Nacelle

Wind Turbine Learning System

FESTO

Renewable Energy

User Guide

Festo Didactic
en
8164382

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User Guide

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Table of Contents

General safety symbols and procedures

The following table lists the safety and common symbols that may be used in this document and on the equipment. Before performing procedures with the equipment, you should read all sections regarding safety in the User Guide accompanying the equipment.

If applicable, following subsections give general procedures related to the tasks you may be asked to perform in this document. Additional safety procedures are given before any task requiring specific safety precautions.

Symbol	Description
	**DANGER** indicates a hazard with a high level of risk, which, if not avoided, will result in death or serious injury.
	**WARNING** indicates a hazard with a medium level of risk, which, if not avoided, could result in death or serious injury.
	**CAUTION** indicates a hazard with a low level of risk, which, if not avoided, could result in minor or moderate injury.
	**NOTICE** indicates a hazard with a potentially hazardous situation, which, if not avoided, may result in property damage.
	Caution, risk of danger. Consult the relevant user documentation.
	Caution, risk of electric shock.
	Caution, lifting hazard.

Symbol	Description
	Caution, hot surface.
	Caution, risk of fire.
	Caution, risk of explosion.
	Caution, belt drive entanglement hazard.
	Caution, chain drive entanglement hazard.
	Caution, gear entanglement hazard.
	Caution, hand crushing hazard.
	Static sensitive contents. Observe precautions for handling electrostatic discharge sensitive devices.
	Notice, non-ionizing radiation.

Symbol	Description
	Consult the relevant user documentation.
	Radio Equipment Directive (RED) geographical restrictions – consult the relevant user documentation.
	Direct current.
	Alternating current.
	Both direct and alternating current.
	Three-phase alternating current.
	Earth (ground) terminal.
	Protective conductor terminal.
	Frame or chassis terminal.
	Equipotentiality.

Symbol	Description
	On (supply).
	Off (supply).
	Equipment protected throughout by double insulation or reinforced insulation.
	In position of a bi-stable push control.
	Out position of a bi-stable push control.

About this document

This document contains the information required to set up, commission, and carry out maintenance on your equipment. However, for specific instructions or information, you may have to refer to the other documents listed in the following table, which form the core documentation for this product.

Table 1: Core documentation.

Name	Type	Part Number
Nacelle – Operation and Maintenance	Instructor Manual	8164378 (paper) 8164379 (electronic)
Nacelle – Operation and Maintenance	Student Manual	8164380 (paper) 8164381 (electronic)

Name	Type	Part Number
Nacelle – Wind Turbine Learning System	User Guide	8164382 (paper) 8164383 (electronic)
Nacelle – Wind Turbine Learning System	Circuit Diagrams	8164384 (paper) 8164385 (electronic)
Nacelle – Wind Turbine Learning System	Read Me First	FDQ663

Important

Documents in the core documentation are part of the product. They contain essential instructions concerning the proper installation, use, maintenance, and commissioning of the equipment. Hence, you must keep the core documentation for the whole life of the product and make it available at all times to the users. Any amendment or addendum is part of the core documentation as well.

If, during the lifetime of the product, part(s) of the core documentation is (are) damaged or missing, please contact your representative to replace the missing document(s).

Since the core documentation is part of the product, you must pass it along to any subsequent holder or user.

Systems of units

Units are expressed using the International System of Units (SI) followed by the units expressed in the U.S. customary system of units (between parentheses).

Tips, feedback, and suggestions

We invite readers to send us their tips, feedback, and suggestions for improving the course.

Please send these to:

services.didactic@festo.com

The authors and Festo Didactic look forward to your comments.

General Requirements for Operating the Devices

Important general note

Safety precautions and regulations are not disruptive, but rather prevent disturbances and enhance safety during use of the system. For this reason, everyone who works with the system must be familiar with safety precautions and regulations and adhere to them. This applies as well to rules and regulations regarding accident prevention at the location of use. Knowledge of these rules, regulations, and precautions are fundamental prerequisites for safe use and trouble-free operation of the Nacelle – Wind Turbine Learning System.

This course includes important instructions for safe use of the Nacelle – Wind Turbine Learning System.

Laboratory/classroom setup

- Residual current devices (RCDs) must protect the test area. Use type B residual current circuit breakers with a residual current rating inferior or equal to 30 mA.
- A supervisor must oversee the test area. A supervisor is a qualified electrician or a person who has the appropriate instruction, has knowledge of the respective safety requirements and safety regulations, and whose training has been accordingly documented.
- No damaged or defective devices may be used. Lockout damaged devices to prevent further use and remove them from the test area.

⚠ WARNING

The ac power outlets in the laboratory or classroom must be protected by overcurrent protection devices.

- Circuit breakers or fuses.

General requirements

General requirements for safe operation of the devices:

- Do not lay cables over hot surfaces. A warning symbol identifies hot surfaces.
- Do not exceed the maximum permissible current loads for cables and devices. Always compare the current ratings of the device, the cable, and the fuse. In the event that these are not the same, use a separate upstream fuse in order to provide appropriate overcurrent protection.
- Always ground devices with an earth terminal. If an earth connection (green-yellow laboratory socket) is available, always connect it to protective earth. Always connect protective earth first (before voltage) and always disconnect it last (after voltage).

Use for intended purpose

The Nacelle – Wind Turbine Learning System has been developed and manufactured exclusively for training and vocational education. Use for intended purpose also encompasses the following:

- The users comply with all instructions included in the manuals
- Respective training companies and/or trainers ensure that all trainees observe the safety precautions described in the accompanying manuals
- Equipment is used for purpose in teaching and training applications
- Equipment safety functions are in flawless condition

Obligations of the operating company

The operating company undertakes to allow only those persons to work with the Nacelle – Wind Turbine Learning System who:

- Are familiar with the basic regulations regarding work safety and accident prevention and have been instructed in the use of the Nacelle – Wind Turbine Learning System.
- Have read and understood the section concerning safety, as well as the safety precautions

Personnel should be tested at regular intervals for safety-conscious work habits.

Obligations of the trainees

All persons who have been entrusted to work with the Nacelle – Wind Turbine Learning System undertake to complete the following steps before beginning work:

- Read the section(s) concerning safety, as well as the safety precautions in this manual
- Familiarize themselves with basic regulations regarding work safety and accident prevention

Dangers associated with the Equipment

The Nacelle – Wind Turbine Learning System is designed in accordance with the state-of-the-art, as well as with recognized safety rules. Nevertheless, life and limb of the user and third parties may be endangered, and the respective machine or other property may be damaged during its use.

The Nacelle – Wind Turbine Learning System may only be used:

- For the intended purpose
- When its safety functions are in perfect condition

⚠ CAUTION

Immediately eliminate any fault that may impair safety.

Guarantee and liability

Our general terms and conditions of sale and delivery are always applicable. These are made available to the operating company no later than on conclusion of the sales contract. Guarantee and liability claims resulting from personal injury and/or property damage are excluded if they can be traced back to one or more of the following causes:

- Use of the Nacelle – Wind Turbine Learning System for other than its intended purpose.
- Improper commissioning and/or operation of the Nacelle – Wind Turbine Learning System.
- Use of the Nacelle – Wind Turbine Learning System with defective safety equipment, or with improperly attached or non-functional safety and protective equipment.
- Non-compliance with instructions included in the core documentation (see Table 1) with regard to commissioning and operation.
- Unauthorized modifications to the Nacelle – Wind Turbine Learning System.
- Improperly executed repairs.
- Disasters resulting from the influence of foreign bodies and acts of God.

Festo Didactic hereby excludes any and all liability for damages suffered by trainees, the training company and/or any third parties, which occur during use of the Nacelle – Wind Turbine Learning System in situations which serve any purpose other than training and/or vocational education, unless such damages have been caused by Festo Didactic due to malicious intent or gross negligence.

Introduction

The Nacelle – Wind Turbine Learning System (see the following figure) is designed for training and vocational education to teach production of electrical energy from wind power. It focuses on operation, troubleshooting, and maintenance of the equipment.

Figure 1: Nacelle – Wind Turbine Learning System.

Trainees must have basic electrical and hydraulic knowledge before using this equipment and a qualified instructor must supervise the training sessions.

This learning system uses industrial grade components to provide an experience as close as possible to field training. However, the complexity and inherent risks associated with industrial components may be present when using the system. Hence, trainees and instructors must understand the principle of operation of the Nacelle – Wind Turbine Learning System before using it.

Diagrams

Overview diagrams of the hydraulic and communication network components of the system are shown in the following figures. The complete electrical plans of the learning system are available in the circuit diagrams (P/N 8164384 or 8164385).

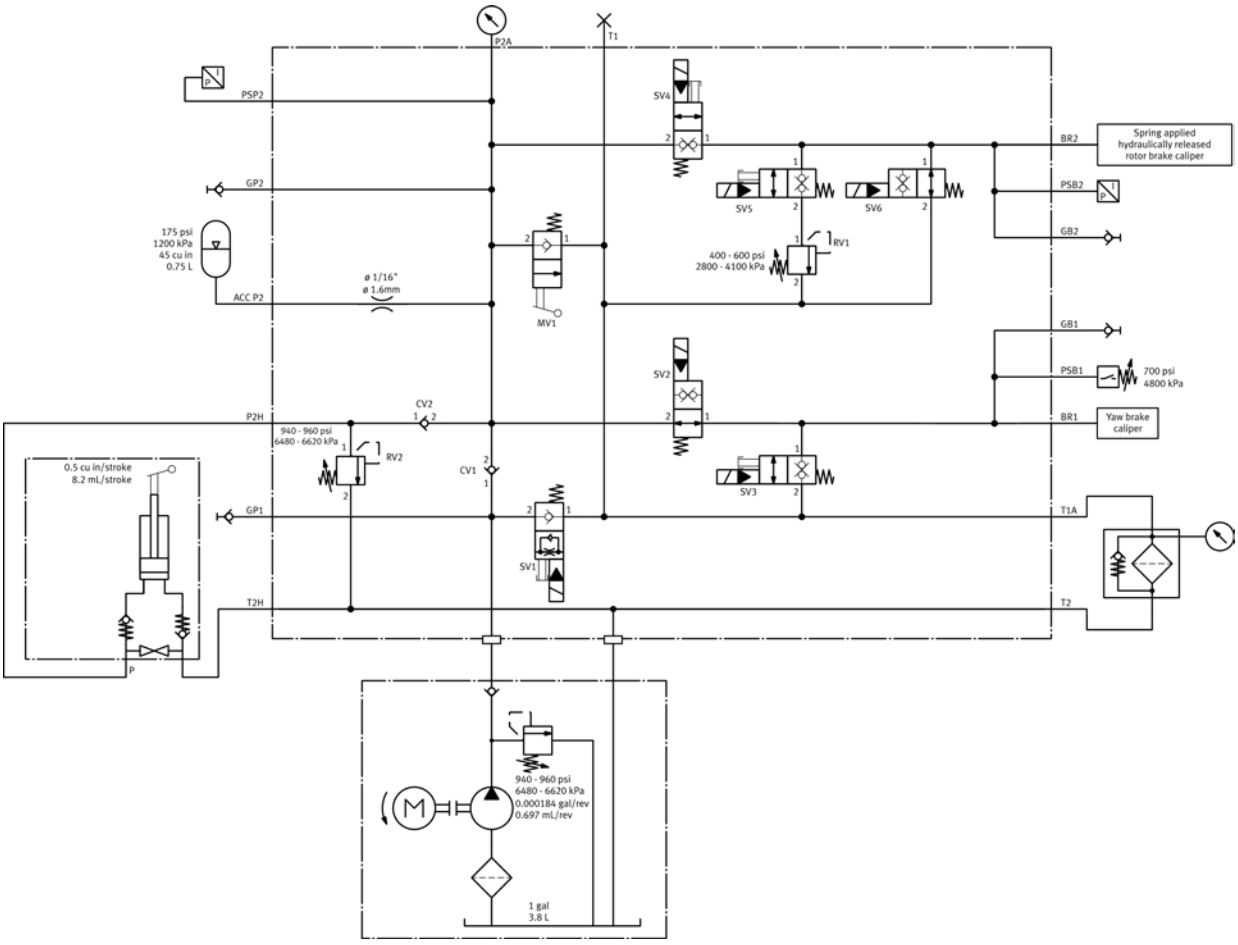

Figure 2: Overview of the hydraulic components.

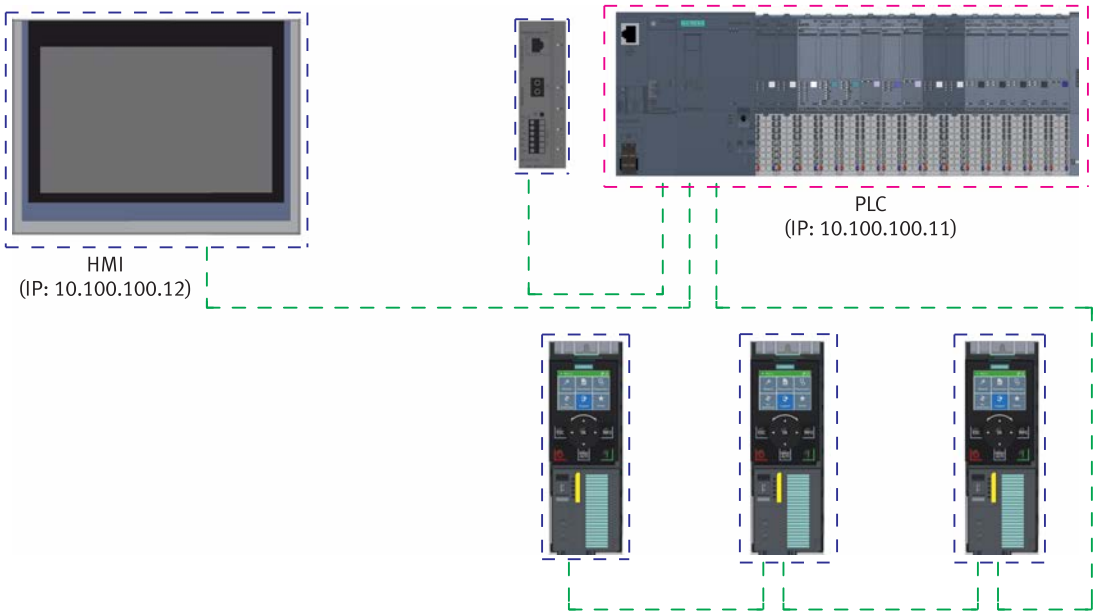

Figure 3: Overview of the communication network.

Mechanical components

Most parts in the learning system can also be found in actual wind turbines. Some components were added to simulate the action of the wind in the context of a classroom. The following figures show the main components of the system.

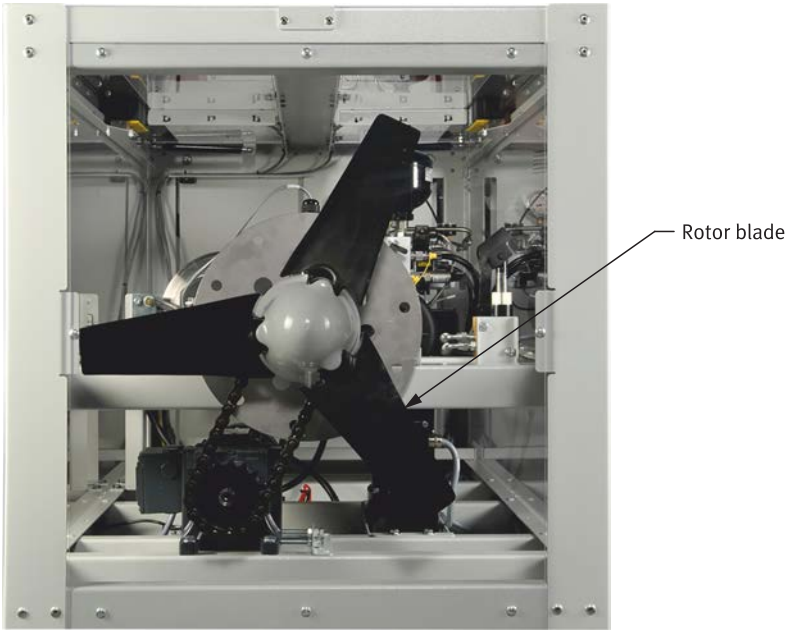

Figure 4: Rotor blades.

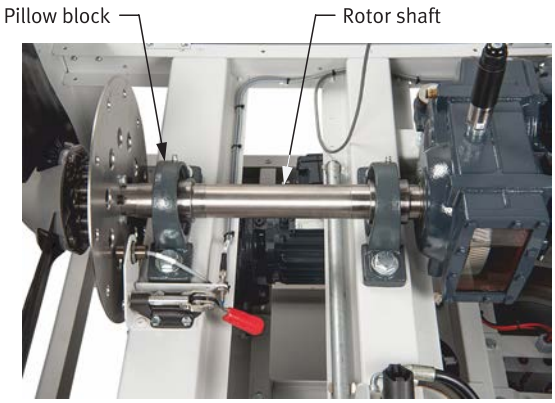

Figure 5: Rotor shaft and pillow blocks.

Figure 6: Gearbox and disk brake.

Figure 7: Generator.

Figure 8: Hydraulic unit.

Figure 9: Hydraulic pressure gauges.

Figure 10: Drive motor.

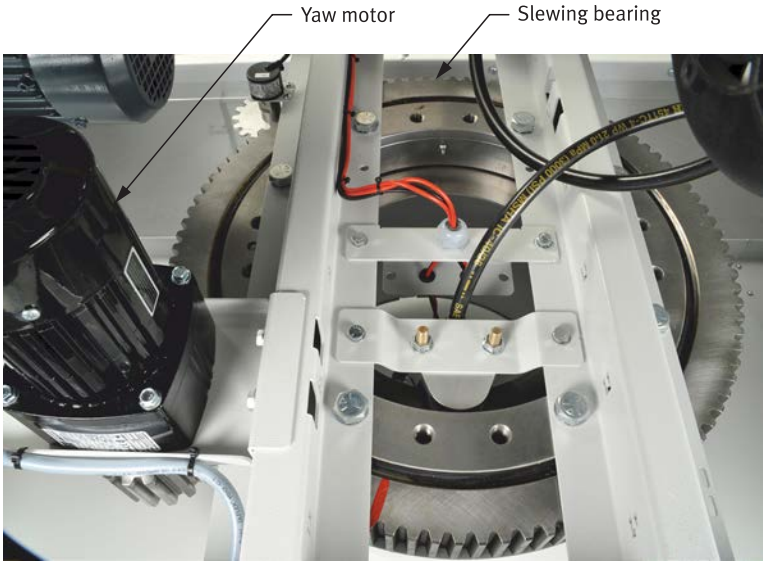

Figure 11: Yaw motor and gear.

Two USB ports are available under the HMI, in the lower left corner. Use those ports to connect a mouse or a keyboard to the HMI.

Figure 12: HMI.

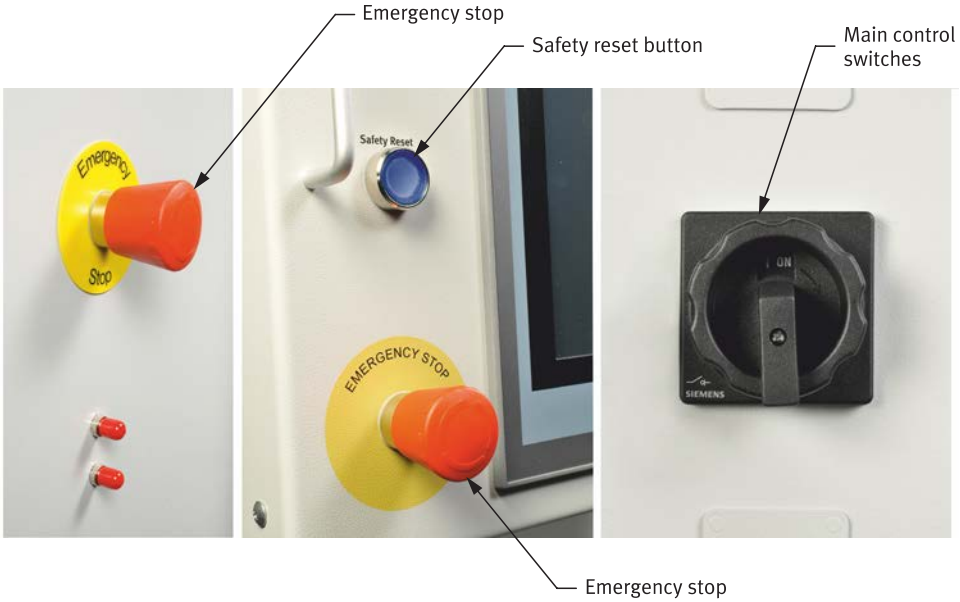

Figure 13: Main control switches.

The learning system has two red-flashing lights. Those lights flash whenever the system is active. They do not indicate any danger on the system; they simulate the aircraft warning lights found on large wind turbines.

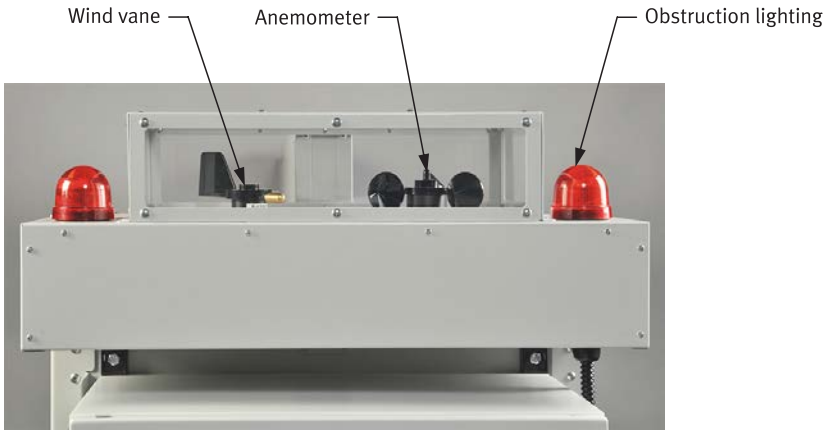

Figure 14: Obstruction lighting and wind measuring devices.

Figure 15: Electrical panel.

Power generation module

The variants of the learning system that feature a power generation module (PN 610875 and PN 610876) include the necessary components to operate and control energy production, as shown in the following figure.

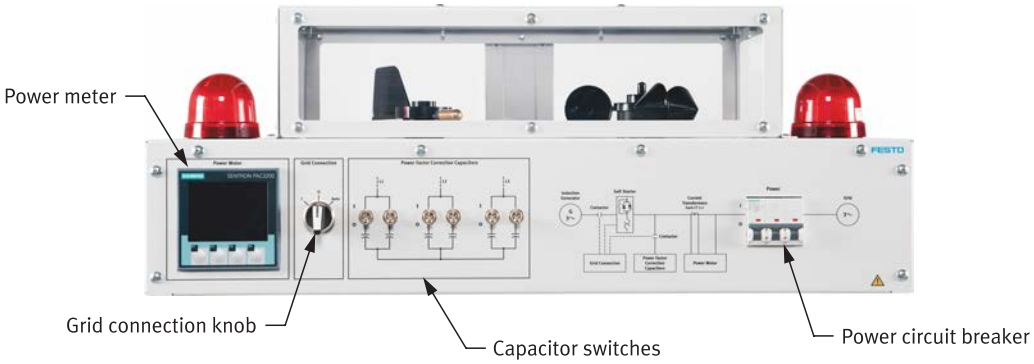

Figure 16: Power generation module.

Indication of conformity

Electrical

The equipment is in conformity with the following directives and standards:

- Machinery Directive 2006/42/EC

- EN 60204-1:2006-06: Safety of machinery – Electrical equipment of machines – Part 1: General requirements

- Electromagnetic Compatibility Directive (EMC) 2014/30/EU
  - IEC 61326-1:2012: Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements
  - EN 55011:2009 (Class A): Industrial, scientific, and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement, modified

- Restriction of the use of certain Hazardous Substances Directives (RoHS) 2011/65/EC
  - EN 50581:2012-09: Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Mechanical

The equipment is in conformity with the following directives and standards:

- Directive 2006/95/EC of the European parliament and of the council of 12 December 2006 (LVD)
  - EN 61010-1:2010-10: European standard – Safety requirements for electrical equipment for measurement, control, and laboratory use

Degrees of ingress protection (IP)

The equipment is rated IP20.

⚠ CAUTION

The equipment is not protected against liquid infiltration or immersion. Keep it away from all types of liquids (except when required for maintenance). Failure to do so could damage the equipment.

EU declaration of conformity

FESTO

(DE) Die alleinige Verantwortung für die Ausstellung dieser Konformitätserklärung trägt der Hersteller. Der beschriebene Gegenstand der Erklärung erfüllt die einschlägigen Harmonisierungsrechtsvorschriften der Union.

(EN) This declaration of conformity is issued under the sole responsibility of the manufacturer. The object of the declaration described is in conformity with the relevant Union harmonisation legislation.

(BG) Настоящата декларация за съответствие е издадена на отговорността на производителя. Предметът на описаната декларация отговаря на съответното законодателство на Съюза за хармонизация.

(CS) Toto prohlášení o shodě se vydává na výhradní odpovědnost výrobce. Popsaný předmět prohlášení je ve shodě s příslušnými harmonizačními právními před-pisy Unie.

(DA) Denne overensstemmelseserklæring udstedes på fabrikantens ansvar. Genstanden for erklæringen, som beskrevet, er i overensstemmelse med den relevante EU-harmoniseringslovgivning.

(EL) Η παρούσα δήλωση συμμόρφωσης εκδίδεται με αποκλειστική ευθύνη του κατασκευαστή. Ο περιγραφόμενος στόχος της δήλωσης είναι σύμφωνος με τη σχετική ενωσιακή νομοθεσία εναρμόνισης.

(ES) La presente declaración de conformidad se expide bajo la exclusiva responsabilidad del fabricante. El objeto de la declaración descrita es conforme con la legislación de armonización pertinente de la Unión.

(ET) Käesolev vastavusdeklaratsioon on välja antud tootja ainuvastutusel. Kirjeldatud deklareeritav toode on kooskõlas asjaomaste liidu ühtlustamisaktidega.

(FI) Tämä vaatimustenmukaisuusvakuutus on annettu valmistajan yksinomaisella vastuulla. Kuvattu vakuutuksen kohde on asiaa koskevan unionin yhdenmukaistamislainsäädännön vaatimusten mukainen.

(FR) La présente déclaration de conformité est établie sous la seule responsabilité du fabricant. L'objet décrit de la déclaration est conforme à la législation d'harmonisation de l'Union applicable.

(HU) Ezt a megfelelőségi nyilatkozatot a gyártó kizárólagos felelősége mellett adják ki. Az ismertetett nyilatko-zat tárgya megfelel a vonatkozó uniós har-monizációs jogszabályoknak.

(IT) La presente dichiarazione di conformità è rilasciata sotto la responsabilità esclusiva del fabbricante. L'oggetto della dichiarazione descritto è conforme alla pertinente normativa di armonizzazione dell'Unione.

(LT) Ši atitikties deklaracija išduota tik gamintojo atsakomybe. Aprašytas deklaracijos objektas atitinka susijusius derinamuosius Sąjungos teisės aktus.

(LV) Šī atbilstības deklarācija ir izdota vienīgi uz ražotāja atbildību. Aprakstītais deklarācijas objekts atbilst attiecīgajam Savienības saskaņošanas tiesību aktam.

(NL) Deze conformiteitsverklaring wordt verstrekt onder volledige verantwoordelijkheid van de fabrikant. Het beschreven voorwerp is in overeenstemming de desbetreffende harmonisatiewetgeving van de Unie.

(PL) Niniejsza deklaracja zgodności wydana zostaje na wyłączną odpowiedzialność producenta. Wymieniony przedmiot niniejszej deklaracji jest zgodny z odnośnymi wymaganiami unijnego prawodawstwa harmonizacyjnego.

(PT) A presente declaração de conformidade é emitida sob a exclusiva responsabilidade do fabricante. O objeto da declaração descrito está em conformidade com a legislação aplicável de harmonização da União.

(RO) Prezenta declarație de conformitate este emisă pe răspunderea exclusivă a producătorului. Obiectul descris al declarației este în conformitate cu legislația relevantă de armonizare a Uniunii.

(SK) Toto vyhlásenie o zhode sa vydáva na vlastnú zodpovednosť výrobcu. Uvedený predmet vyhlásenia je v zhode s príslušnými harmonizačnými právnymi predpismi Únie.

(SL) Za izdajo te izjave o skladnosti je odgovoren izključno proizvajalec. Opisani predmet izjave je v skladu z ustrezno zakonodajo Unije o harmonizaciji.

(SV) Denna försäkran om överensstämmelse utfärdas på tillverkarens eget ansvar. Föremålet för försäkran överensstämmer med den relevanta harmoniserade unionslagstiftningen.

(TR) Bu Uygunluk Belgesi tamamen üreticinin sorumluluğu altındadır. Belgede açıklanan obje, Birliğin ilgili uyum mevzuatına uygundur.

EG-Konformitätserklärung
EU Declaration of Conformity
Декларация за съответствие на ЕС
Prohlášení o shodě ES
EF-overensstemmelseserklæring
Δήλωζη ζσμμόρθωζης ΕΚ
Declaración de conformidad CE
EÜ vastavusdeklaratsioon
EY-vaatimustenmukaisuusvakuutus
Déclaration CE de conformité
EK megfelelőségi nyilatkozat
Dichiarazione di conformità EU
EB atitikties deklaracija
EK atbilstības deklarācija
EG-verklaring van overeenstemming
Deklaracja zgodności WE
Declaração de conformidade CE
Declarație de conformitate CE
Vyhlásenie o zhode ES
Izjava ES o skladnosti
EG-försäkran om Överensstämmelse

The installation instructions according to the manual have to be followed. The person authorized to compile the technical documents is Philippe Drolet, Product conformity, Festo Didactic Ltée/Ltd. Canada.

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Figure 17: EU declaration of conformity (page 1 of 2).

FESTO

2021-09-03

46122-2C	610874	WIND TURBINE NACELLE
52910-0C	8064358	XFMR ISOLATION
46123-1C	8091729	WIND TURBINE ELE HUB
46124-1C	8095228	WIND TURBINE HYD HUB
88450-1C	8110916	POWER GEN 46122
46122-CC	610876	NACELLE W/ POWER GEN.

2014/35/EU	EN ISO 14121-1:2007 EN ISO 12100:2010 EN 60204-1:2018
2014/30/EU	EN 61326-1: 2013-01
2011/65/EU	IEC 63000:2016-10

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Figure 18: EU declaration of conformity (page 2 of 2).

UK declaration of conformity

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2021-09-03

UK Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the manufacturer. The object of the declaration described is in conformity with the relevant statutory requirements.

Festo Didactic Ltd

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Francis Larrivée
Head of Engineering and Instructional Design

Philippe Drolet
Product Compliance

Figure 19: UK declaration of conformity (page 1 of 2).

FESTO

2021-09-03

46122-2C	610874	WIND TURBINE NACELLE
52910-0C	8064358	XFMR ISOLATION
46123-1C	8091729	WIND TURBINE ELE HUB
46124-1C	8095228	WIND TURBINE HYD HUB
88450-1C	8110916	POWER GEN 46122
46122-CC	610876	NACELLE W/ POWER GEN.

SI 2016 No. 1101	EN ISO 14121-1:2007 EN ISO 12100:2010 EN 60204-1:2018
SI 2016 No. 1091	EN 61326-1: 2013-01
SI 2012 No. 3032	IEC 63000:2016-10

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Figure 20: UK declaration of conformity (page 2 of 2).

Product identification

The product identification labels are reproduced in the following figures.

Figure 21: Ratings label.

Figure 22: CE label.

The location of the product identification details is shown in the following figure.

Figure 23: Location of the product identification details.

Other labels

Figure 24: Pressurized tank label.

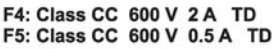

Figure 25: Fuses label for the 230 V 50/60 Hz version of the learning system.

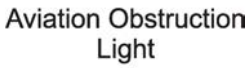

Figure 26: Obstruction lights label.

Safety Precautions

Preliminary warning

Even though the equipment has been carefully designed to ensure trainees safety, there are residual risks that cannot be reduced via technical solutions without impairing the learning process. The first and foremost safety measure that must be enforced at all times is the proper supervision of the trainees.

Nothing can replace the supervision and guidance of a qualified instructor. Trainees have an incomplete mastery of the subject. They can make mistakes and most certainly will. That is an essential part of the learning process.

The role of the instructor is to let trainees make mistakes that have no consequences on their safety, while protecting them from mistakes that can have unfortunate consequences.

⚠ CAUTION

Nothing can replace the supervision and guidance of a qualified instructor.

This is a Class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

Warning symbols

The following table lists the symbols that may appear on the equipment. Whenever you encounter one of these symbols, you must refer to the present documentation. Those are warning symbols indicating potential hazards. Specific actions may be required to ensure your safety and prevent damage to the equipment. Other common symbols that could be found on the equipment or in the manuals are listed in the Safety and Common Symbols section at the beginning of this document.

Table 2: Warning symbols.

Symbol	Description
	Caution, possibility of electric shock
	Caution (documentation must be consulted in all cases where this symbol is marked)
	Caution, hot surface

General warnings

⚠ CAUTION

The solenoids actuating the valves connected to the hydraulic unit can get hot.

A-weighted emission sound pressure level of 80 dB(A) may be present; use the appropriate hearing protection.

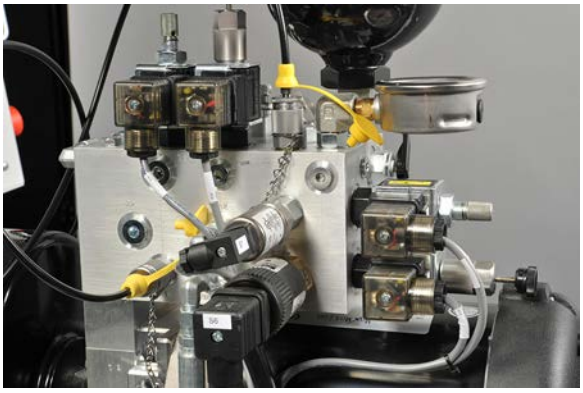

Figure 27: The solenoids of the hydraulic unit can get hot.

⚠ CAUTION

- Make sure the floor around the system is clean and free of liquids at all times to prevent slipping hazards.
- Oil may leak from the hydraulic power unit. Always inspect the system for leaks before operating it.
- Turn the system off when a leak is detected. Do not operate the equipment until the source of the leak has been repaired.
- Leaks can cause floors to become wet. Any spilling of liquid on the floor must be thoroughly cleaned.
- In case of spilling (for example, when changing oil), clean immediately.

Electrical equipment

⚠ DANGER

- Risk of death in case of interrupted protective earth conductor! The protective conductor (green-yellow) must never be interrupted, either inside or outside the device. The insulation of the protective conductor must never be damaged or removed.
- Dangerous voltage! After opening the electrical panel, parts which may be charged with dangerous voltage are accessible. Switch off the power supply before working on the device.
- This device conducts dangerous voltage and controls rotating mechanical parts, which may also be dangerous. Disregard of the warnings and/or non-observance of the instructions included in this manual may result in life-threatening danger, severe bodily injury, or major damage to property.

⚠ CAUTION

High leakage current! Be sure to establish an earth connection before connecting the equipment. Thedevice may only be operated with an additional protective conductor. A terminal is available at thebottom of the device. The protective earth connection must have a cross-section of at least 1.5 mm^2 (EN60204-1).

⚠ CAUTION

- Read the operating instructions carefully!
- These devices may only be worked on by suitable, qualified personnel, and only after theyhave familiarized themselves with all safety, installation, operating, and maintenanceinstructions included in this manual. Successful, hazard-free operation of the device dependson its proper handling, installation, use, and maintenance.

Guards and interlocking of guards

Transparent panels protect the user from most of the equipment that poses potential hazards. Some of those panels can be opened easily, while others cannot be opened without a tool. Panels that can be opened are equipped with safety switches preventing motors from rotating if a panel is open.

This section describes the guards preventing access to hazardous sections of the nacelle; it describes how they should be used, and in which circumstance(s) they should or should not be removed.

Top and side doors

On each side of the nacelle are two transparent panels that can be opened to access the components (see the following figure). Each top and side door has a safety switch hardwired to prevent the motors from rotating if either the top or side door is open. The following figure shows the safety mechanism when the top and side doors are open.

⚠ WARNING

Do not modify or disable the safety switch mechanisms. Do not operate the equipment if a door safetymechanism has been modified or is defective.

Figure 28: Top and side doors.

If a safety switch is defective, have it replaced by a certified technician. Replacement of the switch must be done in accordance with the circuit diagrams (P/N 8164384 or 8164385).

Figure 29: Top doors safety mechanism.

Figure 30: Side doors safety mechanism.

Each of the top doors is equipped with a gas spring to slow down its descent when closing. Nevertheless, the top doors are heavy. Always use both hands to close a top door. The gas spring of one of the top doors is shown in the following figure.

⚠ CAUTION

The two top doors are heavy. Be careful when closing them to avoid crushing your fingers or otherbody parts. Do not let the door fall into place; hold it with both hands when closing it.

If a gas spring is defective, replace it immediately.

Figure 31: Gas spring.

Yaw motor and gears panels

The yaw motor and gears are enclosed on four sides by protective panels, as shown in the following figure. These panels cannot be removed without a tool. They should not be removed unless absolutely required for maintenance.

⚠ CAUTION

Do not operate the equipment if a protective panel is missing or damaged.

Figure 32: Side protective panels.

Wind measuring equipment enclosure

Transparent panels enclose the anemometer and wind vane, as shown in the following figure. Those panels should not be removed.

Figure 33: Measuring equipment enclosure.

Electrical enclosure

The electric panel is in a grounded metallic enclosure. This enclosure is locked, and it should not be opened by the users without the approbation and supervision of a qualified instructor.

Great care must be taken when the electric panel is open; the recommendations of this section should be followed at all times.

⚠ DANGER

Devices in the electrical panel carry potentially lethal currents. It should only be opened by a qualifiedtechnician or under the supervision of an instructor.

Figure 34: Electrical panel.

Figure 35: Lock the electrical panel door to prevent unauthorized access.

Pressure gauge guard

The hoses connected to the two hydraulic pressure gauges are not equipped with check valves. Hence, unscrewing those hoses may lead to a serious hydraulic oil leak. To prevent hoses from being unscrewed from the pressure gauges, a permanent steel guard prevents access to the hose connectors. This guard is riveted to the frame of the system and must not be removed.

⚠ CAUTION

Do not unscrew the hoses from the pressure gauges.

Figure 36: Pressure gauge guards.

Securing the equipment

This section gives general lockout/tagout instructions, and specific procedures to shut down and lockout the nacelle for maintenance or inspection and to restart the system. The system must be locked and tagged anytime maintenance must be performed or whenever the user works on the system with the protective panels opened or removed.

General description of a lockout/tagout procedure

Lockout/tagout procedures are measures taken to ensure that machines or equipment on which personnel are performing service or maintenance are safe and cannot be powered unless every employee is prepared.

The lockout procedure is the installation of a locking mechanism to isolate the main power switch and any other source of energy on a piece of equipment. The objective of the lockout is to physically prevent any unexpected start of machinery. Each person involved in the job must install a padlock to the lockout/ tagout device.

Figure 37: Lockout/tagout hasp, lock, and tag.

The tagout procedure is the installation of a tag to warn that a mechanism was locked. It indicates that no one should attempt to operate the equipment. The tag also indicates the name of the person(s) who can remove the lockout/tagout device.

Prior to any operation of a machine or equipment, tasks that may expose workers to the inadvertent release of hazardous energy must be identified and proper training must be provided to personnel. Sources of hazardous energy may be electrical, mechanical, hydraulic, pneumatic, chemical, thermal, gravitational, or others. To make a machine or equipment safe:

- Notify all affected employees that a procedure is going to be performed on a machine or equipment.
- De-energize the machine or equipment.
- Isolate and block all forms of hazardous energy using locks and/or tags. In general, lockout devices are preferred over tags. If more than one person is assigned to a task, all workers must use a personal and identifiable lock and/or tag at each energy-isolating device. A group lockout/tagout is also possible, providing that all workers are properly protected. The last hole of a locking hasp is usually reserved to accommodate an additional hasp.
- Verify that no one is near the machine or equipment and test if it is possible to start the equipment.

Special additional procedures may be required in cases where dangerous products like chemicals are involved.

When energizing a machine:

- Check that the machine or equipment is ready to operate, that the area is clear and secure, and that guards are positioned correctly.
- Notify all affected employees that the machine or equipment is about to be energized, and check that no worker is within reach of the machine or equipment.

- Remove your own lock and tag and ask the other workers to do the same thing. The machine or equipment must not be energized if a lock has not been removed by its owner.
- Start the equipment and make sure that it is working properly.

System shutdown procedure

1. Make sure that all safety panels are closed.
2. Look around the equipment and make sure no debris is in the way.
3. Install the lockout hasp in the main switch. Next, install the padlocks and tags in the hasp.

Figure 38: Installation of the lockout hasp, padlocks and tags.

4. Try to turn on the main switch to verify that the system is electrically isolated. Press the safety reset button to test whether the system can be energized.
5. Open the front safety panels.
6. Depressurize the accumulator of the hydraulic system by lifting the appropriate lever. Return the lever to the original position once the accumulator is depressurized (i.e., after approximately ten seconds).

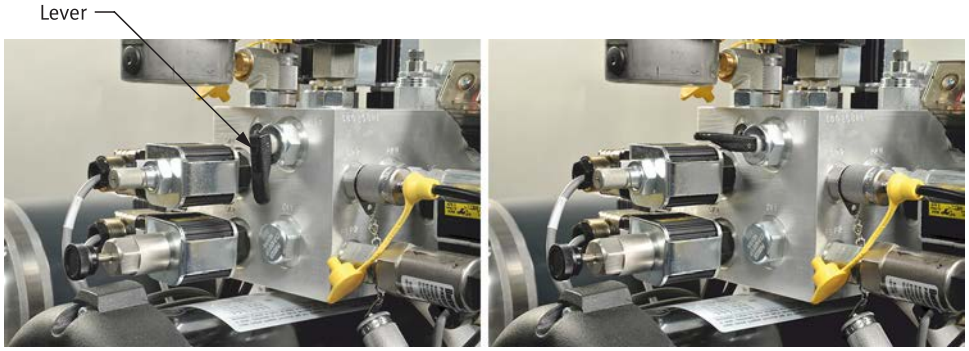

Figure 39: Depressurizing the hydraulic accumulator.

At this point, the system can be considered secure. The safety pin does not lock the rotor hub, but the hydraulic rotor parking brake is on by default.

⚠ CAUTION

Be sure to depressurize the hydraulic accumulator. When the accumulator is still under pressure, components may move or the parking brake can be released inadvertently.

⚠ DANGER

Never unscrew the accumulator. Unscrewing the accumulator when it is pressurized may transform it into a life-threatening projectile.

NOTICE

Only qualified personnel may perform maintenance on the accumulator.

Re-energizing procedure

1. Make sure everything is secure inside and around the nacelle and close all safety panels.
2. Notify all the people working around the nacelle that the system is about to be energized.
3. Ask everyone to remove his or her individual padlock and tag. Next, remove the hasp from the main switch.
4. Ask your instructor for permission to power the learning system. Apply power to the learning system by turning on the main power switch.

5. Wait for the HMI to boot and log into Windows. The HMI should start automatically. The MAIN screen should open with some (flashing red) visual alarms.

The PLC may take a minute or two to boot after the HMI starts.

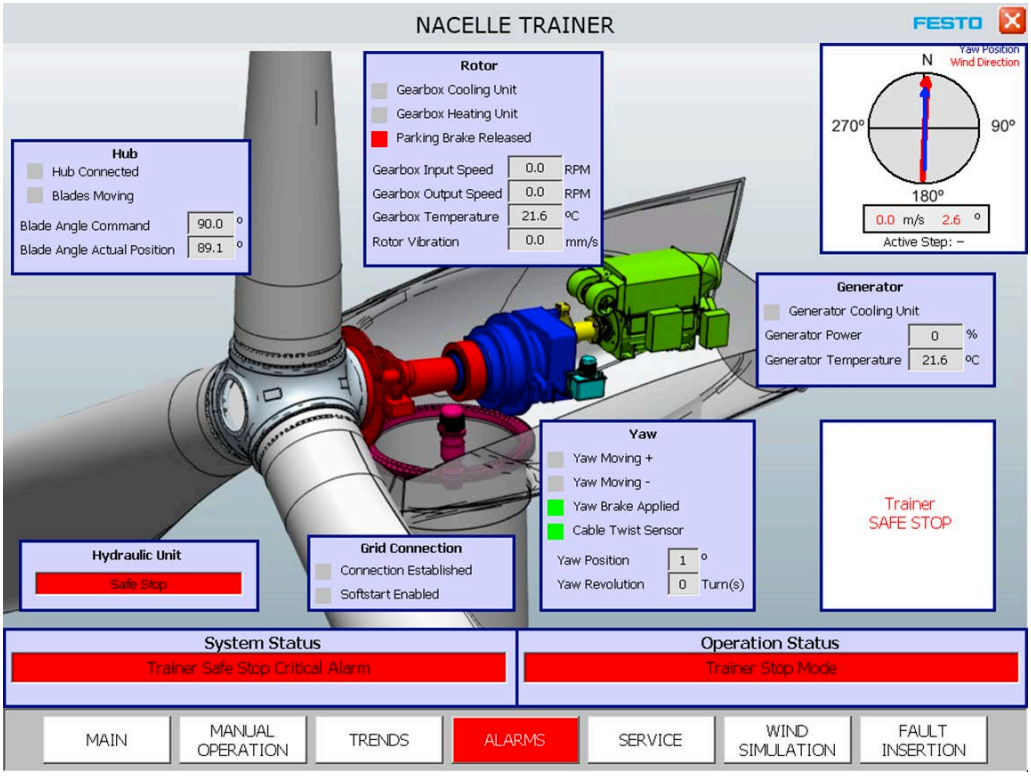

Figure 40: MAIN screen when the HMI starts.

6. Press the safety reset button. The MAIN screen should resemble the following figure.

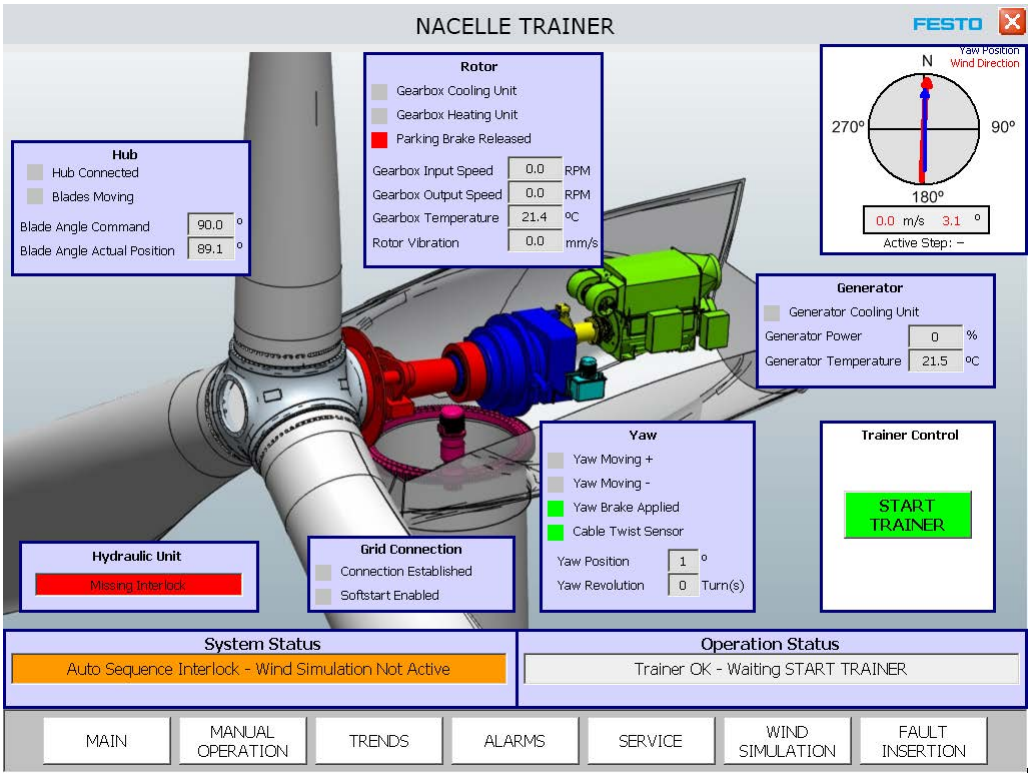

Figure 41: MAIN screen as system starts.

If the ALARMS button is flashing red at this point, press it. In the opening ALARMS screen, press the checkbox in the bottom-right of CURRENT ALARMS to acknowledge each current alarm. Next, press RESET ALARMS, if necessary.

How to work in an electrical panel safely

Maintenance, and some of the exercises in the student manual, requires working in the electrical panel. Whenever working in the electrical panel, remember the following general safety rules.

Working safely inside the electrical box requires you to be alert for potential electric shock hazards and to follow some basic safe operating guidelines. Equipment manufacturers normally supply manuals (or other documentation) with recommendations that should be followed to ensure safe operation. Likewise, local and national building, fire, and electrical codes provide important safety guidelines.

Again, wearing appropriate clothing and protective equipment and using the proper tools is essential to limit the risk of injury. However, it is important to bear in mind that equipment alone is not a substitute for safe work habits and a safe work environment.

Whenever installing, operating, servicing, or maintaining machines and equipment, always follow lockout/tagout procedures as required, use electrically-insulated hand tools, and ensure that proper electrical grounding techniques are implemented. Grounding will ensure that exposed metal parts are never electrically charged, either

by electrostatic build-up or by a shorted power cable, causing potential hazard to the technician. If there is ever a short circuit (e.g., the electrical insulation of a cable fails and the copper wire touches a metal bracket), the path to the earth will make the circuit protection trip.

Personal protective equipment (PPE)

Even with all the safety features implemented on the equipment, there are still residual risks due to misuse or defective part(s). To further reduce the risks of injury, always follow the rules below when using the equipment:

- Wear safety glasses
- Wear safety shoes
- Do not wear anything that might get caught, such as a tie, jewelry, or loose clothing
- Tie long hair
- Clean the working area; it must be free of oil and water

Product modification

Do not modify the equipment without prior written permission of Festo Didactic. This product uses complex industrial components, and some modifications can have undesired consequences on the product integrity or safety.

Technical Data

Table 3: Main specifications of the Nacelle – Wind Turbine Learning System.

Parameter	Subparameter	Main specifications
Power requirements	Nominal voltage and frequency	• Learning systems 610873 and 610875: 120 V/ 60 Hz • Learning systems 610874 and 610876: 230 V 50/60 Hz
	Current	5 A
	Power	1.15 kW
	Service installation	• Learning systems 610873 and 610874: Standard single-phase outlet • Learning systems 610875 and 610876: Three-phase outlet
Power generator	Voltage and frequency	• Learning system 610875: 3-phase, 120 V, 60 HZ • Learning system 610876: 3-phase, 230/400 V, 50/60 Hz
	Current	• Learning system 610875: 1 A • Learning system 610876: 2 A
Physical characteristics	Intended location	On the floor (stands on casters)
	Dimensions (H x W x D)	1660 x 2120 x 760 mm (65 x 83 x 30 in)

Parameter	Subparameter	Main specifications
	Net weight	• Learning systems 610873 and 610874: 430 kg (948 lb) • Learning system 610875: 445 kg (981 lb) • Learning system 610876: 469 kg (1034 lb)
Yaw system	Slewing bearing	520 mm (20.5 in) steel, external teeth
	Gear motor	125 W (1/6 hp), 28 rpm
	Hydraulic brake	Single-acting, hydraulically-applied
Drive train (low-speed side)	Gear motor	555 W (0.73 hp), 50 rpm
	Main shaft size (L x D)	610 x 45 mm (24 x 1.8 in)
	Speed sensor	Inductive proximity switch
	Vibration sensor	4-20 mA feedback
	Quantity of pillow blocks	2
Gearbox	Ratio	38.53
	Features	Lexan window on the side, magnetic plug, breather, sight-glass plug, shrink-disc connection
	Oil	1.6 L (0.42 gal) of synthetic oil CLP ISO PAO VG220
Drive train (high-speed side)	Coupling	Torsion-proof multi-disc coupling
	Braking disc diameter	254 mm (10 in)
	Hydraulic brake	Spring-applied, hydraulically released

Parameter	Subparameter	Main specifications
Induction generator	Nominal rating	249 W (1/3 hp) – 208 V – 1.7 A
	Number of poles	4
Electrical panel	Content	Contactors, breakers, fuses, power supplies (24 V dc and 5 V dc), variable frequency drives, remote inputs/outputs, disconnect switch, emergency button
	Remote inputs/ outputs types	24 V dc digital inputs, relay outputs, 4-20 mA analog inputs, 0-10 V analog inputs, high-speed counters, 0-10 V analog outputs, thermocouple inputs
Hydraulic unit	Operating pressure	5700 to 6400 kPa (825 to 925 psi)
	Reservoir	3.8 L (1 gal)
	Oil type	ISO32 or AW32
	Motor	370 W (0.5 hp)
	Content	Relief valves, adjustable pressure switch, pressure transmitters, two pressure gauges (which can be connected at different points in the unit), and one fixed accumulator gauge.
Weather sensors	Anemometer	Pulse signal
	Wind vane	0-5 V dc signal
PLC and HMI	PLC model	SIEMENS 1512SP F-1 PN CPU for ET200SP
	HMI model	SIEMENS SIMATIC HMI TP1500 COMFORT, Touch Panel with PROFINET and MPI/PROFIBUS DP INTERFACE
	Programming	No PLC programming or HMI development required by the end-user
	Communication Protocols	Ethernet (PROFINET), USB

Parameter	Subparameter	Main specifications
	Program and HMI features	• Monitoring and control of each section of the nacelle • Alarms management • Service and troubleshooting • Historical trends of several operation values • Fault insertion through the HMI • Automatic/manual operation • Wind simulation pattern configuration
Included accessories		Padlock and danger tags, oil accessories (pan, bucket, tubing, measuring cup, etc.), coupling alignment tool, grease gun and tube, torque wrench, standard wrenches, hex keys, shims.

Electrical requirements

This device must be connected to a 120 V/60 Hz or a 230 50/60 Hz electrical network, depending on the version of the system (see Technical data), that cannot provide a current above 16 A.

The earth terminal must always be grounded, and the green-yellow wire must always be connected to protective earth. Protective earth must always be connected first (before voltage) and must always be disconnected last (after voltage).

⚠ WARNING

If a Residual Current-operated protective Device (RCD) is to be used, it must be an RCD type B.

Mechanical specifications

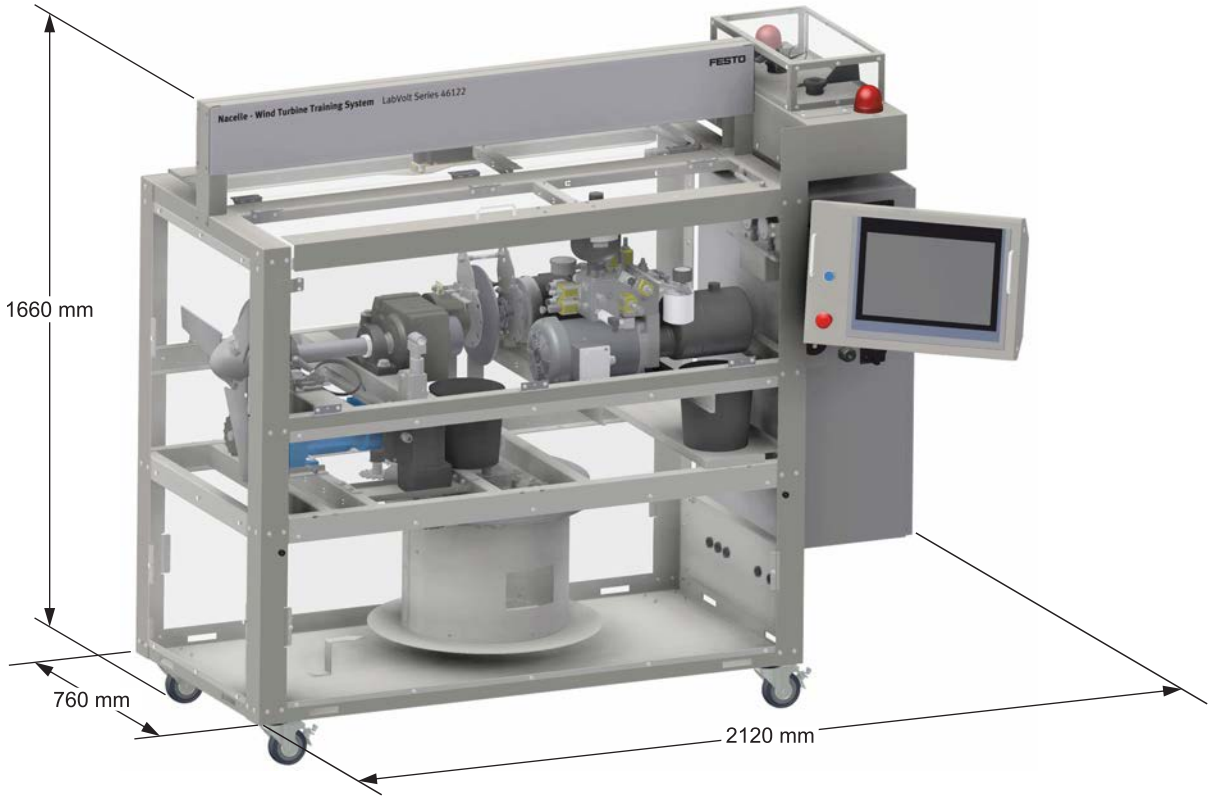

Figure 42: Dimensions.

Transport, Unpacking, Scope of Delivery

Unpacking

Large equipment, such as the Nacelle – Wind Turbine Learning System, is shipped in wooden crates built on a wooden pallet. Only heat-treated wood is used in the packaging according to IPPC standards. Therefore, wooden packaging can be disposed of, or reused without risk of pest proliferation. Paper and cardboard packaging should be recycled in accordance with local regulation.

Upon unpacking your equipment, check that every item on the packing list is present. For your convenience, the packing list is reproduced in this manual. However, in case of discrepancy between the list in this manual and the packing list with the equipment, use the packing list with the equipment. This list is printed when the equipment is packaged, and it should correspond exactly to the equipment shipped.

Packing list, tools, and consumables

The following table lists the equipment shown in the packing lists along with each item's part number. Other consumables and components that may require replacement are listed in the Maintenance section.

Table 4: Packing list equipment.

Name	Quantity	Part Number
Nacelle – Wind Turbine Learning System	1	• 610873 and 610875 (120 V/ 60 Hz version) • 610874 and 610876 (230 V 50/60 Hz version)
Fuse (class CC 600 V, 3 A TD)	2	• 8060744 for learning systems PN 610873 and PN 610875
Fuse (class CC 600 V, 0.5 A TD)	2	• 8060741 for learning systems PN 610873 and PN 610875

Name	Quantity	Part Number
Fuse (class CC 600 V, 2 A TD)	2	• 8060743 for learning systems PN 610874 and PN 610876
Fuse (class CC 600 V, 0.5 A TD)	2	• 8060741 for learning systems PN 610874 and PN 610876
Electrical enclosure key	2	8060737
Shell hydraulic oil S1 M32	19 L	773115
Safety lockout	1	781250
Grease gun	1	776745
Grease	1	8060745
Padlock	2	781251
Drive torque wrench	1	776756
Funnel	1	776759
Hexagonal key (1/4 in)	1	790333
Hexagonal key (6 mm)	1	790332
Danger tag	2	776151
Shims (0.005 in)	1	776155
Shims (0.010 in)	1	776156
Shims (0.020 in)	1	776157
Shims (0.030 in)	1	776158
Socket (10 mm)	1	8158392
Oil bucket	1	785284

Name	Quantity	Part Number
Filter wrench	1	785287
Steel funnel	1	785285
Oil filter	1	8060742
Bucket lid	2	765697
Measuring cup	1	763956
Plastic tubing	0.6 m (2 feet)	773588
Wrench (3/4 in)	2	774881
Wrench (13 mm)	1	774882
Wrench (1/2 in)	2	781464
Wrench (9/16 in)	2	787065
Wrench (10 mm)	2	8099833
Wrench (16 mm)	1	8158393
Wrench (1/4 in)	1	785286
Pillow block	1	776162
Bucket	2	765696
Stylus indicator alignment kit	1	792259
Storage case (Systainer)	1	780025
Power cord	1	• 582145 for the 120 V/60 Hz learning system (PN 610873) • 582146 for the 230 V 50/60 Hz learning system (PN 610874)

Transport

The learning system has sturdy swivel casters, which makes it easy to move around. However, to prevent accidents, lock the casters when you do not move the system.

⚠ CAUTION

Always lock the casters when using the learning system.

Figure 43: Lock the swivel casters.

The learning system is heavy; use it and move it only on a flat floor.

⚠ DANGER

Once the learning system is out of its packaging, it is not recommended to move it using a forklift. However, if you do so, bear in mind that most of the learning system's weight is located on the electrical panel side. Incorrect positioning of the forks could cause the learning system to tilt and fall. This could damage the equipment and cause serious injuries to nearby personnel.

Moving parts

Some of the nacelle components, such as the HMI, the protective panels, and the electrical-panel door, are equipped with hinges to open or move them easily. However, those components can be hazardous when the system is moved. Whenever you need to move the system, follow the precautions below to reduce risks of injuries or damages.

⚠ CAUTION

- Always close the security panels before moving the system. The two top doors are heavy and could cause injury if they fall during transport.
- Always close and lock the electrical panel door before moving the system.
- When moving the learning system, place the HMI close to the frame of the system by collapsing the HMI mount as much as possible.

Shipping to a new location

If you need to ship the system to a new location, pack it similarly to the way it was packed initially. The pallet on which the system was shipped is a custom pallet, built to protect the system integrity and the casters. Either use the original pallet or build a custom pallet that fits the system.

The system accumulator is charged with pressurized nitrogen. Whether shipping the system by truck, boat, or plane, the carrier must be, at least, notified that it contains pressurized gas. Make sure to conform to the local regulation.

⚠ CAUTION

If shipping the learning system, add a note on the waybill such as:

COMPRESSED GAS, N.O.S./QTY 1/WEIGHT 3.2 KG (7LBS)/CLASS 2.2/UN1956

24 HRS CONTACT PERSON: CONTACTNAME (Phone: xxx-xxx-xxxx)

Disposal

Do not discard this equipment with normal waste. It contains electrical and electronic components. A specialist must dismantle the product; each component must be recycled or disposed according to your local legislation.

Before dismantling the equipment, a technician must purge the nitrogen from the accumulator and must drain oil from the gearbox and hydraulic system. Please dispose of the oil according to local regulation.

It is the owners responsibility to make provisions for the equipment recycling and safe disposal.

Layout and Function

Communication

The electrical schematic provides information on how the PLC communicates with the various devices. The communication standards involved are PROFINET and Ethernet.

PROFINET is an industrial Ethernet networking standard that is often used for real-time automation of manufacturing processes.

By default, the HMI IP address is 10.100.100.12 and the PLC IP address is 10.100.100.11.

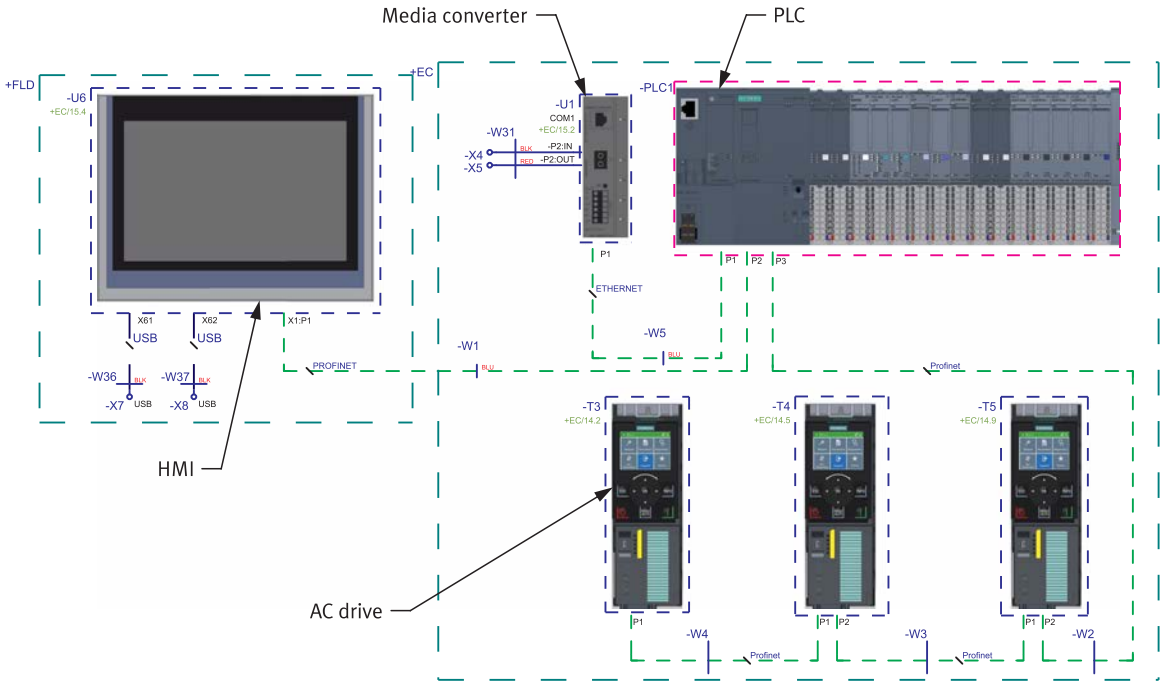

Figure 44: Network arrangement.

Commissioning

Quick start

System preparation

1. Remove all wrapping material.
2. Remove the tie wraps around the vibration sensor.
3. Add approximately 4 L of ISO 32 hydraulic oil to the system (refer to the Hydraulic unit oil and filter change procedure on the Maintenance unit of this document).
4. Install the HMI screen on the mount.

Starting the system

⚠ WARNING

Before operating the equipment, verify that the phase sequence at the power supply terminals is 1-2-3. If the sequence is incorrect, have a qualified electrician correct the wiring.

1. Make sure the main switch is off and everything is secure inside and around the system.
2. Open the safety panels and position the vibration sensor on the first pillow block.

⚠ CAUTION

Never let the vibration sensor cable run near moving parts as it could be stuck and become damaged.

3. Close all safety panels.
4. Notify all the people working around the nacelle that the system is about to be energized.
5. Turn on the main power switch. Wait for the HMI to boot and log into Windows. The HMI should start automatically.
6. Press the safety reset button.

Figure 45: Never let the vibration sensor cable run near moving parts as it could be stuck and become damaged.

Changing the HMI language

The HMI is available in four languages: English, French, Spanish, and German. To change the language of the HMI:

1. Select the SERVICE screen.
2. At the top of the TRAINER window, a Languages drop-down list allows changing the HMI language.
3. This drop-down list is password protected. At the prompt, enter the default user: admin and the password: festo.
4. Select the desired language from the drop-down list.

Using the automatic mode

1. Press Start Trainer in the HMI MAIN screen.
2. If the ALARMS button is flashing red at this point, press it. In the ALARMS screen, acknowledge each current alarm. Next, press RESET ALARMS, if necessary.
3. Press START AUTOMATIC in the main screen to change Operation Status to Automatic.

4. In the WIND SIMULATION screen, press START.

Starting the system in manual mode

1. Press Start Trainer in the HMI MAIN screen.
2. If the ALARMS button is flashing red at this point, press it. In the ALARMS screen, acknowledge each current alarm. Next, press RESET ALARMS, if necessary.
3. Then, press MANUAL to change Operation Status to Manual Mode.
4. You can manipulate the nacelle from the MANUAL screen. To rotate the yaw, for example, release the brakes and use the jog buttons.

Bleeding the brakes

To bleed the brakes, perform the procedure shown in the following video:

Bleeding the brakes.

https://lx.festo.com/media/6a5d370636084394a797f8a71b5bac03

Locking the rotor hub

To lock the rotor hub, perform the procedure shown in the following video:

Locking the rotor hub.

https://lx.festo.com/media/42e610ac865b443aae03190bc95c2c5d

Accessing log files

When the system is running, various information and parameters are displayed in the TRENDS section. The data is also recorded in a log file in CSV format. To access the log file, follow the steps below.

1. Click on the X in the upper right corner of the HMI interface to close the window.
2. In the Windows interface, click on the "My Computer'' icon.

3. The log files are located on the ''Storage Card SD'' in the log folder.

4. You can copy those log files on a USB drive. To do so, connect a USB drive to one of the two USB ports available under the HMI, in the lower left corner. Then, proceed to a standard copy and paste operation.

You can connect a mouse or a keyboard to one of the USB ports.

Fault insertion

Instructors can insert faults in the system to help students practice troubleshooting. To insert one or several faults into the system:

1. Press FAULT INSERTION at the bottom of the screen.

2. At the prompt, enter the default user: "admin" and the password: "festo".

3. Press FAULT INSERTION a second time to access the screen shown in the following figure.

4. From this screen, you can enable or disable the fault using the on/off button. You can also set a delay before the fault turns on.

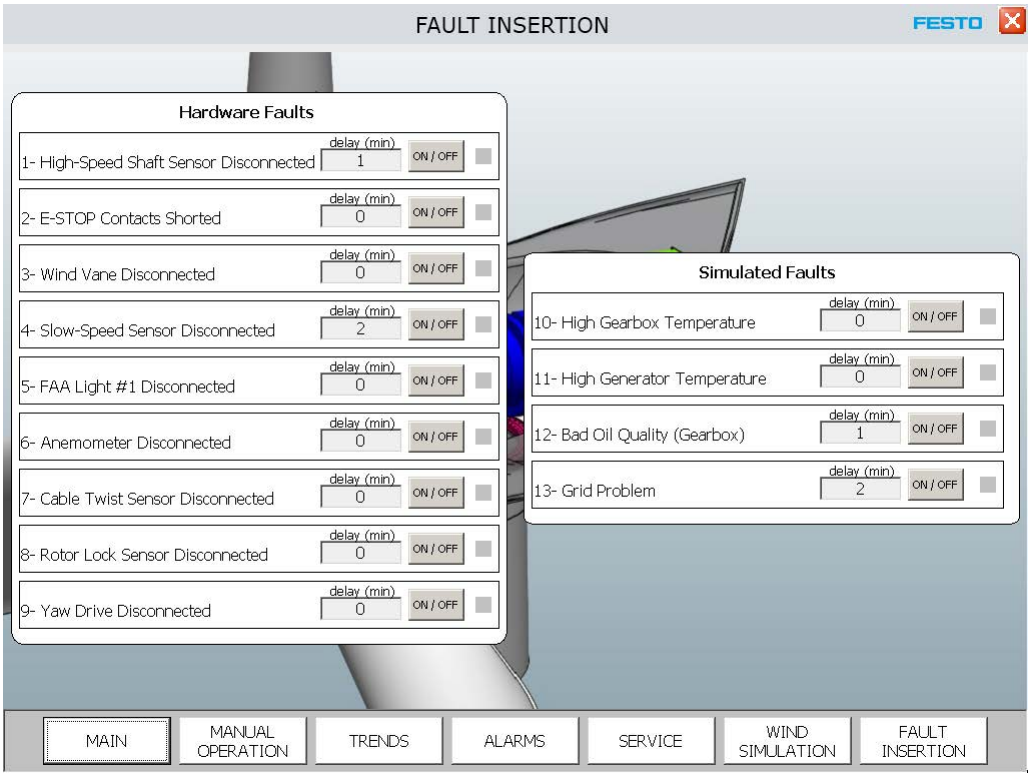

Figure 46: Fault insertion screen.

Maintenance

General note

The learning system requires periodical maintenance. Students will perform some of this maintenance as part of their training. Qualified personnel must periodically perform other maintenance tasks.

Defective or missing components must be replaced immediately. Please contact our service department to order replacement parts and for specific instructions to replace those parts.

⚠ CAUTION

Do not operate the equipment with missing or damaged parts.

Securing the equipment for maintenance

It is of the utmost importance to secure the equipment before performing any of the maintenance tasks described in this section. To do so, follow all the recommendations for securing the equipment given in the Safety Precautions section.

⚠ DANGER

Secure the learning system before performing maintenance. Failing to do so greatly increases the risk of electrocution or limb crushing.

Main power cord

Before each usage, check if the main power cord is damaged. If the cord is damaged, it must be replaced with one of the power cords listed below. Select the type of power line according to your local electrical requirements.

Table 5: Replacement power cords.

Type	Connector angle	Part number
EF (C)	90°	582145
EF (C)	90°	582146
G	90°	582148
H	90°	582149
J	90°	582150
L	90°	582151
N	90°	582152
I	90°	582147
EF (C)	0°	789182
G	0°	789407
H	0°	789408
J	0°	789409
L	0°	789410
N	0°	789411
I	0°	789406

⚠ WARNING

Never use the equipment with a damaged power cord.

Fuse replacement

Four fuses protect the system from overcurrent. Those fuses are located in the electrical panel as shown in the following figure.

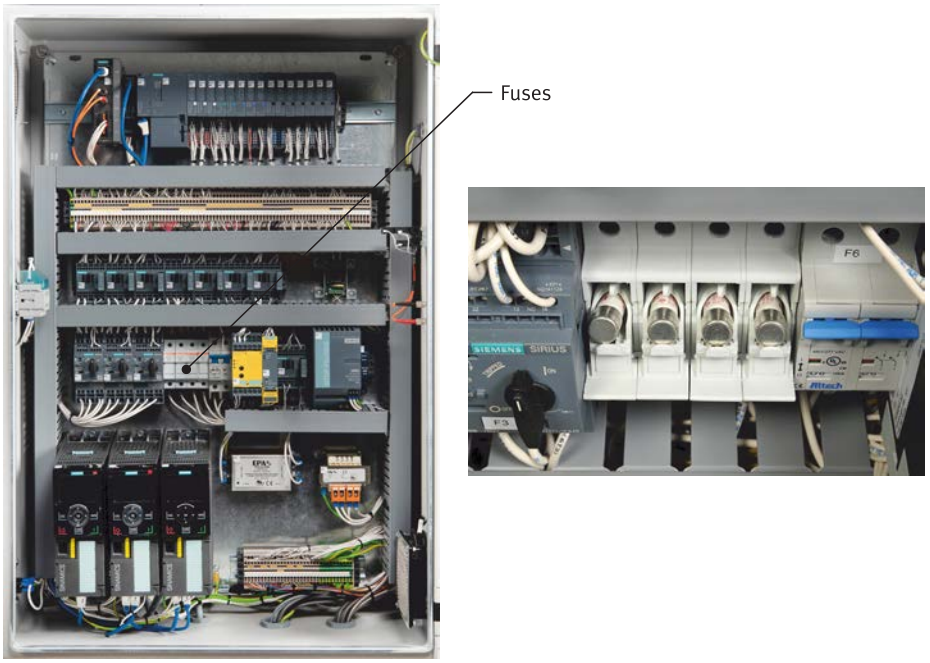

Figure 47: Fuses location.

⚠ CAUTION

- Before replacing a blown fuse, identify and correct the problem that caused the overcurrent.
- Replace a blown fuse with a fuse of the exact same type. Using the wrong type of fuse may cause damage to the equipment or cause injury.

The 230 V 50/60 Hz versions of the learning system (PN 610874 and PN 610876) have two class CC 600 V, 2 A TD fuses, and two class CC 600 V, 0.5 A TD fuses. The 120 V/60 Hz versions (PN 610873 and 610875) have two class CC 600 V, 3 A TD fuses, and two class CC 600 V, 0.5 A TD fuses. The position of each fuse is shown in the following figure for the 230 V 50/60 Hz version of the learning system.

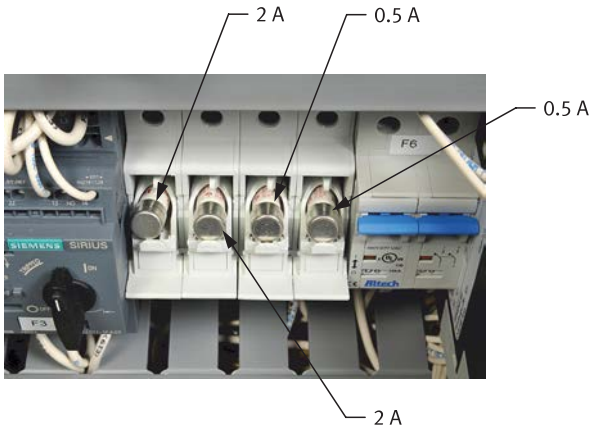

Figure 48: Fuses position.

Consumables and other replaceable equipment

The learning system requires consumables such as oil and grease. It also includes equipment such as cables and fuses that may be lost or damaged during the lifetime of the system. Consumables and replaceable equipment are listed in the Transport, Unpacking, Scope of Delivery section.

Risks for service personnel

This section lists the risks to which service personnel are more likely to be exposed when using or servicing the equipment. It also gives recommendations to reduce those risks.

Risks of pinching

The HMI, the protective panels, and the electrical-panel door are equipped with hinges to open or move them easily. Keep your hand away from these components to reduce risks of pinching injuries.

⚠ CAUTION

- Always close the security panels before moving the system. The two top doors are heavy and could cause injury if they fall during transport. Watch your (and your colleagues) hands and fingers when closing the security panels.
- Always close and lock the electrical panel door before moving the system or when you do not need access to the electrical panel components. Watch your hands and fingers when closing the electrical panel door.
- When extending or moving the HMI mount, watch your hands and fingers.

Risks of cuts and bruises

Be careful not to hit yourself or someone else when using the HMI screen.

⚠ CAUTION

- Watch out for your colleagues before moving or extending the HMI mount.
- When moving the nacelle system, place the HMI close to the frame of the system by collapsing the HMI mount as much as possible. This reduces the risk of being hit by the HMI while moving the system.

The protective panels are there for your security. However, they also limit access to the interior of the nacelle. If something falls into the enclosure, do not bend over into the enclosure. Instead, take time to unscrew one of the side safety panels. Removing a side panel is the safest way to access the bottom of the system for maintenance or to pick-up a fallen object. This also reduces risks of bruises, cuts, and back injuries. Be sure to secure the equipment for maintenance before removing any of the safety panels.

⚠ CAUTION

- Do not bend over into the system enclosure.
- If a safety panel has to be removed, be sure to put it back before using the equipment. Never use the equipment if a safety panel is missing or damaged.
- The electrical cabinet has sharp parts. To reduce the risks of cuts, do not slide your hands or fingers on the cabinet door or enclosure.

Risks of foot injuries

The learning system is heavy, be careful not to crush your or someone else's foot when moving the system.

⚠ CAUTION

To reduce the risks of foot injuries when moving the equipment, always wear safety shoes.

Hot surfaces

⚠ CAUTION

The solenoids on the hydraulic unit may get hot. Avoid touching them.

Frequency of inspection

This equipment is destined to be used by trainees. They may not yet have the experience or background required to detect problems with the system. Therefore, before each use, a technician or the instructor should inspect the system. The system should also be inspected after trainees have used it.

Bolt torque

Like on any real nacelle, bolt loosening can occur on the learning system because of vibration, resulting forces, or thermal differences.

⚠ CAUTION

Never operate the learning system with loosened bolts. Permanent damage to the learning system may result.

A click-type torque wrench is provided with the system, along with a 10 mm socket.

Figure 49: Torque wrench and socket.

Notes on using the torque wrench

To adjust the wrench, pull down on the collar and rotate the handle until you obtain the desired torque value (indicated on the Metric or SAE scale), then release the collar.

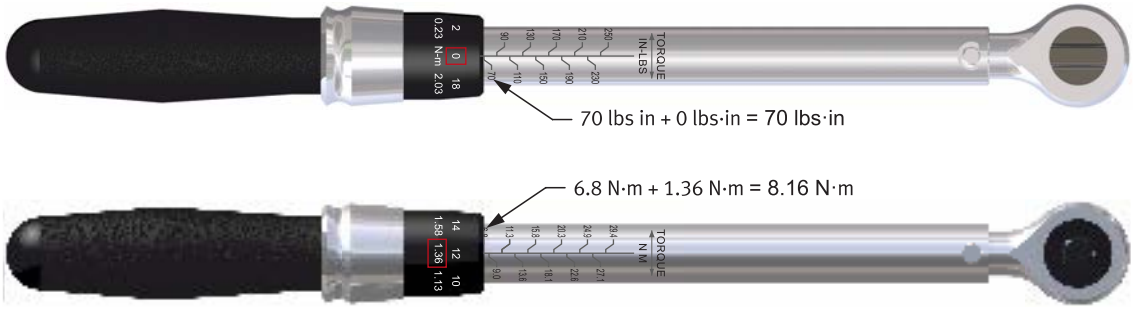

Figure 50: Examples of wrench adjustments (Metric and SAE).

If the torque wrench can be used in reverse direction, it is because some bolts are threaded in the other direction (although not on the nacelle).

To apply torque, attach the proper socket, set the direction of operation properly, and follow the recommendations of the component manufacturer as to how to torque the fasteners. Hold the handle by the grip and apply a slow and steady force.

Usually, you will follow a pattern (criss-cross, clockwise, etc.) and apply only a small torque to the fasteners the first time. You will increase the torque during subsequent rounds until you hear and/or feel a little click for all of the bolts during a single round.

You should always return a torque wrench adjustment to zero after use to maintain the tool calibration.

To tighten a fastener to a lesser torque value, loosen the fastener first before you retighten it. Do not use a torque wrench with excessive force (more than the rated capacity). Always use a different tool (e.g., a ratchet) for disassembly.

Checking bolt torque

1. Take the 3/8 torque wrench and the 10 mm socket.
2. Adjust the torque wrench to 12 N·m (106 lb·in) in the clockwise direction.
3. Verify that each bolt is adjusted to 12 N·m (106 lb·in). Start with the top bolt and proceed clockwise. Go slowly so you can feel the small click (or shock) when the wrench reaches the given torque. Be careful: if you miss the click, you will over-torque the bolt.

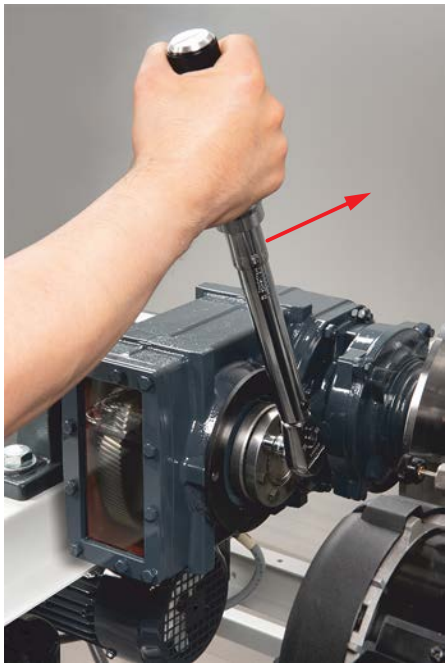

Figure 51: Verifying the torque of a bolt.

4. Return the torque wrench adjustment to zero.
5. Reinstall the gasket and shrink disk cover.

Greasing of the bearings

A grease gun and a grease cartridge are provided to maintain good lubrication of the rotor and yaw bearings. The grease that was selected for the bearings of the low-speed shaft is an NLGI grade 2 lithium multipurpose grease. Grease specifications can be found in the Lubricants, Pump, and Gearbox Specifications unit.

The grease gun model can vary. If you are using a different model, refer to the manufacturer's directions.

Loading the gun

1. Take the grease gun. Pull back the rod handle and lock it.

Unscrewing the barrel while the rod is not pulled and locked can cause a mess.

Figure 52: Locking the rod handle.

2. Unscrew the gun head from the barrel.

Figure 53: Opening the grease gun.

3. Remove the plastic cap.

Figure 54: Removing the plastic cap.

4. Insert the new cartridge, open end first, into the barrel. Push the cartridge until the pull-tab seal is level with the barrel rim.

Figure 55: Inserting a new grease cartridge.

5. Remove the seal.

Figure 56: Removing the seal.

6. Screw the gun head back into place.
7. Unlock the rod handle and push it back to exert pressure on the grease and depress the air bleeder valve to expel air.
8. Pump the lever until grease flows out.

Figure 57: Grease flowing out of the gun.

Using the grease gun

1. Wipe the first pillow block grease fitting with a clean rag to prevent dirt from entering the bearing. Insert your loaded gun coupler into the fitting.

Figure 58: Inserting the grease gun into the pillow block nipple.

2. Pump the gun once in this pillow block.

3. Clean the grease fitting with a rag to prevent dust from sticking to the grease left on the fitting.

Gearbox oil change

1. Open the safety panels.

The pressure breather valve allows the gearbox to compensate for the change of oil volume by letting some air in or out while keeping dirt particles out.

2. Remove the (brass) pressure breather valve using the 13 mm wrench to facilitate draining and pour new oil later.

Figure 59: Opening the pressure breather valve.

3. Position a plastic bucket under the gearbox from the lower safety panel.

Use a clean bucket if you plan to reuse the oil.

4. Take the 6 mm hex key and remove the drain plug.

The first time that you unscrew the drain plug, you may need to remove some paint and apply more force.

Figure 60: Removing the drain plug.

5. Let the oil drain completely. This should take a couple of minutes.

If you change synthetic for mineral oil or vice versa, it is important keep the volume of old oil to a minimum to avoid mixing different types of oil.

6. Clean the drain plug, check the sealing element, and screw the plug back into place.

Filling with some new, clean oil

1. Take the 16 mm wrench and remove the sight glass plug

The sight glass plug is located just above the normal oil level.

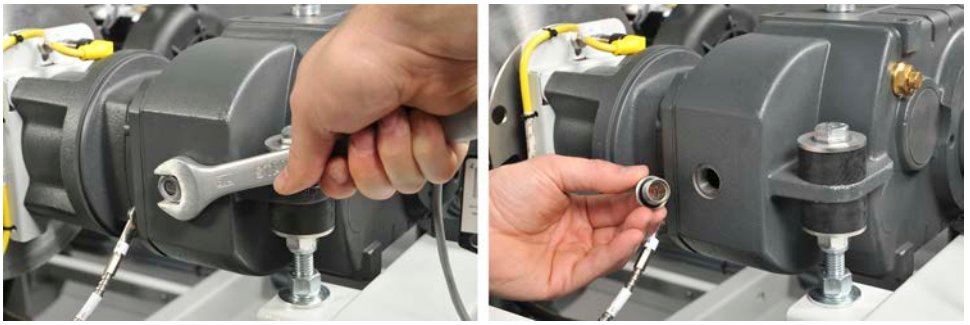

Figure 61: Removing the sight glass plug.

2. Using the metal funnel, pour oil into the gearbox through the breather valve opening. You will need approximately 1.6 L (0.42 gal) of oil. A filled gearbox will have oil up to the bottom of the sight glass plug.

The strainer inside the metal funnel prevents residues from entering the gearbox.

Figure 62: Pouring new oil into the gearbox.

3. Verify that there is no oil leak around the drain plug.

4. Check the condition of the pressure breather valve and sight glass plug. Change their sealing element if necessary and screw them back into place.

Hydraulic unit oil and filter change

1. If GP2 pressure is not zero, actuate valve MV1 for about 10 seconds to discharge the accumulator completely.

If the accumulator is not discharged, that portion of the oil will not be drained.

2. Deactuate valve MV1.

3. Position a plastic bucket under the drain plug at the bottom of the nacelle.

Use a clean bucket if you plan to reuse the oil.

Figure 63: Positioning the bucket.

4. Remove the plug on top of the oil tank.

5. Unscrew the drain plug using a 1/4-inch hex key, let the oil drain, and continue with the next steps.

Figure 64: Unscrewing the drain plug.

6. Put a clean drain pan under the oil filter and use the filter wrench to unscrew the oil filter.

Figure 65: Removing the oil filter.

7. Apply a thin oil coat on the filter seal you are about to use. Oil will help with screwing the filter smoothly and preserve its leak tightness. If you are reusing the same filter, make sure it is still in good condition (seal and body).

Figure 66: Coating the filter seal with oil.

8. Screw the oil filter in place using only your hands.
9. Take the drain plug, make sure the seal is in good condition, and screw it back into place.
10. Put the plastic funnel on top of the tank.
11. Fill the tank with about four liters (one gallon) of oil.

Figure 67: Filling up the hydraulic oil tank.

Be sure to use the four liters (one gallon) bucket to fill the tank. This way, you are sure the content of the tank will fit in the bucket next time you drain the oil.

12. Put the plug back on top of the oil tank.

13. Clean the area and close the safety panels.

Bleeding the rotor brake

1. Install one end of the clear plastic tubing on top of the rotor brake caliper bleed screw. Put the other end of the tubing inside the measuring cup.

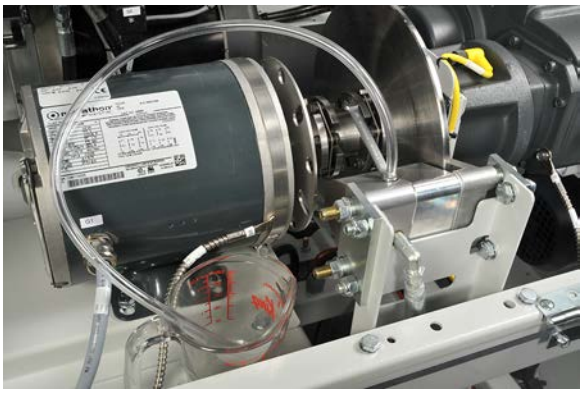

Figure 68: Preparing to bleed the rotor brake.

2. Unscrew the rotor brake caliper bleed screw slowly using the 1/4” wrench. Use the bleed screw on top because air sits on top of the oil.

⚠ CAUTION

Do not unscrew the bleed screw too much or it will come out of the caliper and generate an oil spill.

3. Actuate SV6 and SV4 from the DEBUG Mode in the Service – Hydraulic screen of the HMI so that system pressure is sent to the rotor brake caliper.

4. Use the hand pump to increase pressure. Oil should start to flow out relatively quickly (see the following figure). Oil coming out of the tubing will accumulate in the measuring cup. Keep GB2 pressure below 30 kPa (5 psi).

Bleeding pressure must be low to avoid a big spill if the bleed screw is accidentally unscrewed completely. This also ensures that the bleed screw O-ring does not extrude and become sheared off when tightened.

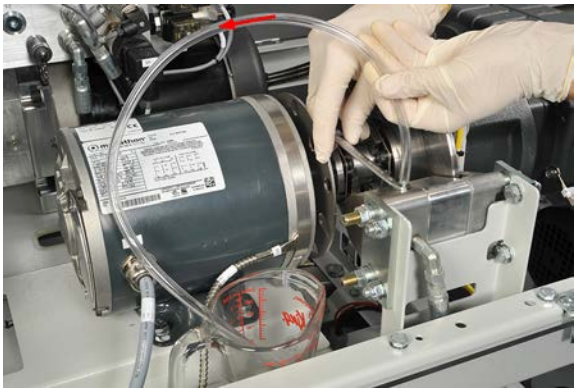

Figure 69: Oil flowing out of the rotor brake caliper.

5. Screw the bleed screw once you have established that no more air bubbles are coming out of the caliper.

6. Disconnect the tubing from the bleed screw.

7. Deactuate SV6 and SV4 from the DEBUG Mode in the Service – Hydraulic screen of the HMI, stop the Debug Mode and make sure that the brake is on.

8. Close the safety panels.

Lubricants, Pump, and Gearbox Specifications

This section provides selected specifications for the lubricants, hydraulic oil filter, hydraulic pump and motor, gearbox, and generator coupling. Specifications of electrical components are provided separately in the circuit diagrams.

Lubricants

Grease

The rotor and yaw bearings, and the drive train chain, must be lubricated using the following grease:

Table 6: Bearings and chain grease specifications.

Recommended product	**Shell Gadus S2 V220, NLGI grade 2**
Part number	8060745
NLGI grade	2
Soap type	Lithium
Base oil	Mineral
Kinematic viscosity @ 40°C	220 cSt
Dropping point	180°C
Cone penetration	265-295

Gearbox oil

The gearbox must be about half full. If the oil level is too low or oil changes colour, the following synthetic or mineral oil can be used as a replacement:

Table 7: Synthetic oil for the gearbox.

Recommended product	**Mobil SHC Gear 220 or equivalent**
Quantity	1.6 L
Oil type	PAO (Polyalphaolefin)
Kinematic viscosity @ 40°C	229.4 cSt
Viscosity index	160
Density @ 15°C	0.881 kg/L
Flash point	250°C
Pour point	-45°C
Service life of the lubricant	20 000 hours/ 4 years (synthetic)

Table 8: Mineral oil for the gearbox.

Recommended product	**Mobilgear 600 XP 220 or equivalent**
Quantity	1.6 L
Oil type	Mineral
Kinematic viscosity @ 40°C	220 cSt
Viscosity index	100
Density @ 15°C	0.899 kg/L
Flash point	199°C
Pour point	-18°C
Service life of the lubricant	10 000 hours / 2 years

Hydraulic oil

The hydraulic oil level in the tank must be half-full when the accumulator is empty.

Table 9: Hydraulic oil.

Recommended product	Shell Hydraulic S1 M32 or equivalent
Part number	773115
ISO fluid type	HM
ISO viscosity grade	32
Technology	Mineral, zinc-based
Kinematic viscosity @ 40°C	32 cSt
Viscosity index	96
Density @ 15°C	0.869 kg/l

Hydraulic oil filter

Table 10: Hydraulic oil filter.

Recommended product	Stauff SF6310-18
Part number	8060742
Filtering paper	10 µm
Diameter	77.5 mm (3.05 in)
Length	87 mm (3.43 in)
Element thread	¾ - 16 UNF
Beta ratio	β10 ≥ 2
Dirt holding capacity	6 g (0.35 oz)
Filtration area	825.2 cm^2 (127.9 in^2)
By-pass setting	124 kPa (18 psi)
Maximum working pressure	1400 kPa (200 psi)

Hydraulic pump and motor

The pump theoretical displacement is 0.000697 L/rev (0.000184 gal/rev). Since the ½ HP motor of the hydraulic unit can rotate at 3450 RPM, the maximum pumped volume is 2.3 L/min (0.6 gal/min).

Gearbox parts

The following two figures show schematics taken from the operating instruction manual of the gearbox included in the learning system. Figure 70 shows a general exploded view of the gearbox, while Figure 71 shows the exploded view of the gearbox adapter. The numbers on the schematics of both exploded views refer to the list in the following table.

This type of gearbox is available in several configurations. The following two figures show the actual configuration used in the learning system.

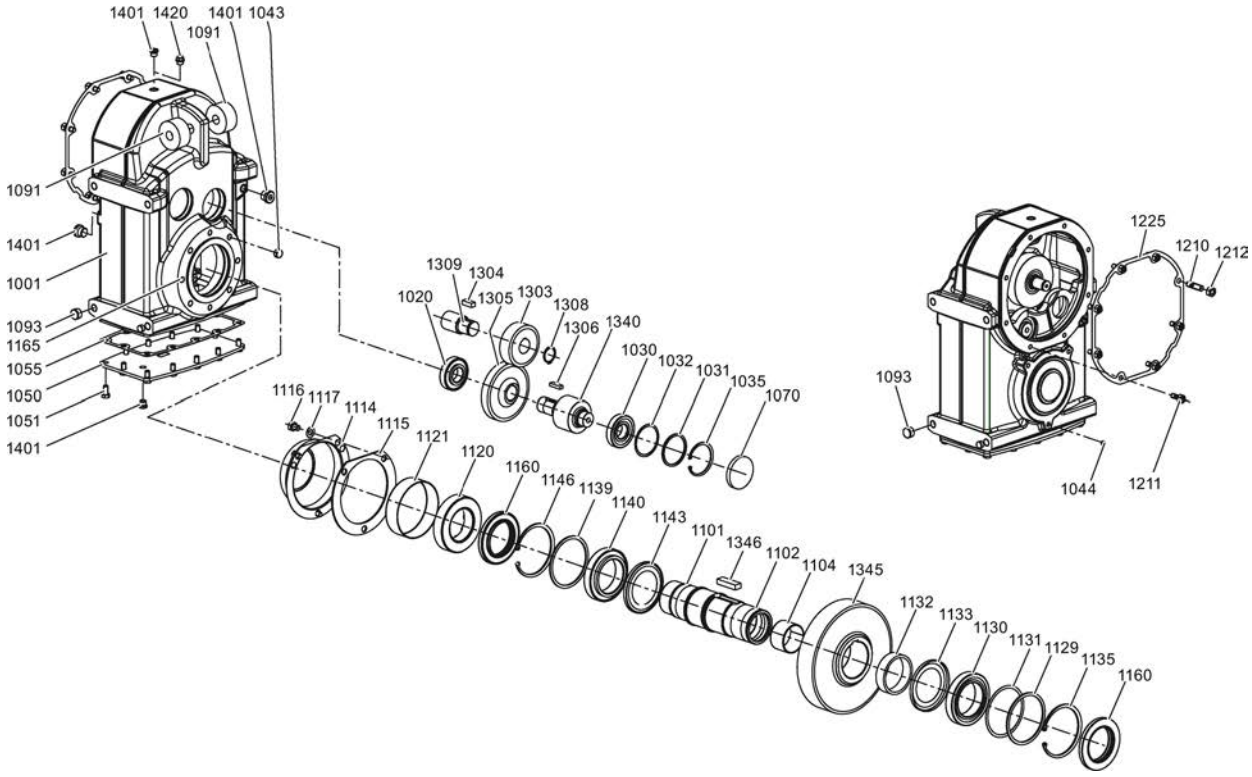

Figure 70: Exploded view of the gearbox.

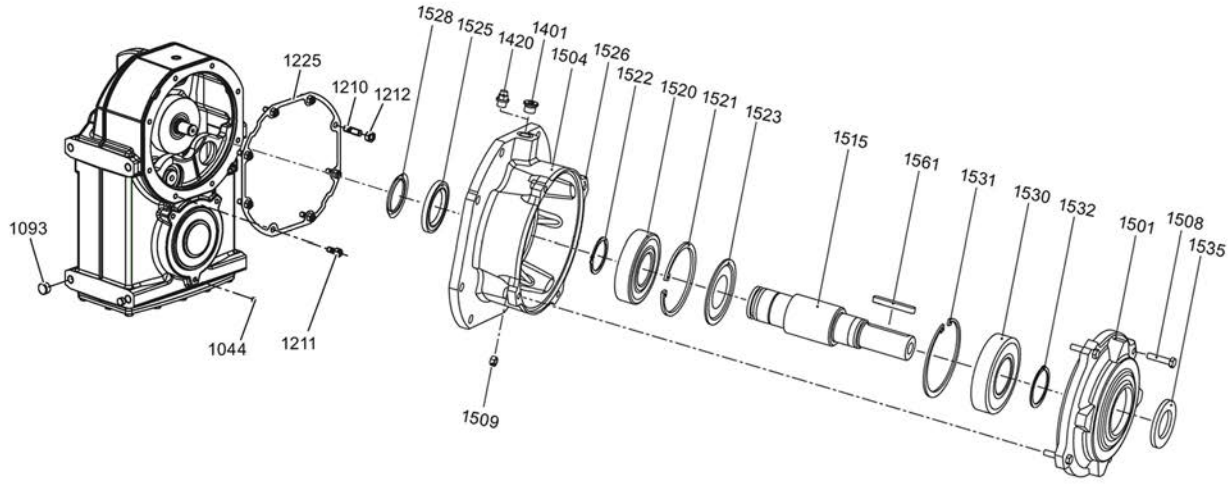

Figure 71: Exploded view of the gearbox adapter.

Table 11: Spares part list for the gearbox.

1001 Gearbox housing 1020 Bearing 1030 Bearing 1031 Supporting disk 1032 Shim 1035 Locking ring 1043 Plug 1044 Plug 1050 Housing cover 1051 Bolt 1055 Seal 1070 Sealing cap 1091 Rubber bush 1093 Plug 1101 Output shaft 1102 Bushing 1104 Seal 1114 Cover NDE 1115 Seal 1116 Bolt 1117 Screw retainer 1120 Shrink disk 1121 Protective cap 1129 Supporting disk 1130 Bearing 1131 Shim1132 Bushing 1133 NILOS ring 1135 Locking ring 1139 Supporting disk 1140 Bearing 1143 NILOS ring 1146 Locking ring 1160 Shaft sealing ring 1165 Seal	1210 Bolt 1211 Screw lock 1212 Nut 1225 Seal 1303 Slip-on pinion 1304 Parallel key 1305 Helical 1306 Parallel key 1308 Locking ring 1309 Seal 1340 Pinion shaft 1345 Helical 1346 Parallel key 1401 Screw/bolt plug 1420 Vent filter 1501 Adapter 1504 Bearing shield 1508 Bolt 1509 Nut 1515 Shaft 1520 Bearing 1521 Locking ring 1522 Locking ring 1523 Sealing washer 1525 Shaft sealing ring 1526 Seal, Loctite 574 1528 Washer 1530 Bearing 1531 Locking ring 1532 Locking ring 1535 Shaft sealing ring 1561 Feather key

Generator coupling tolerance

The following figure shows the allowable axial offset for different angular misalignments of the double disk coupling ARPEX ARS-6 NEN 78 (in yellow).

FLENDER

ARPEX Disc Couplings
Allowable Shaft Misalignment

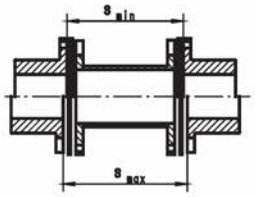

Figure 23.1
Axial Movement (End Float)

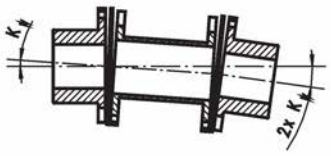

Figure 23.2
Angular Movement

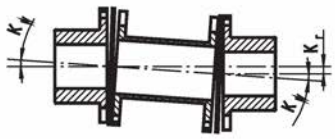

Figure 23.3
Radial Movement

ARS-6

Table 23.1

Size	Permissible Angular Misalignment (°)							
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
	Permissible Axial Offset (in.)							
78-6	0.043	0.037	0.031	0.025	0.019	0.012	0.006	0.000
105-6	0.071	0.061	0.051	0.041	0.030	0.020	0.010	0.000
125-6	0.080	0.068	0.057	0.045	0.034	0.023	0.011	0.000
140-6	0.095	0.081	0.068	0.054	0.041	0.027	0.013	0.000
165-6	0.108	0.093	0.077	0.062	0.046	0.031	0.015	0.000
175-6	0.112	0.096	0.080	0.064	0.048	0.032	0.016	0.000
195-6	0.120	0.104	0.086	0.069	0.052	0.035	0.017	0.000
210-6	0.124	0.106	0.088	0.071	0.053	0.035	0.018	0.000
240-6	0.145	0.124	0.104	0.083	0.062	0.041	0.021	0.000
255-6	0.152	0.130	0.108	0.087	0.065	0.043	0.022	0.000
280-6	0.165	0.141	0.118	0.094	0.071	0.047	0.024	0.000
305-6	0.175	0.150	0.125	0.100	0.075	0.050	0.025	0.000
335-6	0.191	0.163	0.136	0.109	0.082	0.054	0.027	0.000
372-6	0.196	0.168	0.140	0.112	0.084	0.056	0.028	0.000
407-6	0.217	0.185	0.155	0.124	0.093	0.062	0.031	0.000
442-6	0.237	0.203	0.169	0.135	0.102	0.068	0.034	0.000
487-6	0.268	0.230	0.191	0.153	0.115	0.077	0.038	0.000
522-6	0.289	0.247	0.206	0.165	0.124	0.082	0.041	0.000
572-6	0.309	0.265	0.221	0.177	0.133	0.088	0.044	0.000
602-6	0.325	0.278	0.232	0.185	0.139	0.093	0.046	0.000

ARC 8 & 10

Table 23.2

Size	Permissible Angular Misalignment (°)				
	0.0	0.1	0.2	0.3	0.4
	Permissible Axial Offset (in.)				
225-8	0.076	0.057	0.038	0.019	0.000
255-8	0.091	0.069	0.046	0.023	0.000
270-8	0.094	0.071	0.047	0.024	0.000
295-8	0.103	0.077	0.052	0.026	0.000
325-8	0.102	0.076	0.051	0.026	0.000
355-8	0.113	0.085	0.057	0.028	0.000
385-8	0.123	0.092	0.061	0.031	0.000
420-8	0.137	0.102	0.068	0.034	0.000
455-8	0.154	0.115	0.077	0.039	0.000
505-8	0.169	0.127	0.084	0.042	0.000
545-8	0.176	0.132	0.088	0.044	0.000
595-8	0.191	0.143	0.096	0.048	0.000
630-8	0.196	0.130	0.065	0.000	
700-8	0.226	0.151	0.076	0.000	
630-10	0.119	0.059	0.000		
700-10	0.141	0.070	0.000		
760-10	0.146	0.073	0.000		
860-10	0.190	0.095	0.000		
950-10	0.212	0.106	0.000		
1035-10	0.228	0.114	0.000		

ARF-6

Table 23.3

Size	Permissible Angular Misalignment (°)							
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
	Permissible Axial Offset (in.)							
84-6	0.043	0.037	0.031	0.025	0.019	0.012	0.006	0.000
111-6	0.071	0.061	0.051	0.041	0.031	0.020	0.010	0.000
132-6	0.080	0.068	0.057	0.045	0.034	0.023	0.011	0.000
147-6	0.095	0.081	0.068	0.054	0.041	0.027	0.013	0.000
171-6	0.108	0.093	0.077	0.062	0.046	0.031	0.015	0.000
182-6	0.112	0.096	0.080	0.064	0.048	0.032	0.016	0.000
202-6	0.120	0.103	0.086	0.069	0.052	0.034	0.017	0.000
218-6	0.124	0.106	0.088	0.070	0.053	0.035	0.018	0.000
252-6	0.145	0.124	0.104	0.083	0.062	0.041	0.021	0.000
267-6	0.152	0.130	0.108	0.087	0.065	0.043	0.022	0.000

ARS-6

Table 23.4

Size	Permissible Radial Shaft Misalignment (in.)						
	NHN	NEN BEN BEB	NUN BUN BUB	NON BON	NZN	NWN
78-6	$(S_B - S_1)\ 12.2\ 10^{-3}$	0.022	—	—	$(S_B - S_1)\ 12.2\ 10^{-3}$	$(S_B - S_1)\ 12.2\ 10^{-3}$
105-6		0.035	—	0.021		
125-6		0.041	—	0.027		
140-6		0.050	0.050	0.028		
165-6		0.059	0.059	0.033		
175-6		0.061	0.061	0.039		
195-6		0.061	0.061	0.039		
210-6		0.070	0.070	0.043		
240-6		0.076	0.076	0.047		
255-6		0.082	0.082	0.059		
280-6		0.100	0.100	0.060		
305-6		0.107	0.107	0.071		
335-6		0.113	0.113	0.074		
372-6		0.119	0.119	0.085		
407-6		0.130	0.130	0.089		
442-6		0.141	0.141	0.098		
487-6		0.161	0.161	0.104		
522-6		0.171	0.171	0.113		
572-6		0.192	0.192	0.119		
602-6		0.202	0.202	0.128		

ARC 8 & 10

Table 23.5

Size	Permissible Radial Shaft Misalignment (in.)	
	BUB	NHN
225-8	0.038	$(S_B - S_1)\ 7\ 10^{-3}$
255-8	0.043	
270-8	0.043	
295-8	0.046	
325-8	0.054	
355-8	0.056	
385-8	0.064	
420-8	0.070	
455-8	0.074	
505-8	0.095	
545-8	0.105	
595-8	0.113	
630-8	0.083	$(S_B - S_1)\ 5.2\ 10^{-3}$
700-8	0.094	
630-10	0.055	$(S_B - S_1)\ 3.5\ 10^{-3}$
700-10	0.062	
760-10	0.063	
860-10	0.073	
950-10	0.076	
1035-10	0.077	

ARF-6

Table 23.6

Size	Permissible Radial Shaft Misalignment (in.)
	GG GJ
84-6	0.007
111-6	0.007
132-6	0.008
147-6	0.008
171-6	0.010
182-6	0.011
202-6	0.011
218-6	0.015
252-6	0.018
267-6	0.019

Note:
Standard ARPEX couplings are designed with two sets of plate packs to accommodate angular, radial, and axial misalignment.
ARPEX couplings with 2 plate packs can accommodate angular, radial, and axial shaft misalignment.
ARPEX couplings with 1 set of plate packs can only accept angular and axial shaft misalignment.
Tables show permissible axial offset for a complete coupling with 2 sets of plate packs.
Values represent the total misalignment. Consult the appropriate operating instructions for allowable shaft misalignment.
The amount of radial misalignment depends on the amount of angular misalignment and on the center distance of the plate pack sets.
Both angular and radial misalignment may occur at the same time, but the total of both misalignments may not exceed the maximum allowable value of either the angular or radial misalignment.

Figure 72: Coupling tolerances.

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