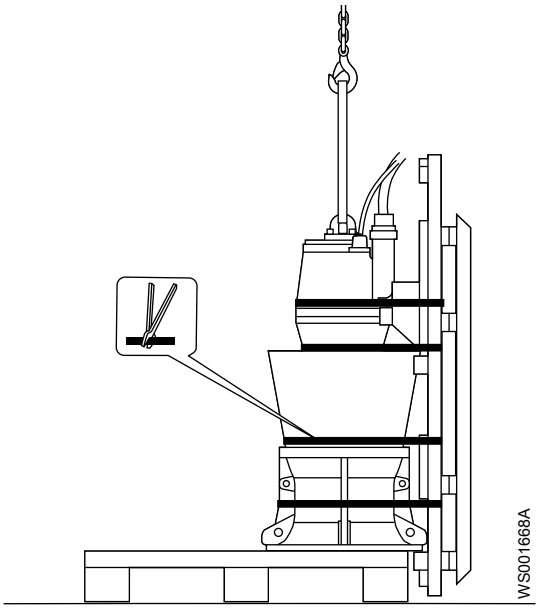
   The unit is still attached to the transport pallet.

3. Slide a pallet or similar object under the outlet section.

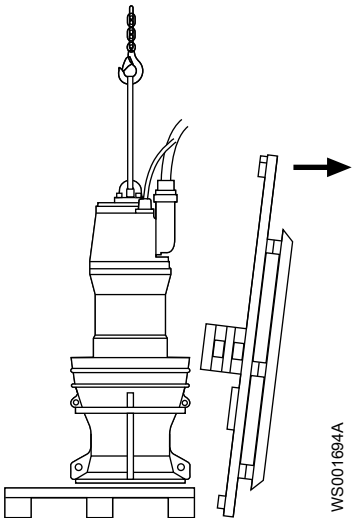
   This will minimize the jolt which may occur later in the lifting, when the unit is almost fully upright.



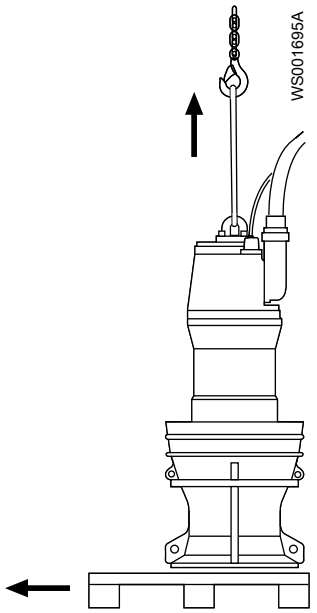
4. Continue raising the unit until it is in an upright position.
   The unit might jolt or sway near the end of the lifting operation.
5. Remove the straps holding the unit to the transport pallet.
   (Location of straps may vary. Figure shows a generic runner unit.)



6. Remove the transport pallet.



7. Lift the unit and remove the support pallet.



8. Place the unit upright on a rigid horizontal surface so that it cannot fall over.

2.5 Temperature ranges for transportation, handling and storage

Handling at freezing temperature

At temperatures below freezing, the product and all installation equipment, including the lifting gear, must be handled with extreme care.

Make sure that the product is warmed up to a temperature above the freezing point before starting up. Avoid rotating the runner blades by hand at temperatures below the freezing point. The recommended method to warm the unit up is to submerge it in the water.

NOTICE:

Never use a naked flame to thaw the unit.

Unit in as-delivered condition

If the unit is still in the condition in which it left the factory - all packing materials are undisturbed - then the acceptable temperature range during transportation, handling and storage is: –50°C (–58ºF) to +60°C (+140ºF).

If the unit has been exposed to freezing temperatures, then allow it to reach the ambient temperature of the surrounding liquid before operating.

Lifting the unit out of liquid

The unit is normally protected from freezing while operating or immersed in liquid, but the runner blades and the shaft seal may freeze if the unit is lifted out of the water into a surrounding temperature below freezing.

Follow these guidelines to avoid freezing damage:

1. Empty all water from the unit.
2. Check all liquids used for lubrication for the presence of water. Change if needed.

2.6 Storage guidelines

Storage location

The product must be stored in a covered and dry location free from heat, dirt, and vibrations.

NOTICE:

Protect the product against humidity, heat sources, and mechanical damage.

NOTICE:

Do not place heavy weights on the packed product.

Freezing precautions

The unit is frost-proof while operating or immersed in liquid, but the runner blades and the shaft seal may freeze if the unit is lifted out of the water into a surrounding temperature below freezing.

Follow these guidelines to avoid freezing damage:

When	Guideline
Before storage	Any remaining water must be allowed to run out.
After storage	If the turbine is frozen, then contact your Xylem representative. **NOTICE:** Never use a naked flame to thaw the unit.

Long-term storage

If the unit is stored more than six months, then the following apply:

- Before operating the unit after storage, it must be inspected with special attention to the seals and the cable entry.
- The turbine must be rotated every other month to prevent the seals from sticking together.

3 Product Description

Intended Use

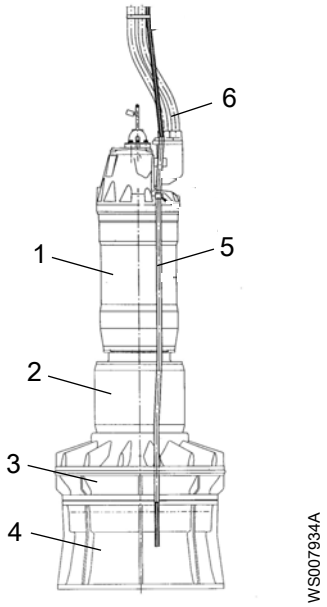
The product is intended for generating electricity. Always follow the limits that are given in *Application limits* on page 58. If there is a question regarding the intended use of the equipment, please contact a Xylem representative before proceeding.

Products included

Fixed blades	Adjustable blades
E7556	–

3.1 Major parts

This section shows the major parts of the hydroturbine (generic unit shown).



1. Generator
2. Gearbox (if used)
3. Turbine
4. Outlet cone
5. Oil tubes for regulating blade angle (if used)
6. Control and power cables

3.2 Generator units

Direct-driven

Turbine units	Generator units								
	705/706	735/736	765/766	805	835	865	905	935/936	965
7556	x	x	x						
7570			x	x	x	x	x	x	
7585							x	x	x
7600							x	x	x

Gear-driven

Turbine units	Generator units									
	705/706	735/736	765/766	805	835	865	885	905	935/936	965
7585	x	x	x	x	x	x	x	x	x	x
7600	x	x	x	x	x	x	x	x	x	x
7620	x	x	x	x	x	x	x	x	x	x
7650			x	x	x	x	x	x	x	

3.3 Spare part requirements

The following applies when the unit is serviced or repaired:

- Modifications to the unit or installation must only be carried out after consulting with Xylem.
- Original spare parts and accessories that are authorized by Xylem are essential for compliance. The use of other parts can invalidate any claims for warranty or compensation. For more information, contact a Xylem representative.

3.4 The MAS 711 monitoring equipment

The MAS 711 system

MAS 711 (Monitoring and Status) is a monitoring system for Flygt products. It monitors and stores measurements from a number of sensors (temperature, leakage, and vibration). These measurements are used to:

- Protect the unit by raising an alarm when undesirable events occur.
- Track operational data.

Alarm levels can be set so that the operator is notified when an alarm event has occurred. Depending on the alarm/event configuration, the MAS 711 system may stop the unit.

The base unit stores all measurement data on its embedded server.

The system also includes a memory module, storing identity data of the hydroturbine.

The parameters that are tracked are chosen by the customer, and may include the following:

- Temperature:
  - Main bearing
  - Support bearing
  - Stator winding
- Vibration
- Leakage:
  - In the stator housing or inspection chamber
  - In the junction box
- Power monitoring

For more information, see the MAS 711 Installation and User Manual.

Sensors, generators up to 1 kV

Table 1: Sensors for hydroturbines using generators up to 1 kV

Parameter Monitored	Sensor	Signal cable, Number of leads Required	Standard or Optional
Vibration	VIS 10	24	Optional
Leakage in the junction box	Float switch leakage sensor (FLS)	12	Standard
Stator winding temperature in one phase	Pt100 analog temperature sensor in one stator winding	12	Standard

Parameter Monitored	Sensor	Signal cable, Number of leads Required	Standard or Optional
Stator winding temperature	Thermal switches (3), or	12	Standard
	PTC-thermistors (3)	24	Optional
Stator winding temperature in phases 2 and 3	Pt100 analog temperature sensors in two extra stator windings	24	Optional
Main bearing temperature	Pt100 analog temperature sensor	12	Standard
Leakage in the stator housing or inspection chamber	Float switch leakage sensor (FLS)	12	Standard
Support bearing temperature	Pt100 analog temperature sensor	24	Optional
Hydroturbine or pump memory	Printed circuit board for memory module includes a temperature sensor.	12	Standard
Power monitoring	Separate electronic instrument using three current transformers.		Optional

For more information on the stator temperature monitoring, see *Stator temperature monitoring methods* on page 18.

Signal cables

The hydroturbine is delivered with the signal cable (also known as “auxiliary,” “control” or “pilot” cable) mounted. The following SUBCAB™ signal cables are available:

- 12x1.5 mm^2 (unscreened, also known as unshielded). Conductors 1-12.
- 24x1.5 mm^2 (unscreened, also known as unshielded). Conductors 1-24.
- S12x1.5 mm^2 (screened, also known as shielded). Conductors 1-12.
- S24x1.5 mm^2 (screened, also known as shielded). Conductors 1-24.

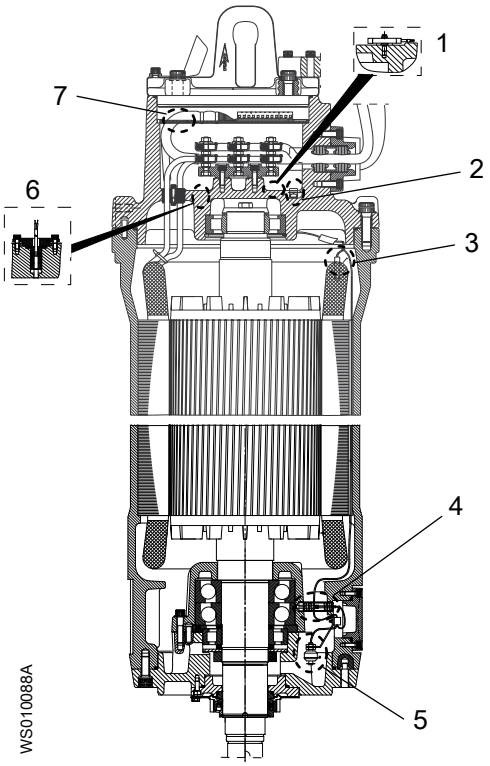
The number of conductors that are required to connect the sensors to the monitoring system depends on the number and type of sensors being used.

3.4.1 Sensors

Turbine speed relay

See the site-specific documentation.

Sensors in 7X5 and 7X6 generator units



1. Vibration – VIS 10
2. Leakage in the junction box – FLS, Float Switch Leakage Sensor
3. Stator winding temperature
4. Main bearing temperature – Pt100 analogue temperature sensor
5. Leakage in the stator housing – FLS
6. Support bearing temperature – Pt100 analogue temperature sensor
7. Memory module

Temperature sensors

Table 2: Thermal switch

Description	Measured value	Fault values
The thermal switch is a normally closed contact.	0-3 ohm, unless the wires are very long.	An infinite value (open circuit) indicates either high temperature or a fault (a wire is broken or there is a bad contact in a connector).

Table 3: PTC-thermistor

Description	Measured value	Fault values
The PTC-thermistor is a semiconductor device.	Resistance at normal temperature: • 50-100 ohm (150-300 ohm for three in series)	• Above the tripping point, T_{Ref}, the resistance increases dramatically to several kilohm. • An infinite value (open circuit) indicates a fault (a wire is broken or there is a bad contact in a connector). • A value close to zero indicates a short circuit in the wiring.

Table 4: Pt100 sensor

Description	Measured value	Fault values
The Pt100 sensor is a resistor changing value almost linearly with temperature.	Resistance: • 100 ohm at 0ºC (32ºF) • 107.79 ohm at room temperature (20ºC, 68ºF) • 138.5 ohm at 100ºC (212ºF) For resistance data between 0–160 0ºC (32–212ºF), see *Pt100 resistance* on page 58. Never connect the Pt100 sensor to a voltage higher than 2.5 V.	> 200 ohm (approximately) can indicate the following situations: • Broken sensor • Bad contact • Broken lead < 70 ohm (approximately) indicates: • Short circuit

For information on the various configurations of switches, thermistors and sensors that are used to monitor the stator winding temperature, see *Stator temperature monitoring methods* on page 18.

FLS

Table 5: Float switch sensor (FLS)

Description	Measured value	Fault values
The float switches are leakage sensors. The float switches are located in the lower part of the stator housing and in the junction box.	Resistance. Two sensor variants: FLS: • Normal: 1530 ohm • Alarm: 330 ohm FLS 10: • Normal: 1200 ohm • Alarm: 430 ohm	> 10% (approximately) deviation from rated ohm values indicates sensor fault, or fault in the wiring.

VIS10

Table 6: Vibration sensor (VIS10)

Description	Measured value	Fault values
The vibration sensor that is located in the junction box measures vibrations in one direction. The output is a 4-20 mA signal proportional to the vibration level.	Current, 4-20 mA	• >> 20 mA indicates a short circuit. • << 4 mA indicates a fault. • A zero value indicates a broken wire or bad contact in a connector.

3.4.2 Stator temperature monitoring methods

The purpose of stator-winding temperature monitoring is to stop the operation at high temperature. There are several monitoring methods, depending on the voltage of the generator, and types of thermal sensors chosen.

By using an analog sensor, two adjustable alarm limits can be used, one for warning (“B”-alarm) and one for hydroturbine stop (“A”-alarm). The configurations which may be used for monitoring the stator-winding temperature depend upon the voltage range of the generator. See *Generator units* on page 14 for the voltage range for each generator.

Up to 1 kV generators

Table 7: Stator temperature monitoring configuration, up to 1 kV

Standard / Optional	Monitoring configuration description
Standard	• Three thermal switches, which are connected in series, are incorporated in the coil ends of the stator winding. The switches are normally closed, and open at 140°C (285°F). • One Pt100 sensor is incorporated in one of the windings.
	Or:
	• Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=140°C (285°F) • One Pt100 sensor is incorporated in one of the windings.
Optional	• Three thermal switches, which are connected in series, are incorporated in the coil ends of the stator winding. The switches are normally closed, and open at 140°C (285°F). • Three Pt100 sensors, one for each phase, are incorporated in the windings.
	Or:
	• Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=140°C (285°F) • Three Pt100 sensors, one for each phase, are incorporated in the windings.

3.4.3 Hydroturbine or pump memory

The memory is located inside the generator unit's junction box. The memory is loaded with data from the factory, which is then uploaded to the MAS system at first startup.

The data that is uploaded contains the following features:

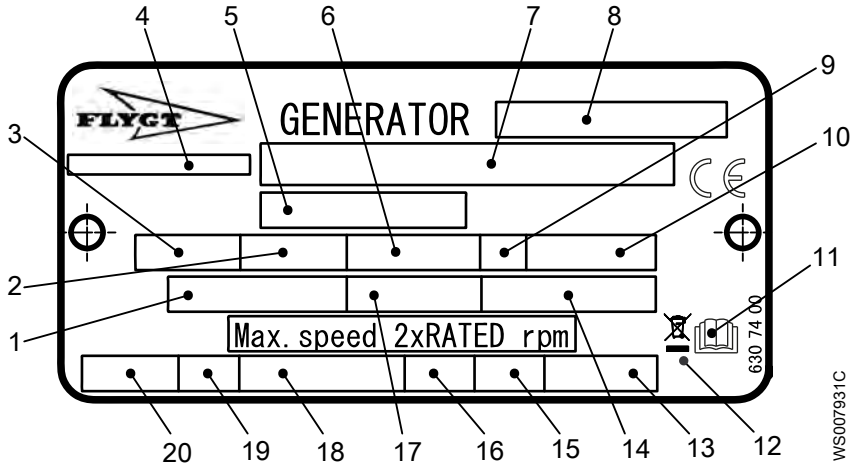
- Data plate information
- Sensor types and manufacturer's recommended alarm settings
- Operational data and data to support service:
  - Histograms of temperatures, vibrations, and cycle length
  - Start and stop registration
  - Service log with a maximum of 200 lines of text
  - Conditions to prompt for service based on e.g. running time, number of starts and stops or specific dates

For more information, see the Installation and User Manual for the MAS 711 monitoring systems.

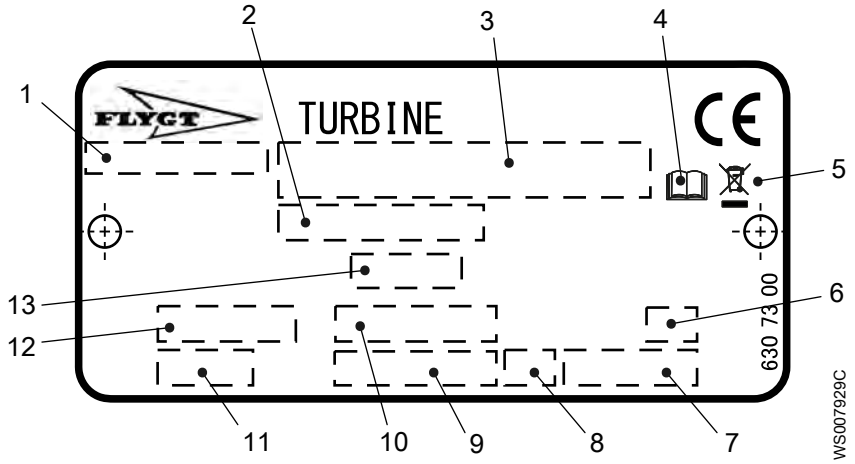
3.5 Motor regulation

This product is submersible and therefore exempted from the motor efficiency requirement, in accordance with EU commission regulation 2019/1781 Article 2(2)(e).

3.6 The data plates



1. Rated voltage
2. Rated output
3. Phase number; type of current; frequency
4. Country of origin
5. Product number
6. Rated speed
7. Serial number
8. Generator number / Stator version
9. Duty class
10. Maximum ambient temperature
11. Read the care and maintenance instructions
12. WEEE-Directive symbol
13. Product weight: generator
14. Power factor
15. Maximum submergence
16. Degree of protection
17. Rated current
18. International standard
19. Thermal class
20. Thermal protection



1. Country of origin
2. Product number
3. Serial number
4. Read the care and maintenance instructions
5. WEEE-Directive symbol
6. Blade angle
7. Product weight: generator + turbine + gear (if applicable)
8. Direction of rotation: runner/generator
9. Rated speed
10. Blade angle interval
11. Turbine housing
12. Turbine column diameter
13. Runner code

3.7 Product denomination

Reading instruction

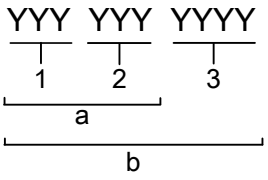
In this section, code characters are illustrated accordingly:

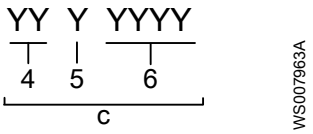
X = letter

Y = digit

The different types of codes are marked up with a, b, and c. Code parameters are marked up with numbers.

Codes and parameters: generator





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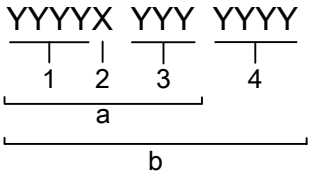
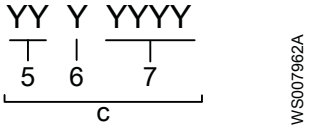
Type of Callout	Number	Indication
Type of code	a	Product code
	b	Product number
	c	Serial number
Parameter	1	Generator unit
	2	Internal number
	3	Sequence number
	4	Production year
	5	Production cycle
	6	Running number

Codes and parameters: turbine





WS007962A

Type of Callout	Number	Indication
Type of code	a	Product code
	b	Product number
	c	Serial number
Parameter	1	Turbine unit
	2	“R” (only for adjustable-blade hydroturbines)

Type of Callout	Number	Indication
	3	Generator unit
	4	Sequence number
	5	Production year
	6	Production cycle
	7	Running number

4 Installation

4.1 Precautions

DANGER: Electrical Hazard

Before starting work on the unit, make sure that the unit and the control panel are isolated from the power supply and cannot be energized. This applies to the control circuit as well.

DANGER: Inhalation Hazard

Before entering the work area, make sure that the atmosphere contains sufficient oxygen and no toxic gases.

Before installing the unit, do the following:

- Provide a suitable barrier around the work area, for example, a guard rail.
- Make sure that equipment is in place so that the unit cannot roll or fall over during the installation process.
- Check the explosion risk before you weld or use electric hand tools.
- Check that the cable and cable entry have not been damaged during transport.
- Always remove all debris and waste material before you install the unit.

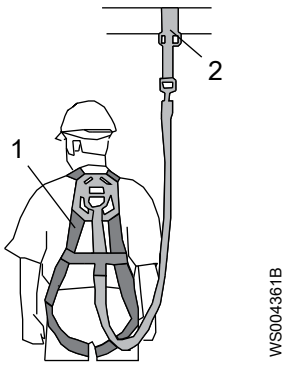
4.1.1 Falling

CAUTION: Fall Hazard

Slips and falls can cause severe injuries. Watch your step.

To minimize the risk of falling, observe the following:

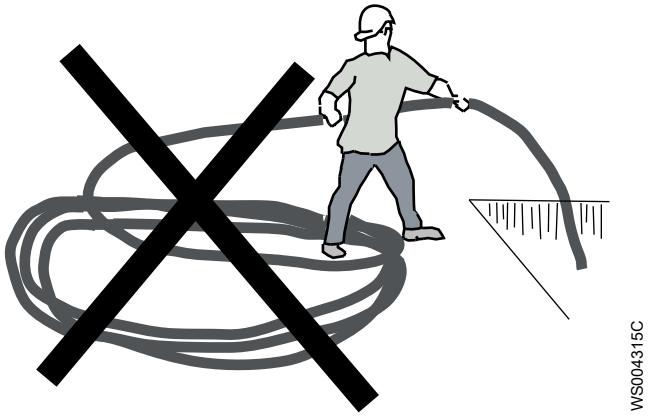
- Use appropriate personal protection equipment when working in or near open basins, shafts, or trenches.



1. Fall protection harness
2. Anchoring point

- Make sure that all safety guards are in place and secure, and that there is a suitable barrier around the work area.
- Wear clean slip-resistant shoes.

- Make sure that any ladders or climbing equipment that is used is correctly sized and in good working condition.
- Never stand in coiled cables, ropes or wires, or between them and the open shaft or basin.



Fasteners

- Only use fasteners of the correct size and material.
- Replace all corroded or damaged fasteners.
- Make sure that all the fasteners are correctly tightened and that there are no missing fasteners.

4.2 Cable handling system

Cable system overview

When the product is installed in a column, it is critically important that a proper cable support and protection system is used, especially with long power cables and closed columns. Characteristics of the cable handling system include:

- Cables must be supported in such a way, so that they do not come in contact with any hard surface which could abrade the cable sheathing. Examples of surfaces include hydroturbine and column components, lifting cables or wires and any other hardware.
- Power cables should be bundled together, using components that will not cut or abrade the cables.
- Proper strain relief and support at prescribed intervals should be provided.
- Spring-controlled tensioning and an integrated guide wire system is recommended for long cables.

Example of the Flygt cable handling system

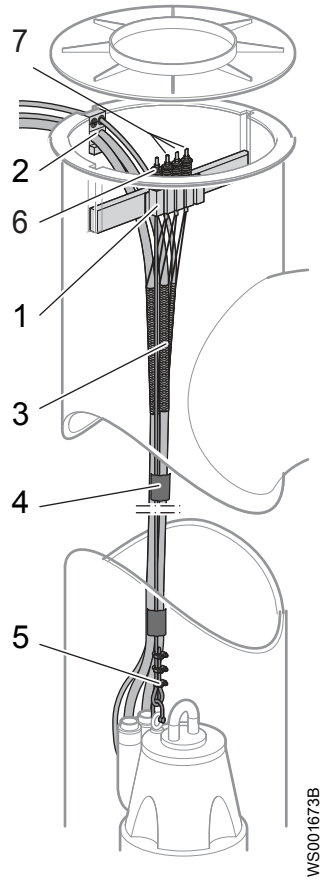


Figure 9: Example of the Flygt cable handling system

Number	Description
1	Support beam and cable holder
2	Cable entry unit
3	Cable support grips
4	Bundling kits
5	Wire unit
6	Lifting eye unit: wire
7	Lifting eye unit: cable

Instructions for installing the cable handling system

Instructions for installing the Flygt cable handling system are given in the document "Mounting Instructions, Flygt Cable Handling System." For more information, please contact your local sales and service representative.

4.3 The installation workflow

This section describes the overall workflow for installing the hydroturbine. Detailed instructions follow for the various tasks.

1. Check the runner rotation, using the generator unit as a motor.
2. Prepare cables and hoses for lowering the hydroturbine.
3. Lower the hydroturbine into the shaft or penstock.
4. Secure cables and hoses.
5. Connect the power and control cables from the generator unit.

4.4 Install the hydroturbine

Consult the local sales and service representative regarding the following topics:

- Sizing of the hydroturbine, station, and access frame
- Choice of auxiliary equipment
- Other aspects of installation

The hydroturbine is installed in a vertical tube on a seat, which is incorporated in the lower end of the tube. No anchoring is required because the weight of the hydroturbine is sufficient to keep it in place. The hydroturbines are equipped with anti-rotation devices.

Before installation, check the following:

- The rubber seal ring underneath the hydroturbine is in place.
- There is no damage to, or debris on, the hydroturbine seat.
- There is no large construction debris present. If debris is present, then there is a risk that it can get into the hydroturbine and cause runner damage.
- A suitable cable support and protection system is in place.

1. Remove the fuses or open the circuit breaker, and check that the runner can be rotated freely.
2. Make sure that the runner rotates in the correct direction.

   See *Check the runner rotation* on page 42.
3. Secure the cables so that they can be fed into the column in a controlled manner.

   When the hydroturbine is lowered into the column, the cables must be fed into the column at the same speed as the hydroturbine is lowered.

   See also the Installation, Operation and Maintenance manual for the Flygt Cable Handling System.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4. Make sure that the lifting strap or chain which will be used to lower the hydroturbine, is shorter than the length of the cables.

   The hydroturbine must not be lifted by its cables.


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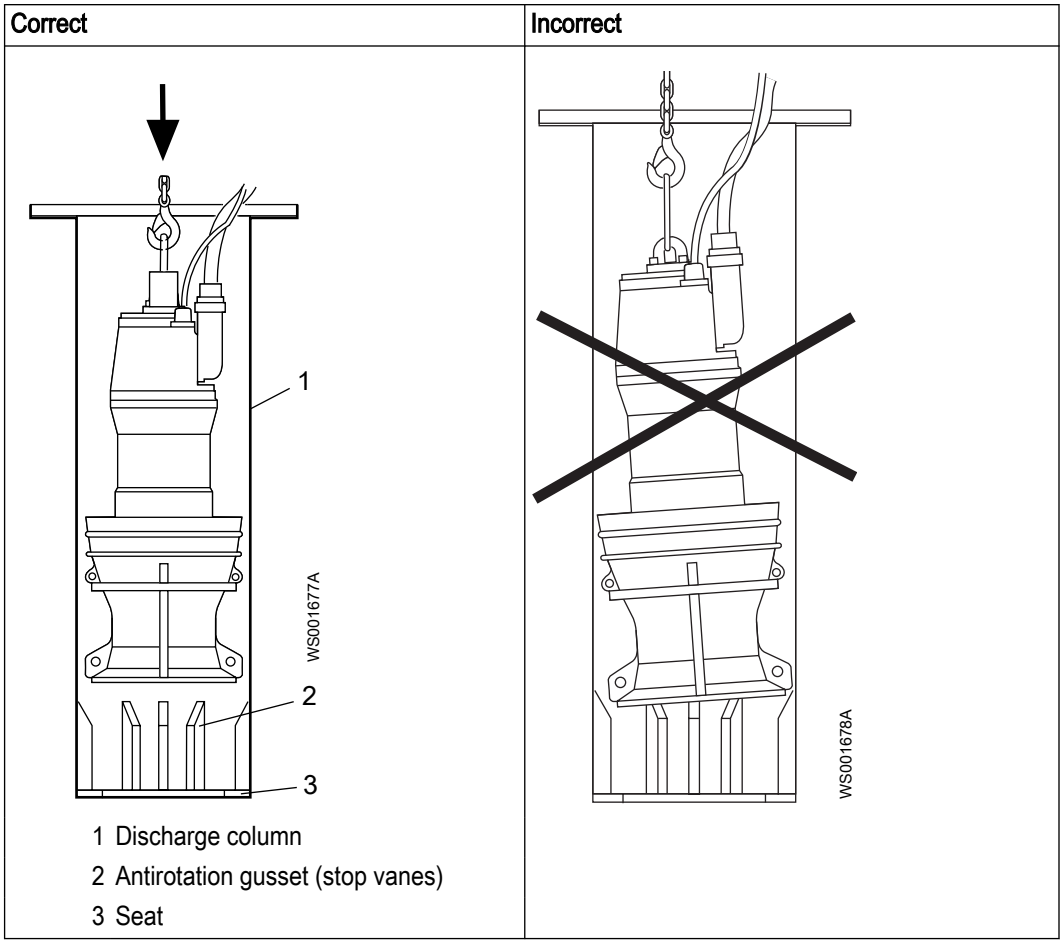
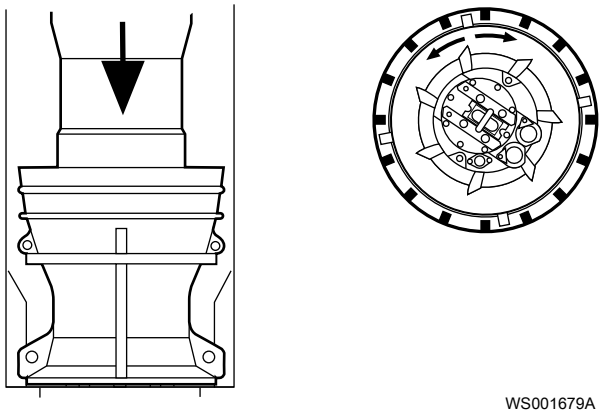
5. After cable preparation, lower the hydroturbine into the column.

   Make sure that the hydroturbine does not tilt on the stop vanes, which are at the bottom of the column.

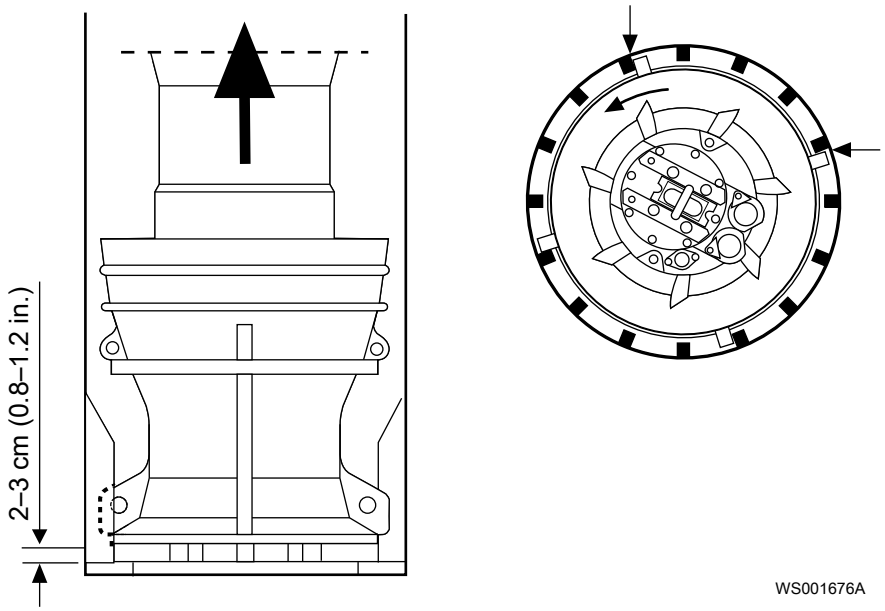


1 Discharge column
2 Antirotation gusset (stop vanes)
3 Seat

6. Lower the hydroturbine to its bottom position, at the same time carefully moving it back and forth between the nearest anti-rotation gusset.

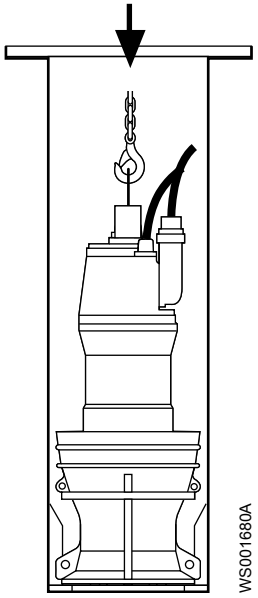


7. Lift the hydroturbine slightly again, approximately 2-3 cm (1 in), and turn it counterclockwise until the anti-rotation device on the outlet cone lands against the nearest adjacent vanes.



8. Lower the hydroturbine to its final bottom position.

   No additional anchoring of the hydroturbine is required. Maximum permissible submersion depth is 20 m (65 ft).



9. If the recommended cable handling system is used, then follow the instructions for finishing the cable connection. See the document "Mounting Instructions, Flygt Cable Handling System."
10. If the recommended cable handling system is not used, then fasten the power cables on the cable holder and run them to the electric junction box.

    Make sure that the cables have no sharp bends, are not pinched, and are not disturbed by the water flow.

4.5 Connect the equipment

For complete information on all the terminals, see *Terminals*.

Use the following instructions to connect the equipment that apply.

General precautions

DANGER: Electrical Hazard

Before starting work on the unit, make sure that the unit and the control panel are isolated from the power supply and cannot be energized. This applies to the control circuit as well.

WARNING: Electrical Hazard

The turbine generates voltage when the shaft rotates, even if power sources are disconnected. The shaft will rotate if water flows through the turbine. Never perform any electrical work if the shaft could rotate.

WARNING: Electrical Hazard

Risk of electrical shock or burn. A certified electrician must supervise all electrical work. Comply with all local codes and regulations.

WARNING: Electrical Hazard

There is a risk of electrical shock or explosion if the electrical connections are not correctly carried out, or if there is fault or damage on the product. Visually inspect equipment for damaged cables, cracked casings or other signs of damage. Make sure that electrical connections have been correctly made.

CAUTION: Electrical Hazard

Prevent cables from becoming sharply bent or damaged.

NOTICE:

Leakage into the electrical parts can cause damaged equipment or a blown fuse. Keep the cable ends dry at all times.

Requirements

These general requirements apply for electrical installation:

- The mains voltage and frequency must agree with the specifications on the data plate.
- The fuses and circuit breakers must have the proper rating, and the product overload protection (motor protection breaker) must be connected and set to the rated current according to the data plate and if applicable the cable chart.
- The fuse rating and the cables must be in accordance with the local rules and regulations.
- The thermal contacts must be connected to a protection circuit in accordance with the product approvals.
- The thermal contacts/thermistors must be in use.

Cables

These are the requirements to follow when you install cables:

- The cables must be in good condition, not have any sharp bends, and not be pinched.
- The sheathing must not be damaged and must not have indentations or be embossed (with markings, etc.) at the cable entry.
- The cable entry seal sleeve and washers must conform to the outside diameter of the cable. For more information, see *Cable charts* on page 36.

- The correct entrance flange must be used with the existing cable according to the table in *Cable charts* on page 36.
- The minimum bending radius must not be below the accepted value.
- If using a cable which has been used before, a short piece must be peeled off when refitting it so that the cable entry seal sleeve does not close around the cable at the same point again. If the outer sheath of the cable is damaged, then replace the cable. For more information, please contact your local sales and service representative.
- The voltage drop in long cables must be taken into account. The rated voltage of the generator is the voltage that is measured at the cable connection point in the hydroturbine.
- If a variable frequency drive (VFD) is used, then the screened cable must be used according to the European CE requirements. For more information, contact your local sales and service representative (VFD-supplier).
- For SUBCAB™ cables, the twisted-pair copper foil must be trimmed.

Grounding (earthing)

Grounding (earthing) must be done in compliance with all local codes and regulations.

DANGER: Electrical Hazard

All electrical equipment must be grounded (earthed). Test the ground (earth) lead to verify that it is connected correctly and that the path to ground is continuous.

WARNING: Electrical Hazard

If the power cable is jerked loose, then the ground (earth) conductor must be the last conductor to come loose from its terminal. Make sure that the ground (earth) conductor is longer than the phase conductors at both ends of the cable.

WARNING: Electrical Hazard

Risk of electrical shock or burn. You must connect an additional earth- (ground-) fault protection device to the grounded (earthed) connectors if persons are likely to come into contact with liquids that are also in contact with the energized unit.

4.5.1 Connect the cables

1. Connect the monitoring equipment.
2. Connect the cable leads to the terminal board.
   – If you have the MAS system, then connect the cable to its terminal board according to the illustration and table in *MAS 711 sensor connections* on page 33.

   NOTICE:

   As the cable ends are sealed to eliminate moisture entrainment during transport and storage, no wire markings for the sensors at the outlet end of the cable are made at the factory. Markings must therefore be carried out during installation of the unit.

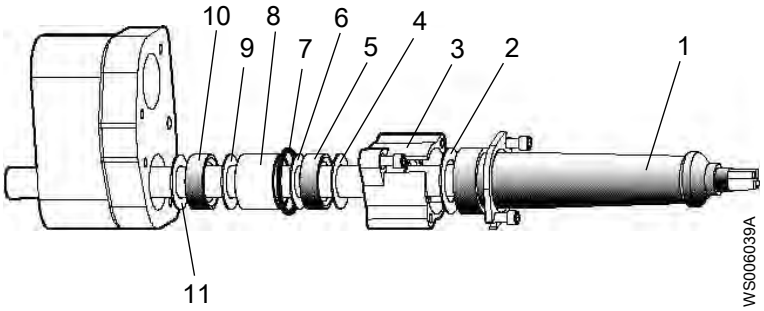
   At the first installation, the MAS base unit and the memory module must be synchronized. To synchronize the units, do the following:

   1. Check that the communication between the hydroturbine and the MAS base unit is activated.
   2. Upload the factory settings of sensors and associated parameters by choosing the command "copy all from pump memory to MAS". For more information about the MAS installation, see the Installation and User Manual for the MAS-711 monitoring equipment.
3. Connect the power cable:

a) Check the data plate to determine which connection, Y or D, is valid for the voltage supply.
b) Arrange the connection on the terminal board in accordance with Y or D.
c) Connect the power cable leads to the terminal board connection U1, U2, V1, V2, W1, W2, and ground (earth) according to the cable chart.
d) If control elements are present and not used, then cut and cap them.

See *Cable charts* on page 36.

4. Install the entrance flange:
   a) Mount the entrance-flange parts according to the illustration for the correct generator.



1. Protective sleeve
2. Washer
3. Connection flange
4. Washer
5. Seal sleeve
6. Washer
7. O-ring
8. Spacer ring
9. Washer
10. Seal sleeve
11. Washer

Figure 10: Generator 905–998

   b) Mount the protective rubber sleeve onto the cable where it leaves the junction box (connection housing).

      The rubber sleeve must have the correct size to give the correct compression around the cable.

   c) Fasten the connection flange to the entrance flange.

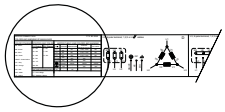
      Make sure that the seal sleeve is not misaligned with the rubber sleeve and that the entrance flange supports the cable so that it cannot be excessively bent.

5. Connect the starter equipment:
   a) Connect the power cable to the starter equipment according to the diagram in *Power cable phase sequence* on page 32.
   b) Connect the auxiliary cable to the starter equipment.

4.5.2 Colors and markings of leads

MOTOR CONNECTION
COLORS AND MARKING OF MAIN LEADS — 773 30 00 (REV 4)

COLOR STANDARD	STATOR LEAD COLORS		MOTOR CABLE LEAD COLORS AND MARKING				
	LV Stators	MV Stators	3 ~	SUBCAB	SUBCAB AWG	SUBCAB S6x95+95+S(4x0.5)	MV cables
BK - Black	U1 - RD	U - BK	L1	BN	RD	1 WH , 4 WH	BK
BN - Brown	U2 - GN	V - BK	L2	BK	BK	2 WH , 5 WH	BK
BU - Blue	V1 - BN	W - BK	L3	GY	WH	3 WH , 6 WH	BK
GN - Green	V2 - BU		T1, T2	WH	WH	WH	-
GN/YE - Green/Yellow	W1 - YE		T3, T4	WH	WH	WH	-
GY - Grey	W2 - BK		⏚	GN/YE	GN/YE	GN/YE	GN/YE
OG - Orange			⏚	WH	-	WH	WH
RD - Red	VOLTAGE DENOMINATIONS		GC	-	YE	-	-
WH - White	LV - Low voltage						
YE - Yellow	MV - Medium voltage						



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Color code standard

Code	Description
BN	Brown
BK	Black
WH	White
OG	Orange
GN	Green
GNYE	Green-Yellow
RD	Red
GY	Grey
BU	Blue
YE	Yellow

4.5.3 Power cable phase sequence

In the following figure, the triangle marked “L1,” “L2” and “L3” shows the phase sequence.

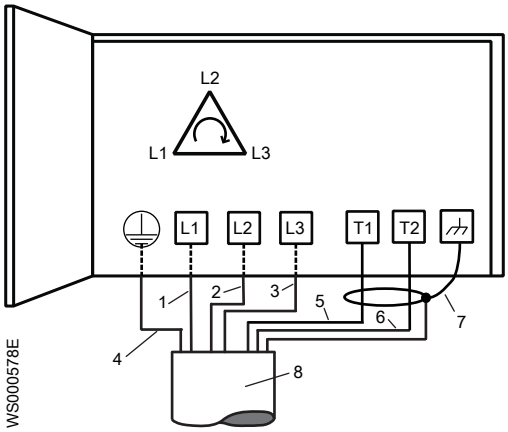


Figure 11: Correct phase sequence

Item	Description	
1	L1 cable lead	Brown
2	L2 cable lead	Black
3	L3 cable lead	Gray
4	Earth PE or ground lead cable	
5	T1 cable lead (control element)	In cables with both power conductors and control element. MAS 801: See the SIO manual for T1, T2, and drain wire connections.
6	T2 cable lead (control element)	
7	Screen (drain wire)	
8	Power cable to unit	

4.5.4 MAS 711 sensor connections

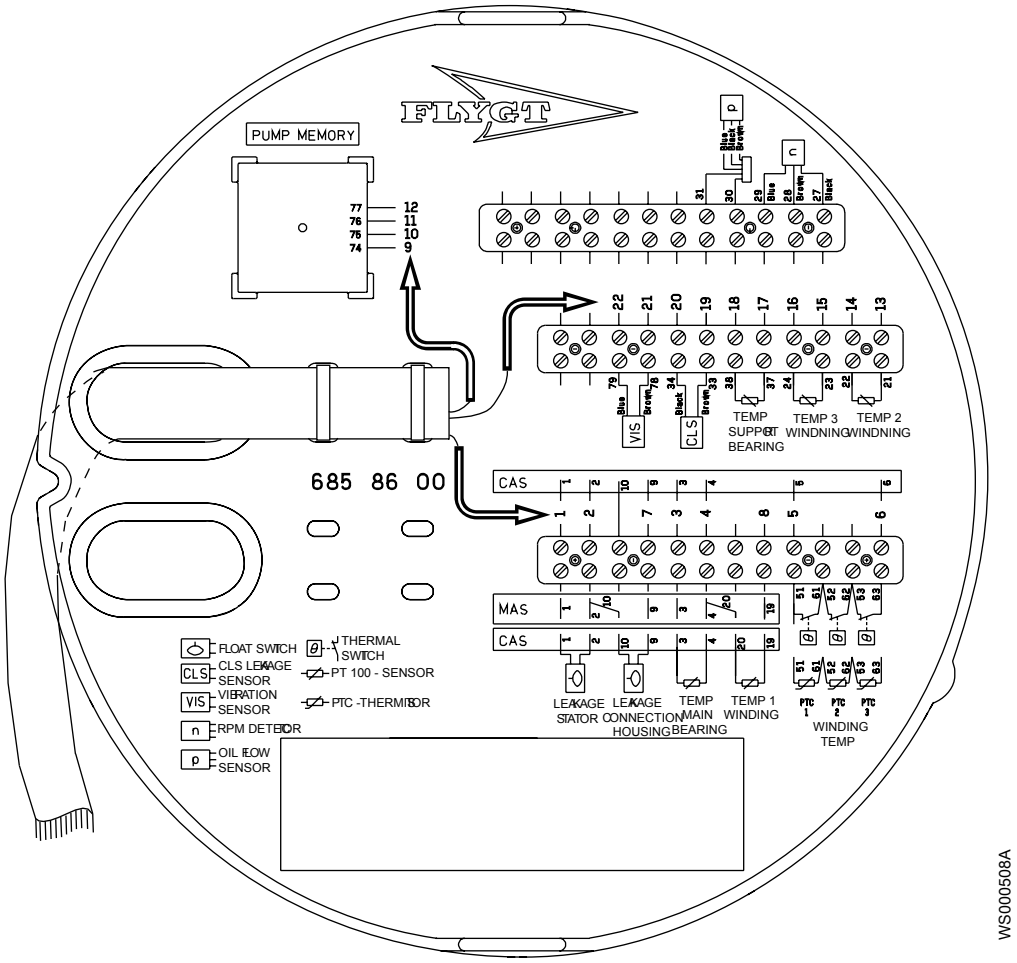


Figure 12: Connections at the product. Arrows indicate SUBCAB cable lead numbers.

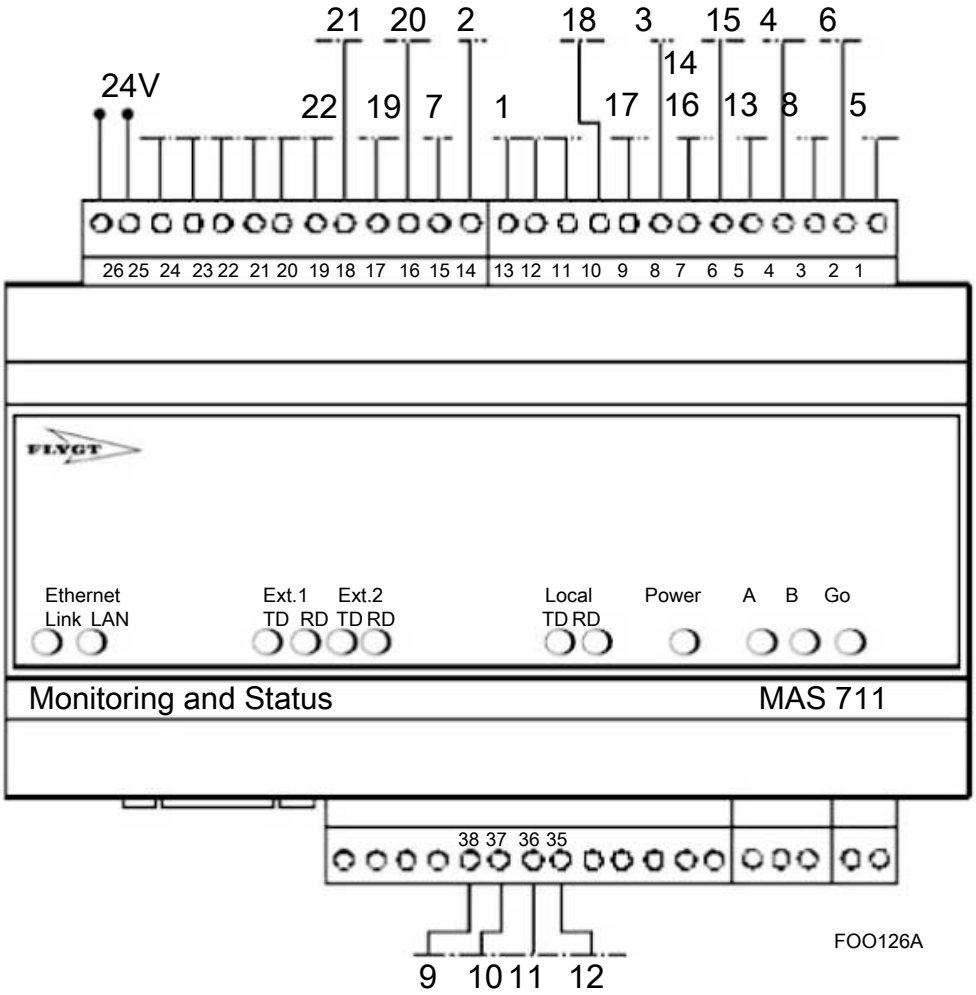


Figure 13: Connections at the MAS 711 base unit

This table shows how the conductors are connected to the different sensors.

Sensor		Terminal block	Conductor number for 12-lead cable	Conductor for 24-lead cable
Float switch in the stator house[1]		1	1	1
		2	2	2
Float switch in the junction box		9	7	7
		2	—	—
Pt100 in the main bearing[2]		3	3	3
		4	4	4
Pt100 in the support bearing		37	—	17
		38	—	18
Thermal switches or thermistors in the stator		5	5	5
		6	6	6
CLS sensor in the oil housing	+	33	—	19
Not applicable for hydroturbines.	–	34	—	20

1 The leakage sensor in the stator housing and the leakage sensor in the junction box use the same terminal (terminal 2) on the terminal block.

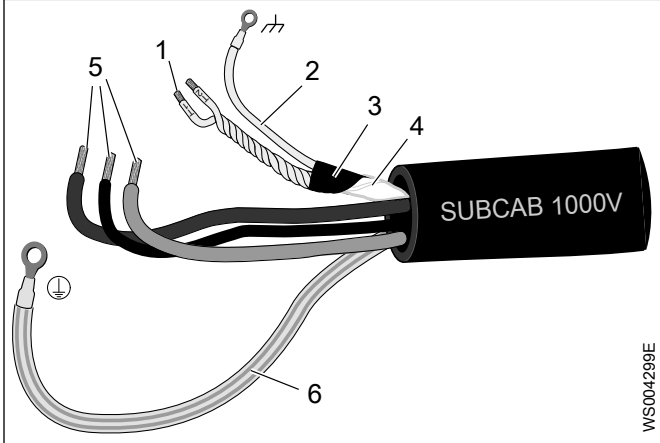
2 The Pt100 sensors in the main bearing and the support bearing use the same terminal (terminal 4) on the terminal block.

Sensor		Terminal block	Conductor number for 12-lead cable	Conductor for 24-lead cable
Pt100 in the stator winding 1		19	8	8
		4	—	—
Pt100 in the stator winding 2		21	—	13
		22	—	14
Pt100 in the stator winding 3		23	—	15
		24	—	16
Memory module RS-485 B		74	9	9
Memory module RS-485 A		75	10	10
Memory module supply, ground (earth)		76	11	11
Memory module supply, 12 VDC+		77	12	12
Vibration sensor VIS 10	+	78	—	21
	–	79	—	22

4.5.5 Prepare the SUBCAB™ cables

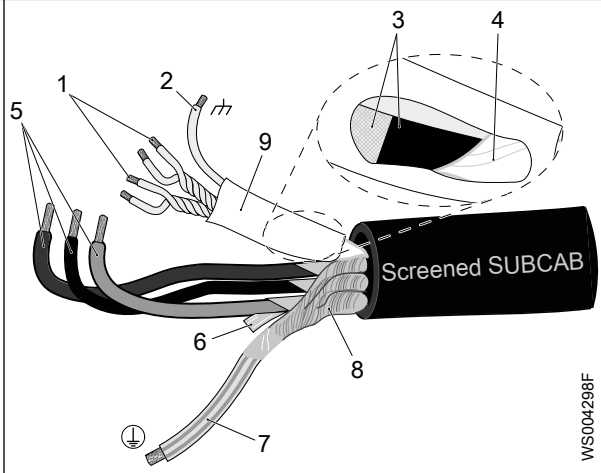
This section applies to SUBCAB™ cables with twisted-pair control conductors.

The prepared SUBCAB™ cable



1. T1+T2 twisted pairs in control element
2. Drain wire in control element (tinned copper strands) with shrink tube
3. Aluminum and textile layers
4. Insulation jacket or plastic jacket, for the control element
5. Power conductors
6. Ground (earth) conductor with yellow-green shrink tube

The prepared screened SUBCAB™ cable, without cable lugs



1. T1+T2 and T3+T4 twisted pairs in control element
2. Drain wire in control element (tinned copper strands) with shrink tube
3. Aluminum and textile layers
4. Insulation jacket or plastic jacket, for the control element
5. Power conductors
6. Plastic laminated aluminum foil, screen
7. Ground (earth) conductor with yellow-green shrink tube
8. Uncovered screen/braided wire
9. shrink tube

1. Peel off the outer jacket at the end of the cable.
2. Prepare the control element:
   a) Peel the insulation jacket or plastic jacket.
   b) Peel the aluminum and textile layers.

      The aluminum foil is a conductive screen. Do not peel more than necessary, and remove the peeled foil.

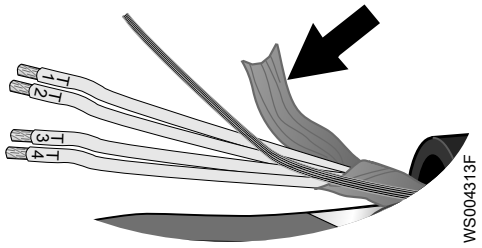


Figure 14: Aluminum foil on the control element.

c) Put a white shrink tube over the drain wire.
d) Twist T1+T2 and T3+T4.
e) Put a shrink tube over the control element.

   Make sure that the conductive aluminum foil and drain wire are covered.

3. Prepare the ground (earth) conductor of the SUBCAB™ cable:
   a) Peel the yellow-green insulation from the ground (earth) conductor.
   b) Check that the ground (earth) conductor is at least 10% longer than the phase conductors in the cabinet.
   c) If applicable, put a cable lug on the ground conductor.
4. Prepare the ground (earth) conductor of the screened SUBCAB™ cable:
   a) Untwist the screens around the power conductors.
   b) Twist all power conductor screens together to create a ground (earth) conductor.
   c) Put a yellow-green shrink tube over the ground (earth) conductor.

      Leave a short piece uncovered.
   d) Check that the connected ground (earth) conductor has sufficient slack. The conductor must stay connected even if the power conductors are pulled loose.
5. Prepare the power conductors:
   a) Remove the aluminum foil around each power conductor.
   b) Peel the insulation from each power conductor.
6. Prepare the ends of the ground (earth) conductor, the power conductors, and the drain wire:

Connection type	Action
Screw	Fit cable lugs to the ends.
Terminal block	Fit end sleeves or leave the ends as they are.

4.6 Cable charts

NOTICE:

Leakage into the electrical parts can cause damaged equipment or a blown fuse. Keep the end of the motor cable dry at all times.

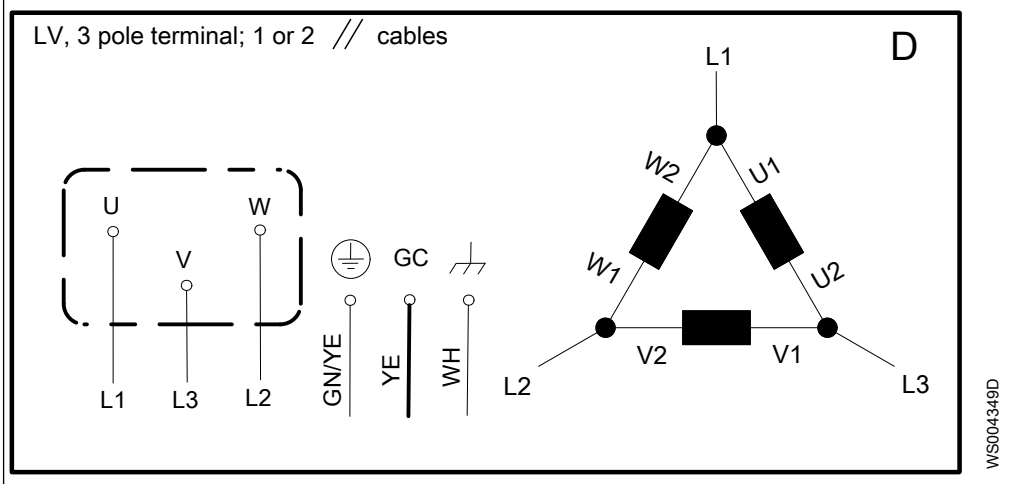
Color code standard

See *Colors and markings of leads* on page 31.

Generators up to 1.1 kV

Table 8: D-connection, 3-pole terminal, 1 or 2 cables

Schematic diagram



Generators: 905, 935/936, 965

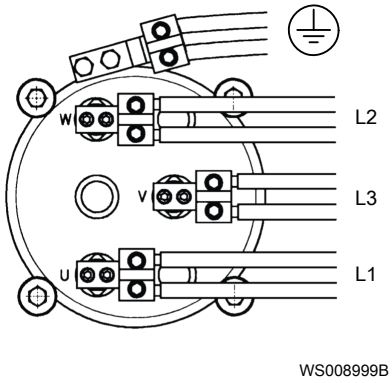
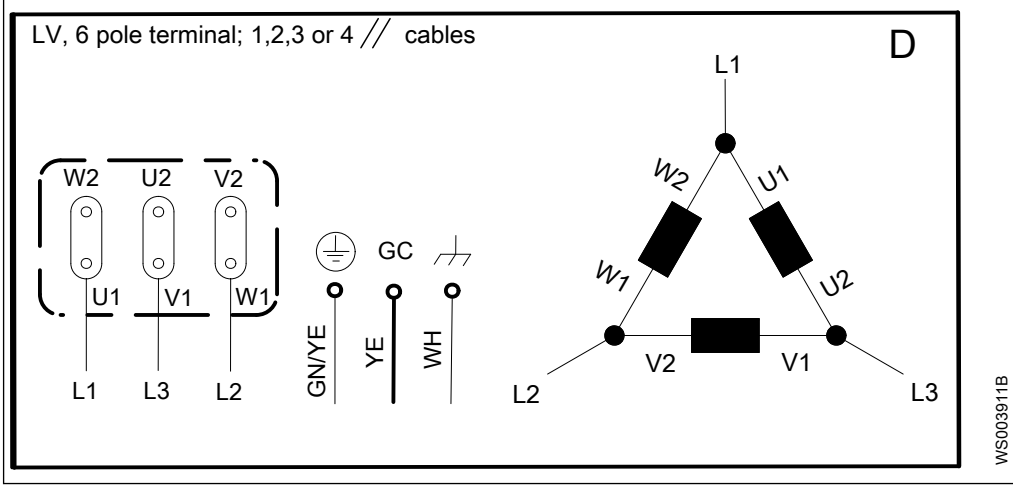


Table 9: D-connection, 6-pole terminal, 2 cables

Schematic diagram



Generators: 905, 935/936, 965

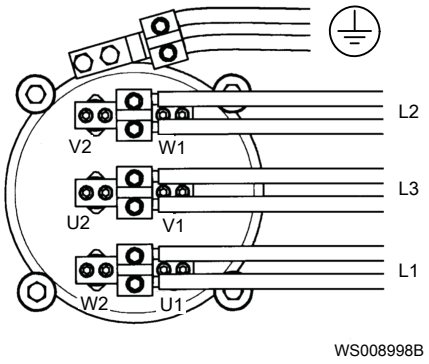
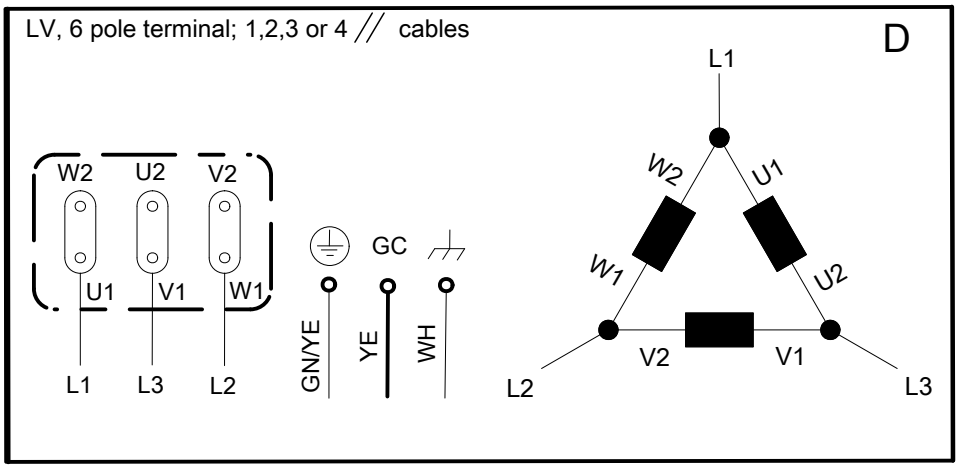


Table 10: D-connection, 6-pole terminal, 3 cables

Schematic diagram



Generators: 905, 935/936, 965

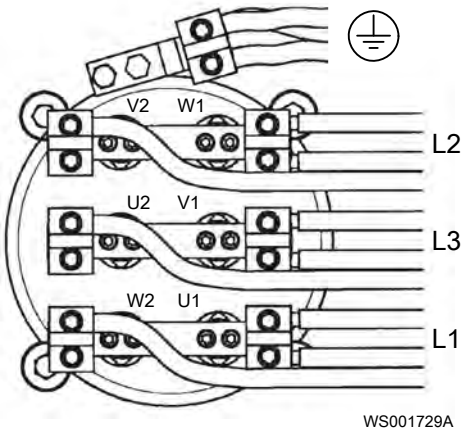
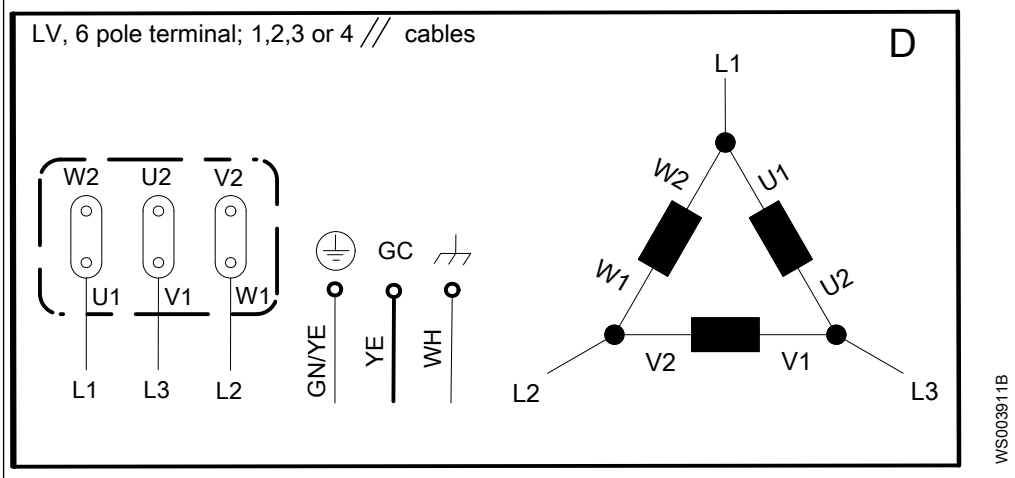


Table 11: D-connection, 6-pole terminal, 4 cables

Schematic diagram



Generators: 965

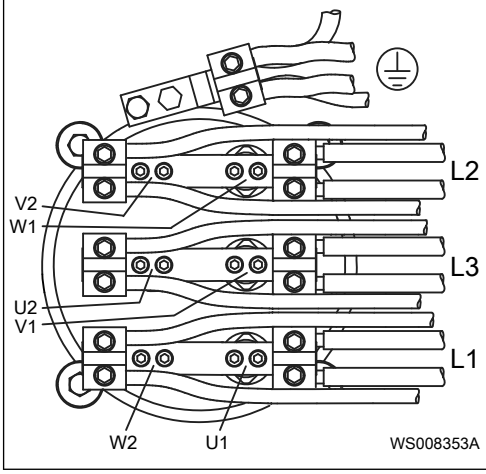
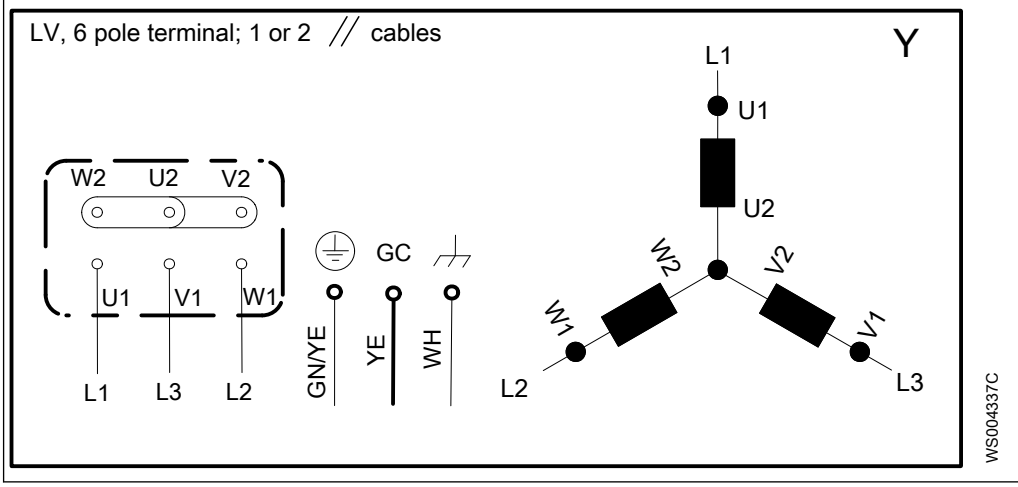
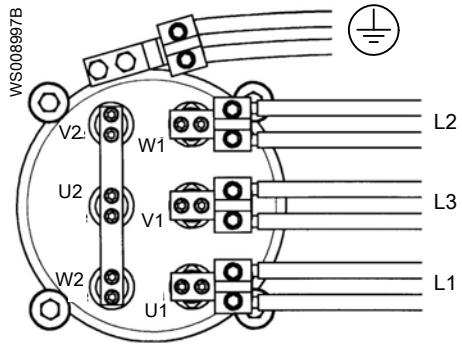


Table 12: Y-connection, 6–pole terminal, 1 or 2 cables

Schematic diagram

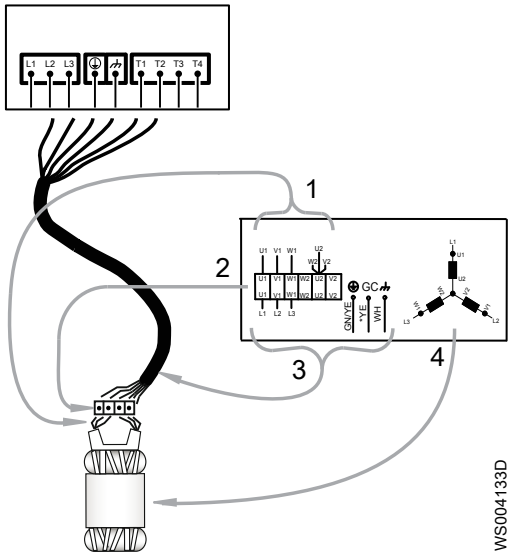


Generators: 905, 935/936, 965

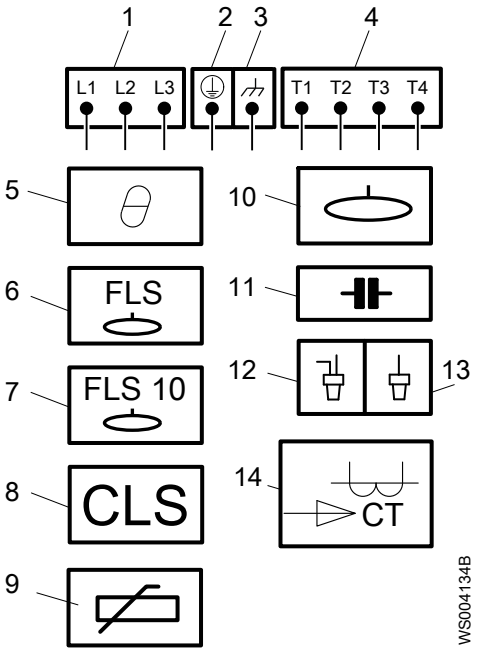


Connection locations

The figures in this section illustrate how to interpret the connection strip symbols.



1. Stator leads
2. Terminal board
3. Power cable leads
4. Stator (internal connection illustrated)



1. Starter equipment and mains leads (L1, L2, L3)
2. Ground (earth)
3. Functional ground
4. Control leads (T1, T2, T3, T4)
5. Thermal contact
6. FLS
7. FLS 10
8. CLS
9. Thermistor
10. Level sensor
11. Capacitor
12. Crimp connection
13. Crimp isolation
14. Current transformer

3-phase connection, screened

If a separate control cable is used, then the control conductors in the power cable are never used.

The following figure shows screened SUBCAB cable without a separate ground conductor. The ground conductor is made of stranded ground conductors. T1 and T2 are twisted together.

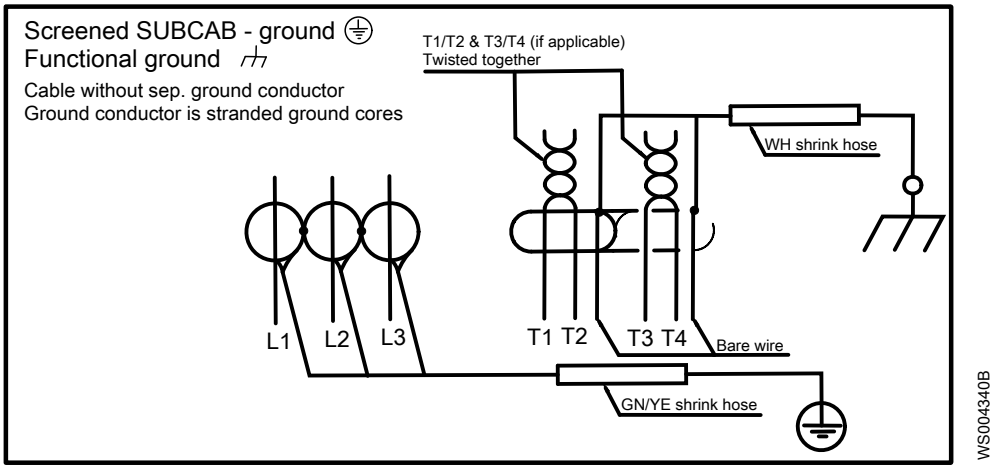


Figure 15: Without separate ground conductor

The following figure shows screened SUBCAB with a functional ground. T1 and T2 are twisted together.

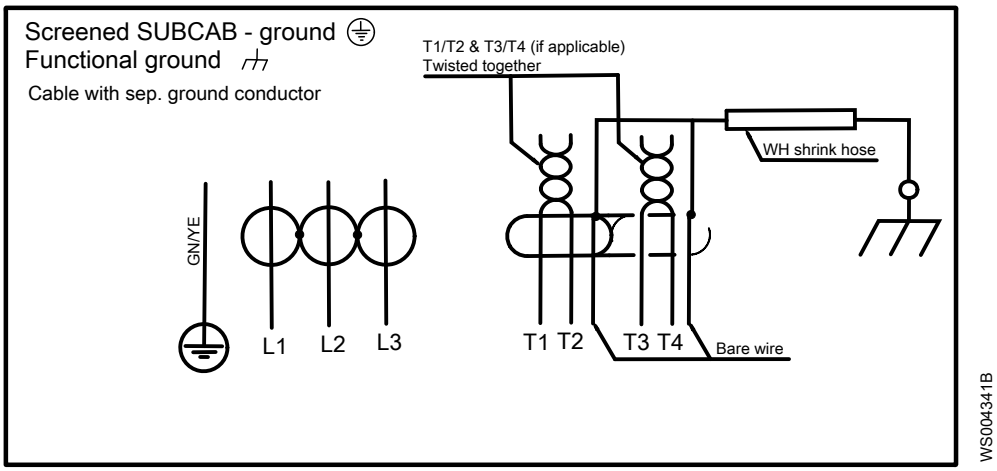


Figure 16: With functional ground

4.6.1 Cable bending radius, weight and diameter

Control cables

Table 13: SUBCAB™ control cables

This table shows the minimum bending radius, weight, and outer diameter for SUBCAB control cables.

Cable	Minimum bending radius in mm	Weight in kg/m	Outer diameter, minimum-maximum in mm
12x1.5 mm^2	190	0.53	Ø 18.2–21.2
24x1.5 mm^2	250	0.90	Ø 24.9–28.9
S12x1.5 mm^2	300	0.78	Ø 29.9–31.0
S24x1.5 mm^2	350	1.59	Ø 33.0–37.0

Power cables with power cores and control element

Table 14: Screened SUBCAB

Cable	Minimum bending radius in mm	Weight in kg/m	Outer diameter, minimum-maximum in mm
S3x16 + 3x16/3 + S(4x0.5)	240	1.1	Ø 24–26
S3x25 + 3x16/3 + S(4x0.5)	290	1.4	Ø 29–31
S3x35 + 3x16/3 + S(4x0.5)	320	2.0	Ø 32–34
S3x50 + 3x25/3 + S(4x0.5)	380	3.0	Ø 38–40
S3x70 + 3x35/3 +2 S(2x0.5)	420	3.5	Ø 42–44
S3x95 + 3x50/3 + 2S(2x0.5)	440	4.6	Ø 44–47
S3x120 + 3x70/3 + 2S(2x0.5)	500	5.5	Ø 50–52
S6x95 + 95 + S(4x0.5)	570	7.6	Ø 57–60

Table 15: SUBCAB

Cable	Minimum bending radius in mm	Weight in kg/m	Outer diameter, minimum-maximum in mm
4 G 16 + S(2x0.5)	260	1.13	Ø 26–28
4 G 25 + S(2x0.5)	320	1.7	Ø 32–34
4 G 35 + S(2x0.5)	350	2.24	Ø 35–37
3x50 + 2G35/2 + S(2x0.5)	350	2.6	Ø 35–37
3x70 + 2G35/2 + S(2x0.5)	380	3.3	Ø 38–41
3x95 + 2G50/2 + S(2x0.5)	470	4.5	Ø 47–50
3x120 + 2G70/2 + S(2x0.5)	540	5.7	Ø 54–56

4.7 Check the runner rotation

CAUTION: Crush Hazard

The starting jerk can be powerful. Make sure nobody is close to the unit when it is started.

1. Start the generator as a motor.
2. Stop the motor after a few seconds. Make sure that the turbine does not run dry for more than 30 seconds.
3. Examine the runner rotation.

   The correct direction of runner rotation is clockwise seen from above.

Direction of runner rotation. Generic unit shown.

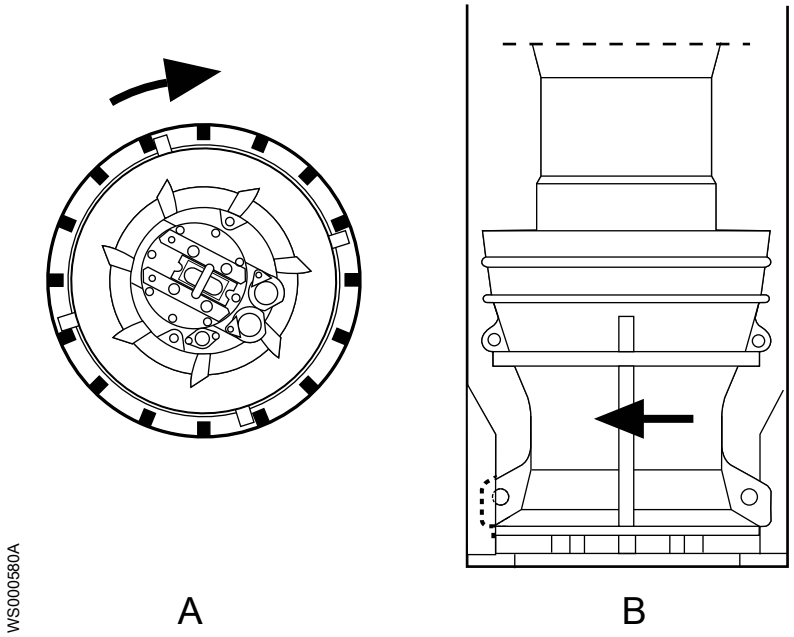


Figure 17: Top view (A) and side view (B)

4. If the runner rotates in the wrong direction, then make sure that the phase leads are correctly connected. See *Power cable phase sequence* on page 32.

   After reconnecting phase leads, do this procedure again.

5 Commissioning

Precautions

Before taking the unit into operation, check the following:

- All recommended safety devices are installed.
- The cables and cable entry have not been damaged.
- All debris and waste material has been removed.

WARNING: Electrical Hazard

Risk of electrical shock or burn. You must connect an additional earth- (ground-) fault protection device to the grounded (earthed) connectors if persons are likely to come into contact with liquids that are also in contact with the energized unit.

WARNING: Electrical Hazard

The turbine generates voltage when the shaft rotates, even if power sources are disconnected. The shaft will rotate if water flows through the turbine. Never perform any electrical work if the shaft could rotate.

Noise level

NOTICE:

The sound power level of the product is lower than 70 dB(A). However, in some installations the resulting sound pressure level may exceed 70 dB(A) at certain operating points on the performance curve. Make sure that you understand the noise level requirements in the environment where the product is installed. Failure to do so may result in hearing loss or violation of local laws.

5.1 Take the hydroturbine into commission

CAUTION: Crush Hazard

The starting jerk can be powerful. Make sure nobody is close to the unit when it is started.

1. Check that the following conditions are fulfilled:
   a) The monitoring equipment works.
   b) All electrical installations are made according to the site-specific documentation.
   c) All the alarms function.
   d) The lubricants are at the correct level.
2. Conduct insulation test phase to ground. To pass, value must exceed 5 megohms.
3. Take the hydroturbine into commission. See the site-specific documentation.

Check that the following conditions are fulfilled:

- The machine works without noise or vibration.
- All electrical values are correct.
- All accessories work correctly.

Note any abnormalities.

6 Maintenance

Precautions

Before starting work, make sure that the safety instructions have been read and understood.

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.

WARNING: Electrical Hazard

The turbine generates voltage when the shaft rotates, even if power sources are disconnected. The shaft will rotate if water flows through the turbine. Never perform any electrical work if the shaft could rotate.

CAUTION: Thermal Hazard

The surfaces or parts of the unit may become hot during operation. Allow surfaces to cool before starting work, or wear heat-protective clothing.

CAUTION: Cutting Hazard

Sharp edges. Wear protective clothing.

Make sure that you follow these requirements:

- Make sure that all safety guards are in place and secure.
- Make sure that equipment is in place so that the unit cannot roll or fall over during the maintenance process.
- Make sure you have a clear path of retreat.
- Never work alone.
- Check the explosion risk before you weld or use electrical hand tools.
- Allow all system and pump components to cool before you handle them.
- Before starting work, make sure that the work area is well-ventilated.

Ground continuity verification

A ground (earth) continuity test must always be performed after service.

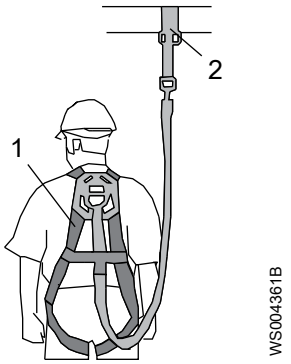
6.1 Falling

CAUTION: Fall Hazard

Slips and falls can cause severe injuries. Watch your step.

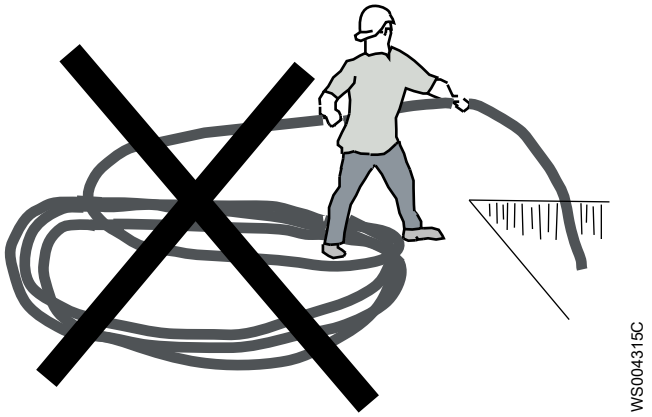
To minimize the risk of falling, observe the following:

- Use appropriate personal protection equipment when working in or near open basins, shafts, or trenches.



1. Fall protection harness
2. Anchoring point

- Make sure that all safety guards are in place and secure, and that there is a suitable barrier around the work area.
- Wear clean slip-resistant shoes.
- Make sure that any ladders or climbing equipment that is used is correctly sized and in good working condition.
- Never stand in coiled cables, ropes or wires, or between them and the open shaft or basin.



6.1 Service

Regular inspection and service of the product ensures more reliable operation.

Every time the site is visited, visually inspect all items on site for corrosion, wear or damage.

Table 16: Service intervals

Type of service	Purpose	Interval
Initial inspection	To make a check up of the condition of the product by an authorized Xylem service representative and, based on the result and findings from these measures, to determine the intervals for periodical inspection and major overhaul for the specific installation.	Within the first year of operation.

Type of service	Purpose	Interval
Periodical inspection	To prevent operational interruptions and machine breakdown. Measures to secure performance and efficiency are defined and decided for each individual application.	12,000 hours or 3 years, whichever comes first. Applies to normal applications and operating conditions at media (liquid) temperatures < 40°C (104°F).
Major overhaul	To secure a long operating lifetime for the product. It includes replacement of key components and the measures that are taken during an inspection.	24,000 hours or 6 years, whichever comes first. Applies to normal applications and operating conditions at media (liquid) temperatures < 40°C (104°F).

NOTICE:

Shorter intervals may be required when the operating conditions are extreme, for example with very abrasive or corrosive applications or when the liquid temperatures exceed 40°C (104°F).

6.1.1 Inspection

CAUTION: Compressed Gas Hazard

Air inside may cause parts or liquid to be propelled with force. Be careful when opening.

Regular inspection and service of the product ensures more reliable operation.

Do the following to service the product:

Part to service	Action
Exterior of the product	Check the entire product and the cables for external mechanical damage.
Cable	1. If the outer jacket is damaged, then replace the cable. 2. Check that the cables do not have any sharp bends and are not pinched. 3. Check that the leads and cable entry screws are correctly connected and tightened to the correct torque.
Lifting handle	Check the lifting handle for corrosion or other damage.
Junction box	1. General: Check that it is clean and dry. If it is wet: a. Check the cable entry. b. Replace the O-rings. (New O-rings should be fitted to all O-ring seal joints opened during inspection.) 2. Terminal board: Check that the connections are properly tightened.
Junction box insulation, generators up to 1.1 kV	Check the condition and function. See *Check the insulation, up to 1 kV drives or generators* on page 49.

Part to service	Action
Stator housing	1. Check that it is clean and dry: – If there is oil in the stator housing, then drain and clean it. After one week of operation, check again. If there is still oil in the stator housing, then change the seals. – If there is water in the stator housing and there was water in the oil, then change the seals immediately. – If there is water in the stator housing, but there was no water in the oil, then check all other connections. 2. Replace the O-rings.
Oil housing	1. Check the oil quality: – If there is water in the oil, then drain the oil and replace with new oil. After one week of operation, check the oil quality again. – If the oil is free from water, then fill the oil to the correct level, if necessary. 2. Replace the filling plug O-rings.
Turbine parts	1. Check the general condition of the runner and the wear ring. 2. Replace if necessary. 3. If applicable, then check the O-ring.
Screw joints	Check all externally accessible screw joints, and tighten if necessary to correct torque. See *Torque values* on page 56.
Electrical cabinets	Check that they are clean and dry.
Connection to power	Check that the connections are properly tightened.
Level regulators	Check the condition and function. See *Check the leakage detectors* on page 50.
Temperature sensors	Check the condition and function. See *Check the temperature sensors* on page 50.
Gear (if applicable)	Check the gear oil. See *Check the gear oil*.

After any service involving the power connections, always check the rotation before operating the product. See *Check the runner rotation* on page 42.

6.1.2 Major overhaul

1. Perform a complete inspection service. See *Inspection* on page 47.
2. Do these additional steps:

Part to service	Action
Isolation check, generators up to 1.1 kV	Check that the resistance between earth and phase lead is more than 5 MΩ.
Cable	Check that the rubber sheathing (jacket) is undamaged. Change if necessary.
Oil housing	Change the oil.
General dismantling and cleaning	1. Dismantle the product completely. 2. Clean all the parts. 3. Re-assemble after replacing bearings, O-rings and seals.
Bearings	Replace the bearings with new bearings.
O-rings and other rubber sealing parts	Replace O-rings and other rubber sealing parts.
Seals	Replace with new seals.

Part to service	Action
Sensors	Check the following: 1. Stator temperature sensors. 2. Bearing temperature sensors. 3. FLS sensors. See *Check the temperature sensors* on page 50 and *Check the leakage detectors* on page 50.
Runner	Check the general status of the runner and wear ring. Change if necessary.
Screw joints	Check all externally accessible screw joints and tighten if necessary to correct torque. See torque table and Parts List.
Lifting handle	Check its condition. Replace if necessary.
Painting	Touch up any painting if necessary.
Rotational direction	Check runner rotation direction. See *Check the runner rotation* on page 42.
Voltage and amperage	Check the running values.
Electrical cabinets/ panels	Check that they are clean and dry.
Connection to power	Check the cable connections. Tighten if necessary.
Overload and other protections	Check settings
Level regulators	Check condition and function.

After any service involving the power connections, you must check the rotation before operating the product. See *Check the runner rotation* on page 42.

6.1.3 Overview of oils

Depending upon configuration, the hydroturbine has one or more of the oils described in the following table.

Oil	Normally replace at service?	Change filter at service?	Check for water at service?	Lab check for oil quality?	Description
Oil housing	Yes	No	Yes	No	All turbines: oil for seal lubrication. See *Change the seal lubrication oil in the oil housing* on page 50.
Gear unit	No	Yes, if oil is changed.	Yes, part of lab check.	Yes	Turbines with gear unit. See *Check the gear oil*.
Hydraulic cabinet oil	Yes	Yes	No	No	Turbines with adjustable runner blades. See *Oil change: hydraulic control panel*.
Runner hub oil	Yes	No	Yes	No	Turbines with adjustable runner blades. See *Oil change: runner hub* on page 51.

6.2 Check the insulation, up to 1 kV drives or generators

1. Check that the resistance between earth and phase lead is more than 5 MΩ.
   Use a 500 VDC or 1000 VDC megger.
2. Keep a record of the results.

6.3 Check the temperature sensors

If the unit is connected to the MAS monitoring system, then it is recommended that the sensors be checked in the MAS unit. Otherwise, use a multimeter.

The different types of temperature sensors are:

- Thermal switches
- PTC thermistors
- Pt100

NOTICE:

Do not use a megger or other device applying a higher voltage than 2.5 V.

1. Disconnect the sensor wires.
2. Check the status of the sensor and wiring by measuring the resistance according to the values in *Product Description* on page 14.
3. Measure between each sensor lead and ground (earth) to establish that the resistance is infinite (or at least several megohms).

6.4 Check the leakage detectors

If the unit is connected to the MAS monitoring system, then it is recommended that the sensors be checked in the MAS unit. Otherwise, use a multimeter.

1. Check the float switch (FLS) in the stator housing, according to the values in *Product Description* on page 14.
2. Check the float switch (FLS) in the junction box or connection housing.
3. If the drive unit is equipped with a CLS water-in-oil sensor in the oil housing, then check the CLS by following this procedure.

   Not applicable for hydroturbines.

   a) Connect the CLS to a 12 VDC supply.

      The sensor must have the correct polarity to be checked. However, a switched plus and minus does not damage the sensor.

   b) Use the multimeter as an ammeter and connect it in series with the sensor.

   c) If the sensor is accessible, then check: the alarm function by gripping the sensor with the hand.

      Skin tissue and blood contain a high content of water.

   For interpretation of the CLS measurement results, see *Product Description* on page 14.

6.5 Change the seal lubrication oil in the oil housing

The oil used to lubricate the seals is a tasteless, odorless, medical white oil of paraffin type that fulfills FDA 172.878.

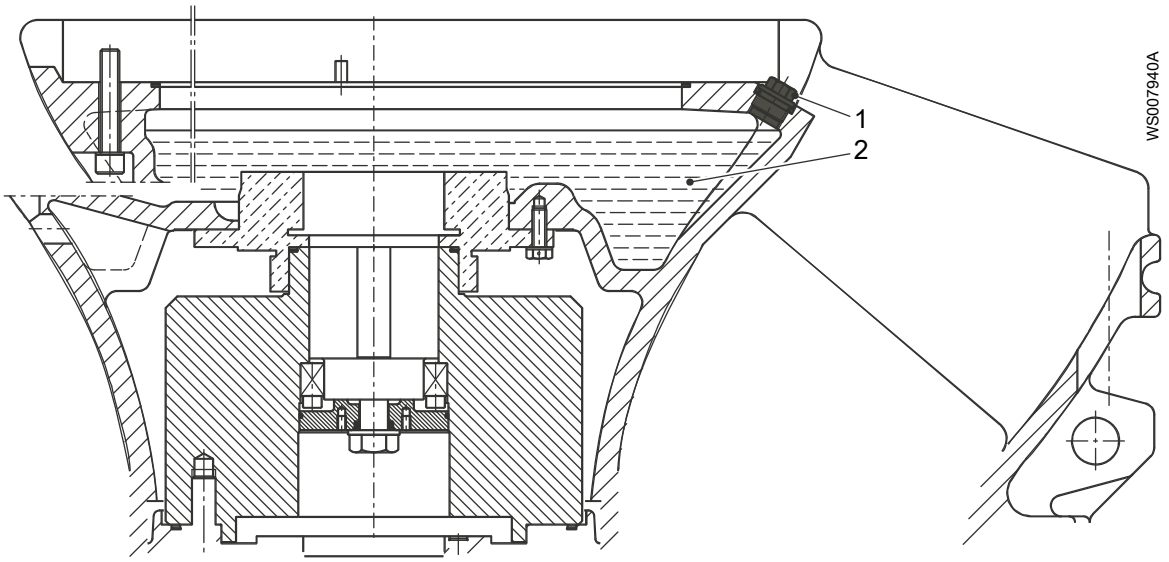
The replacement oil must have a viscosity class of ISO VG 45. Examples of suitable oil types are the following:

- Shell Dromus B
- Exxon Cutwell 40
- Mobil Solvac 1535

The amount of oil that is required is given below. Fill up the oil to the bottom thread.

Table 17:

Hydroturbine unit	Volume of oil
E7556	5.5 L (5.8 quarts)



1. Oil plug
2. Oil

Empty the oil

1. Unscrew the oil plugs.

CAUTION: Compressed Gas Hazard

Air inside the chamber may cause parts or liquid to be propelled with force. Be careful when opening. Allow the chamber to de-pressurize before removal of the plug.

2. Pump out the oil.

   Use oil drainage pump 83 95 42. Make sure that the plastic tube goes all the way to the bottom of the oil housing.

Fill with oil

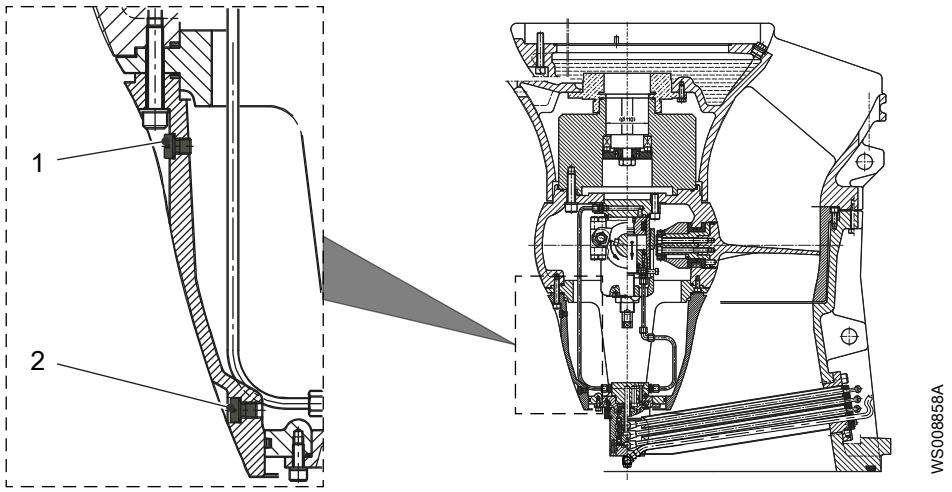
1. Fill the housing with new oil.
2. Insert and tighten plugs with the new O-rings and plugs.

   Tightening torque: 50 Nm (37 ft-lbs).
3. Check the paint; if damaged, repaint.

6.6 Oil change: runner hub

CAUTION: Compressed Gas Hazard

Air inside the chamber may cause parts or liquid to be propelled with force. Be careful when opening. Allow the chamber to de-pressurize before removal of the plug.



1. Oil in
2. Oil out

Figure 18: Location of oil plugs on runner hub

6.7 Replace the turbine unit parts

6.7.1 Measure the clearance

Depending on the type of media, the turbine will more or less be exposed to wear, mainly in the gap between the runner blades and the wear ring.

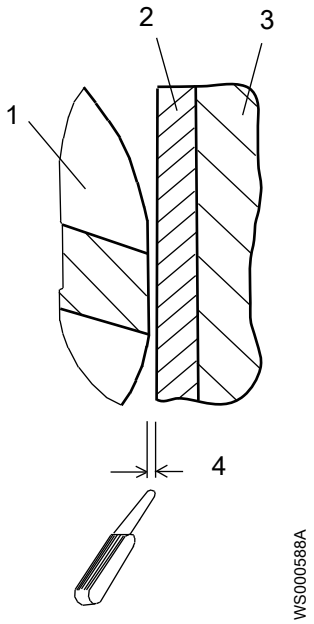
The clearance between the runner blades and the wear ring will increase. The effect of this is that the output power as well as the efficiency will drop. Note that these effects are not linearly proportional to the size of the clearance, but progressive.

Operating the hydroturbine when the wear ring clearance has reached or exceeded the clearance threshold will result in a loss of output power and hydroturbine efficiency.

It is therefore recommended that the clearance is checked at routine inspections and worn parts be replaced as necessary. If the measured wear ring clearance exceeds the critical limit, then we recommend that the efficiency drop is evaluated and replacement of worn parts be considered.

Measure the clearance between the runner blades and the wear ring in a few places to get an average value.

The clearance can vary slightly as the runner might not be perfectly centered due to manufacturing tolerances.



1. Propeller
2. Wear ring
3. Bellmouth
4. Critical clearance

Figure 19: Critical clearance

Hydroturbine	Clearance threshold for efficiency drop, mm (in)
E7556	2 (0.08)

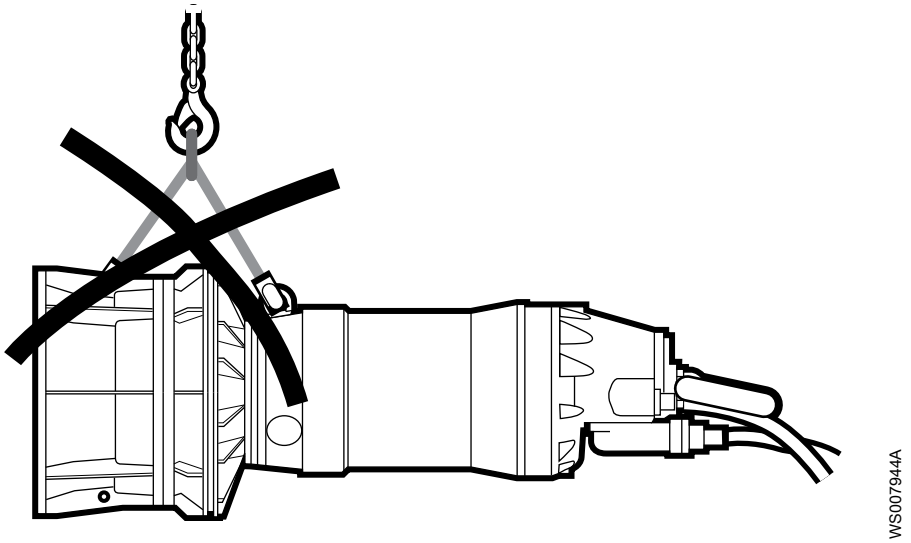
If the measured wear ring clearance is less than the threshold value given in the table above, then the rest of the steps in this section can be omitted. If the measured clearance is greater than the threshold value in the table above, then we recommend that the efficiency drop is evaluated and replacement of worn parts be considered.

6.7.2 Replace the wear ring: hydroturbines without gearbox

Necessary equipment:

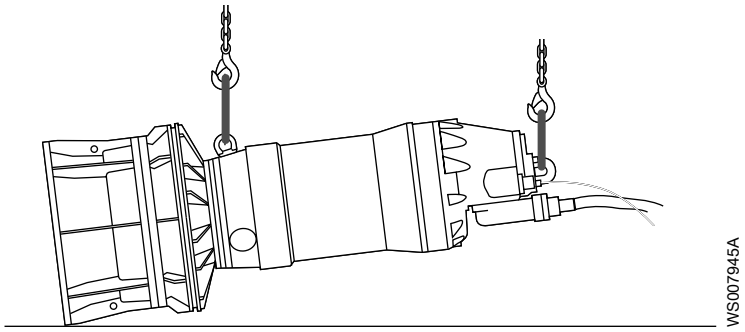
- Lifting equipment with two lifting hooks

An assembled hydroturbine must never be lifted by the holes in the turbine unit.



Remove the wear ring

1. Using two lifting hooks, lay the hydroturbine down on the floor. Support the generator end, for example with wooden blocks.



2. Remove the outlet cone.
   a) Fasten the outlet cone in a sling.
   b) Remove the screws securing the outlet cone.
   c) Pull the outlet cone off of the turbine unit.

      Use care to avoid damaging the runner.

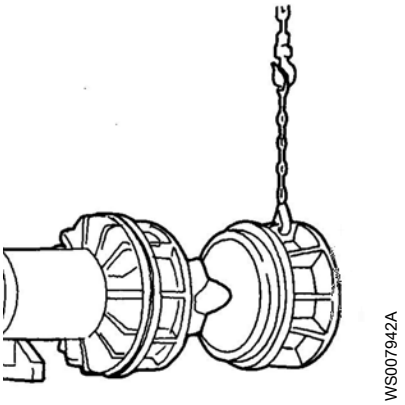


Figure 20: Pulling the outlet cone off of the turbine unit

   d) Remove the bolts that hold the wear ring to the outlet cone.
   e) Set the outlet cone upright.
3. Insert 3 12 mm bolts in the separating holes. Turn the bolts until the wear ring comes loose.
4. Attach lifting eyebolts to the wear ring and lift it out with a lifting device.

Figure 21: Lifting the wear ring out of the outlet cone

Install the wear ring

1. Attach lifting eyebolts to the wear ring.
2. Connect lifting slings to the eye bolts and the lifting device.
3. If there are bolts in the separating holes, then remove them.
4. Lift the wear ring and lower it into the outlet cone.

Figure 22: Lowering the wear ring into the outlet cone

5. Remove the lifting eyebolts from the wear ring.
6. Secure the outlet cone in a sling.
7. Lift the outlet cone with wear ring up, and turn it on its side.
8. Line the outlet cone with wear ring up with the turbine unit.
9. Using care to avoid damaging the runner, maneuver the outlet cone onto the turbine unit.

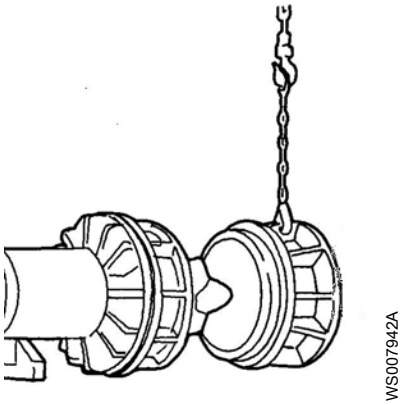


Figure 23: Maneuvering the outlet cone onto the turbine unit

10. Mount the screws securing the outlet cone to the turbine unit.
11. Return the hydroturbine to the upright position.

6.7.3 Replace the runner

If it is necessary to replace the runner, then contact your Xylem representative.

6.8 Horizontal lifting: hydroturbines without gearboxes

This information is applicable to hydroturbines without gearboxes.

Two sets of lifting equipment must be used to lift the hydroturbine for repair work.

If the unit will be turned completely upside-down, so that the turbine unit is at the top, then use two slings or straps at the turbine unit. The two slings/straps should be placed directly opposite each other, so that the hydroturbine can hang between them.

The generator unit must never be placed on the shaft unit or the runner. Damage to the runner, seals, or bearings can result from placing the generator unit on the runner or shaft.

To lift the unit in the horizontal position, use the following method.

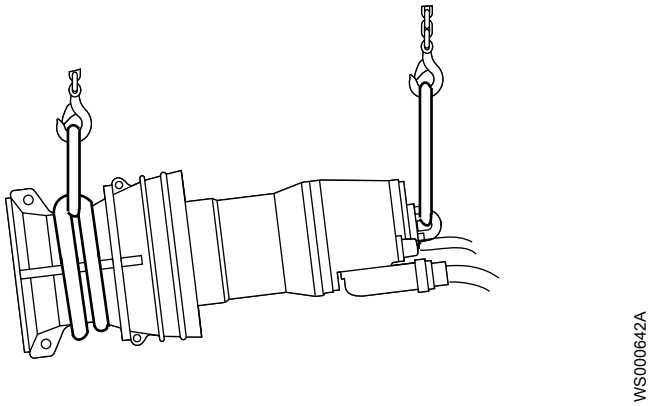


Figure 24: Lifting unit for repair work (generic unit shown)

6.9 Torque values

All screws and nuts must be lubricated to achieve correct tightening torque. Screws that are screwed into stainless steel must have the threads coated with applicable lubricants to prevent seizing.

If there is a question regarding the tightening torques, then contact a sales or authorized service representative.

Screws and nuts

Table 18: Stainless steel, A2 and A4, torque Nm (lbf·ft)

Property class	M4	M5	M6	M8	M10	M12	M16	M20	M24	M30
50	1.0 (0.74)	2.0 (1.5)	3.0 (2.2)	8.0 (5.9)	15 (11)	27 (20)	65 (48)	127 (93.7)	220 (162)	434 (320)
70, 80	2.7 (2)	5.4 (4)	9.0 (6.6)	22 (16)	44 (32)	76 (56)	187 (138)	364 (268)	629 (464)	1240 (915)
100	4.1 (3)	8.1 (6)	14 (10)	34 (25)	66 (49)	115 (84.8)	248 (183)	481 (355)	—	—

Table 19: Steel, torque Nm (lbf·ft)

Property class	M4	M5	M6	M8	M10	M12	M16	M20	M24	M30
8.8	2.9 (2.1)	5.7 (4.2)	9.8 (7.2)	24 (18)	47 (35)	81 (60)	194 (143)	385 (285)	665 (490)	1310 (966.2)
10.9	4.0 (2.9)	8.1 (6)	14 (10)	33 (24)	65 (48)	114 (84)	277 (204)	541 (399)	935 (689)	1840 (1357)
12.9	4.9 (3.6)	9.7 (7.2)	17 (13)	40 (30)	79 (58)	136 (100)	333 (245)	649 (480)	1120 (825.1)	2210 (1630)

Table 20: Brass, torque Nm (lbf·ft)

M5	M8	M10
2.7 (2.0)	11 (8.1)	22 (16.2)

Hexagon screws with countersunk heads

For hexagon socket head screws with countersunk head, maximum torque for all property classes must be 80% of the values for property class 8.8.

7 Technical Reference

7.1 Application limits

Table 21: Process data

Parameter	Value
Liquid temperature	Max. +40°C (+105°F)
Depth of immersion	Max. 20 m (65 ft.)
pH of liquid	pH 5.5–14
Liquid density	Max. 1100 kg/m^3 (9.17 lb per gal.)

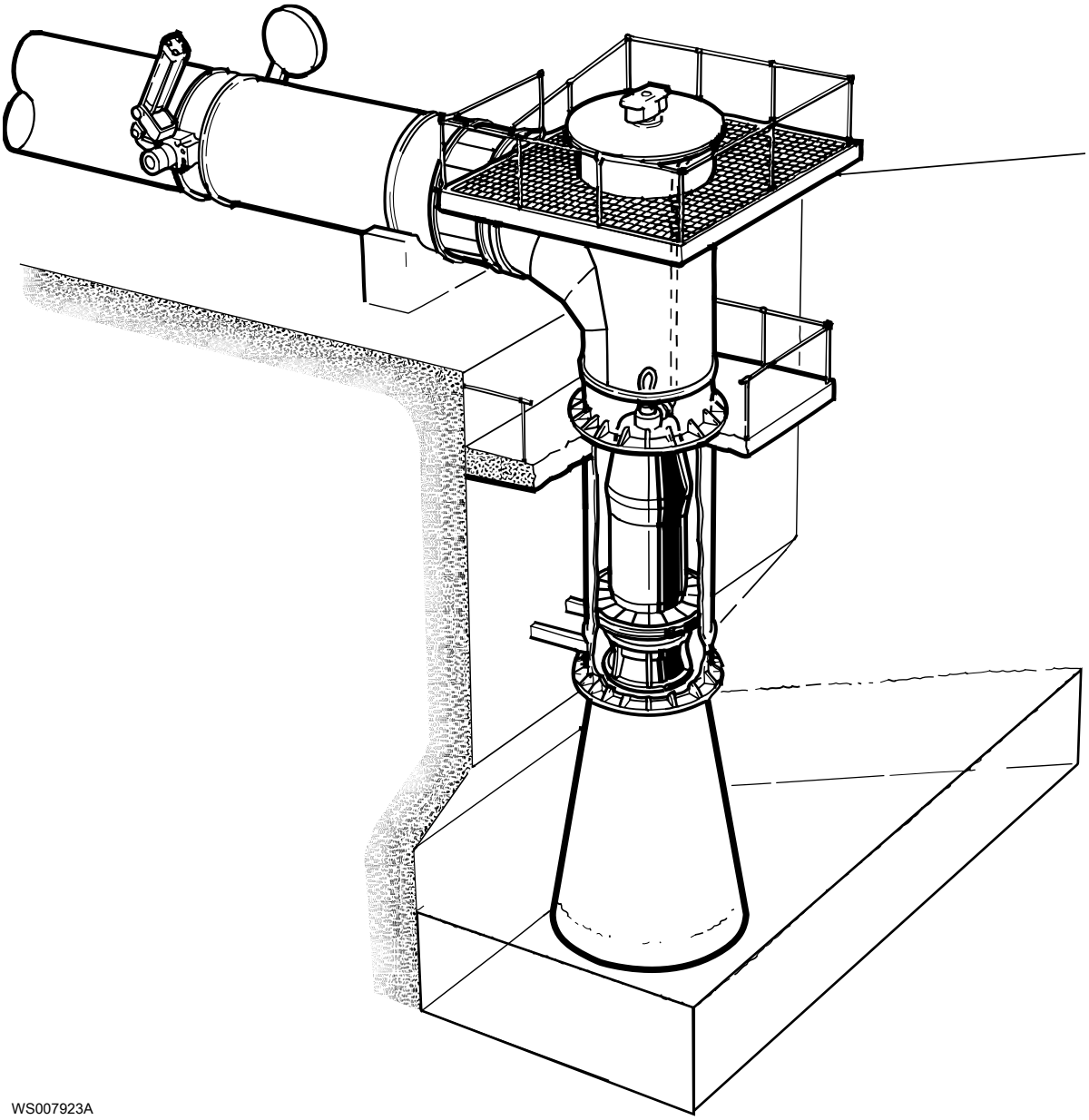
7.2 Pt100 resistance

This table shows the relationship between temperature (°C) and resistance (ohms).

T, °C	R, ohms	T, °C	R, ohms	T, °C	R, ohms	T, °C	R, ohms	T, °C	R, ohms
0	100.00	33	112.83	66	125.54	99	138.12	132	150.57
1	100.39	34	113.22	67	125.92	100	138.50	133	150.95
2	100.78	35	113.61	68	126.31	101	138.88	134	151.33
3	101.17	36	113.99	69	126.69	102	139.26	135	151.70
4	101.56	37	114.38	70	127.07	103	139.64	136	152.08
5	101.95	38	114.77	71	127.45	104	140.02	137	152.45
6	102.34	39	115.15	72	127.84	105	140.39	138	152.83
7	102.73	40	115.54	73	128.22	106	140.77	139	153.20
8	103.12	41	115.93	74	128.60	107	141.15	140	153.58
9	103.51	42	116.31	75	128.98	108	141.53	141	153.95
10	103.90	43	116.70	76	129.37	109	141.91	142	154.32
11	104.29	44	117.08	77	129.75	110	142.29	143	154.70
12	104.68	45	117.47	78	130.13	111	142.66	144	155.07
13	105.07	46	117.85	79	130.51	112	143.04	145	155.45
14	105.46	47	118.24	80	130.89	113	143.42	146	155.82
15	105.85	48	118.62	81	131.27	114	143.80	147	156.19
16	106.24	49	119.01	82	131.66	115	144.17	148	156.57
17	106.63	50	119.40	83	132.04	116	144.55	149	156.94
18	107.02	51	119.78	84	132.42	117	144.93	150	157.31
19	107.40	52	120.16	85	132.80	118	145.31	151	157.69
20	107.79	53	120.55	86	133.18	119	145.68	152	158.06
21	108.18	54	120.93	87	133.56	120	146.06	153	158.43
22	108.57	55	121.32	88	133.94	121	146.44	154	158.81
23	108.96	56	121.70	89	134.32	122	146.81	155	159.18
24	109.35	57	122.09	90	134.70	123	147.19	156	159.55
25	109.73	58	122.47	91	135.08	124	147.57	157	159.93
26	110.12	59	122.86	92	135.46	125	147.94	158	160.30
27	110.51	60	123.24	93	135.84	126	148.32	159	160.67
28	110.90	61	123.62	94	136.22	127	148.70	160	161.04

T, °C	R, ohms		T, °C	R, ohms		T, °C	R, ohms		T, °C	R, ohms		T, °C	R, ohms
29	111.28		62	124.01		95	136.60		128	149.07			
30	111.67		63	124.39		96	136.98		129	149.45			
31	111.94		64	124.77		97	137.36		130	149.82			
32	112.45		65	125.16		98	137.74		131	150.20			

7.3 Example installations



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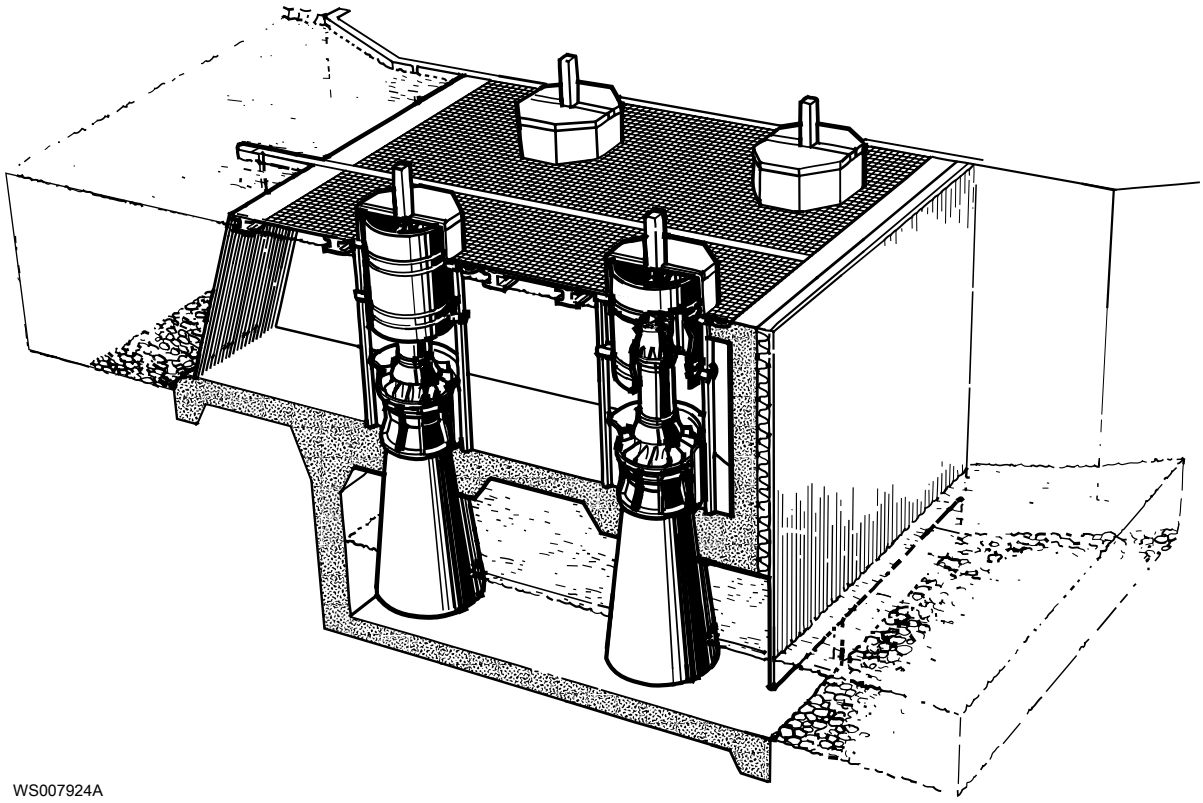

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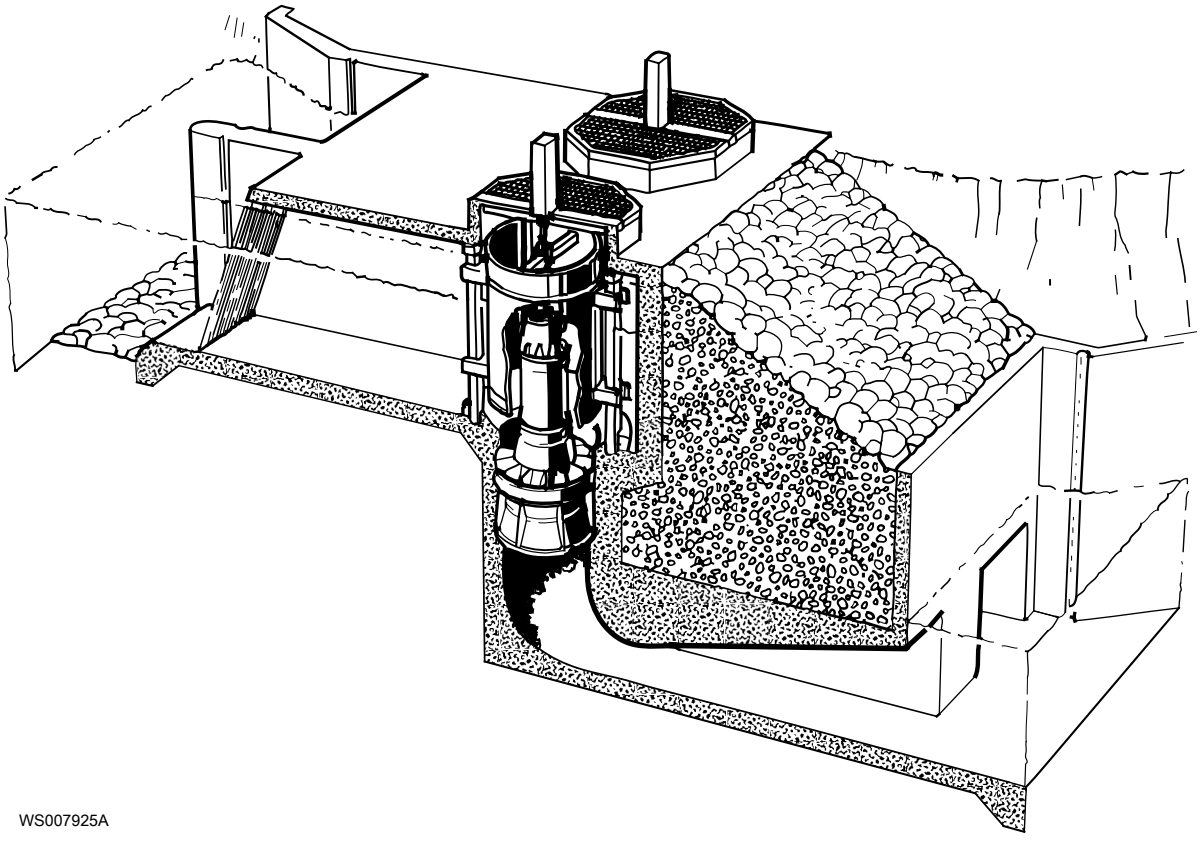

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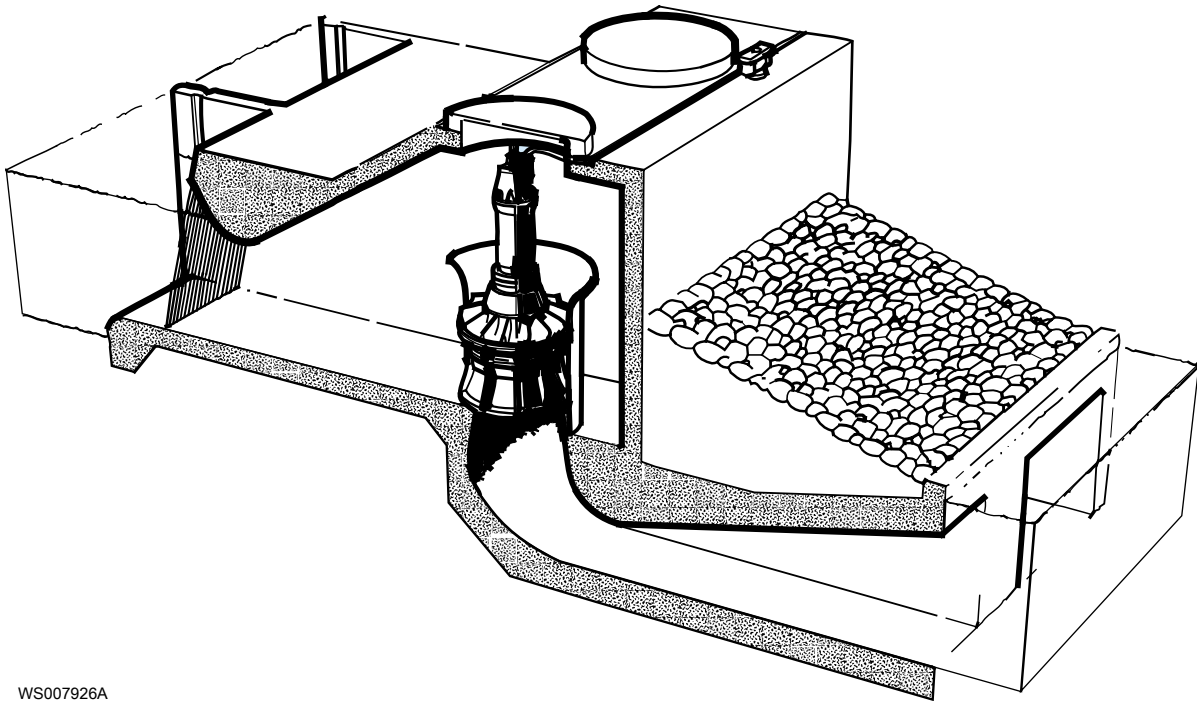

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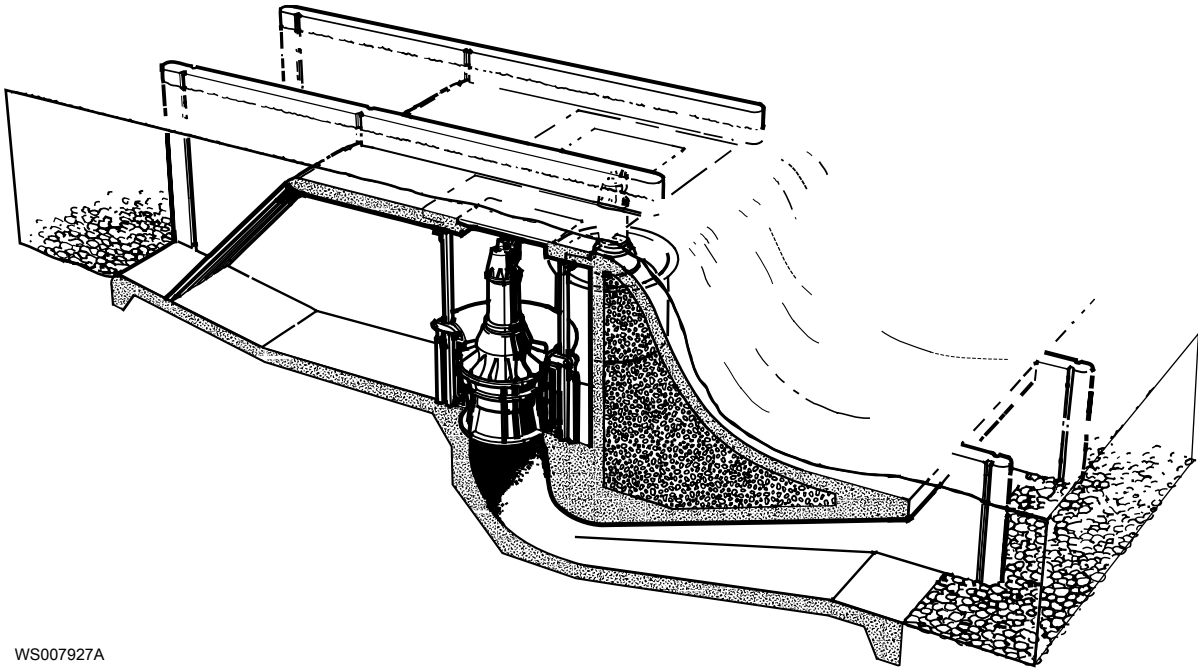

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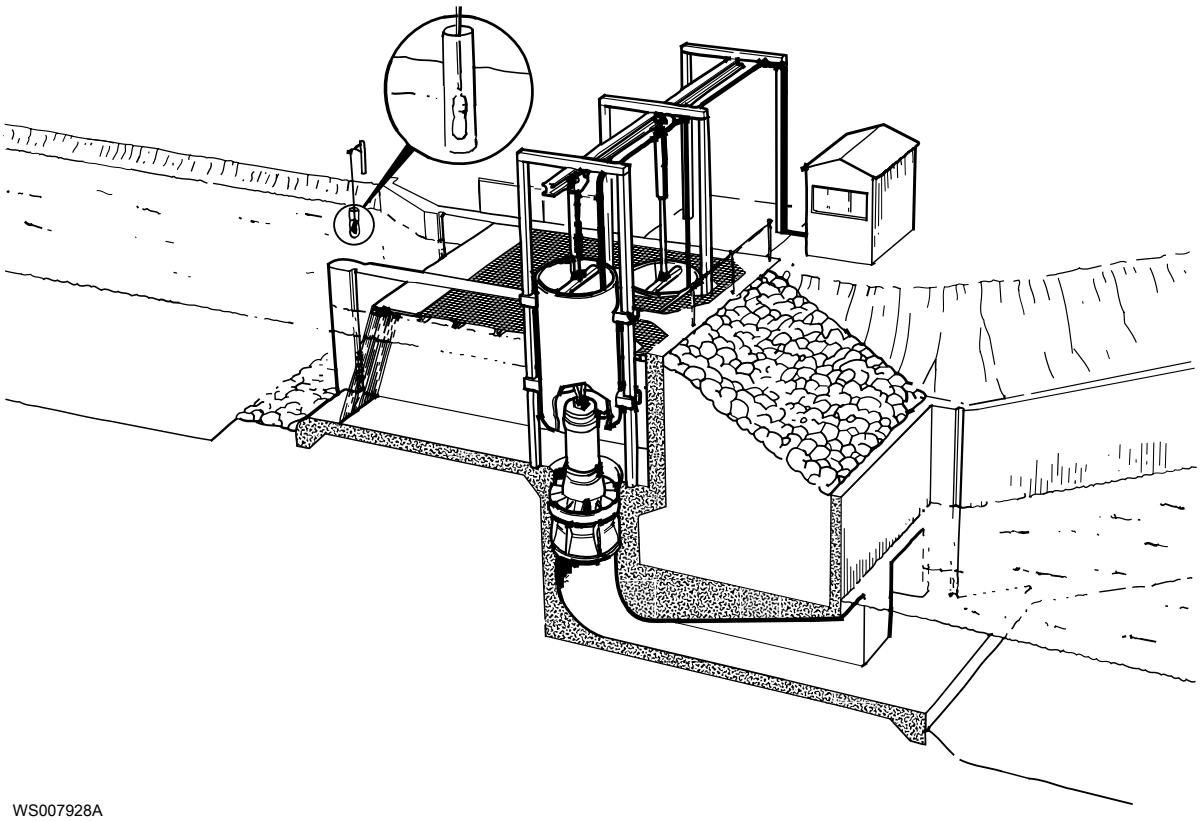

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