



TECHNICAL STANDARDS ORLEN S.A. MAINTENANCE OFFICE

TECHNICAL REQUIREMENTS FOR THE ELECTRICAL BRANCH

DESIGN AND CONSTRUCTION

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1. INTRODUCTION

This document defines technical standardization, covers the general requirements for the design, construction, in the technical scope of electrical branch.

The subjects of this document are issues correlated with design, construction, modernization, reconstruction, etc. of production plants, technological facilities on the area of ORLEN S.A.

The document is internal regulation of ORLEN S.A., compliance with its provisions is the responsibility of all employees of the Company, and third parties that provide services for the Company, based on concluded contracts.

Implementation of technical standardization, design guidelines, contained herein should contribute, among others to:

- increase the availability of production plants technological facilities,
- extend cycles between overhaul,
- reduce breakdowns rate,
- optimize investment costs and maintenance costs.

2. DEFINITIONS

The following definitions apply in this document:

- **PN** – National Polish Standards.
- **CENELEC** – the European Committee for Electrotechnical Standardization.
- **IEC** – International Electrotechnical Commission.
The latest issue of standards shall be used.
- **Client** – ORLEN S.A. or a company acting on behalf of ORLEN S.A.
- **Project Manager/Investment Coordinator** – ORLEN S.A. representative responsible for the execution and coordination of the project.
- **Contractor** – The party carrying out the design and/or supply and/or construction.
- **End User** – The person responsible for running the installation in terms of the electrical branch, e.g. the relevant Production Support Engineer.
- **Design Office** – The Contractor's entity carrying out the design work.
- **Reacceleration** – The automatic resumption of operation of the equipment after a momentary loss and return of the supply voltage for a maximum of 3.5 seconds (e.g. after a successful ATS cycle).
- **AC** – Alternating current.
- **DC** – Direct current.
- **ATS/ACO** – Automatic Transfer Switch/Automatic Change Over.
- **LV switchgear** – Low voltage switchgear.
- **MV** – Medium voltage switchgear.
- **TSH** – Over-temperature alarm.
- **AH** – DCS over-temperature alarm.
- **OPR** - Unit Distribution Points - term applies to medium voltage 6kV/10kV switchgear.
- **OPT** – Unit Transformer Points.

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- **PPZ** – Scheduled Power Supply Changeover (automatic scheduled changeover of power supplies ensuring uninterruptible changeover).
- **SDM** – Power Distribution Cabinet.
- **NRB** – abbreviation from polish: Nadzor – supervision, Rejestracja – recording, Bilansowanie - balancing. Computer supervision system for electric power system.
- **NRB - RE** – Dedicated system for the electric power system Operator.
- **NRB - UR** – Dedicated system for the Production Electrical branch connected to a local computer network (Ethernet), intended for the End User.
- **NRB - DCS** – Dedicated system for the Process Operator.
- **STS** – Static Transfer Switch.
- **LSK** – Local Computer Network.
- **Production Plant and Process Facility Self-Start** – Resumption of technological processes after restart of electrical equipment using applied Reacceleration functions.
- **LOTO** – Lockout/Tagout system.

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3. GENERAL REQUIREMENTS

Process plant and technological facilities shall be adapted for self-start-up. If the self-start-up of production installation or technological facilities is not possible, an explanation should be included in the offer. For process units with self-start-up impossible it is mandatory to provide in offer appropriate explanations.

Existing electrical systems shall be taken into consideration.

The entire Polish legal status, laws/acts, rules, regulations and procedures/practices shall be strictly applied during the execution of the contract, from building permit, through detailed design, construction/assembly to testing & commissioning even if it is not mentioned in this specification.

There is the contractor obligation to get acquainted with existing electrical systems before submitting the offer and to clarify any doubts.

It is mandatory to execute the object of the Contract in the scope of Electrical discipline in accordance with the European Parliament Directives with subsequent amendments, in particular:

- Directive 2014/34/EU on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (ATEX 114).
- Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (ATEX153).
- Low Voltage Directive 2014/35/EU on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits (LVD).
- Directive 2014/30/EU on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (EMC).

Whenever the word “shall” or “should” has been used, its meaning is to be understood as mandatory.

Whenever the word “recommended” has been used, its meaning is to be understood as strongly recommended or advised.

Whenever the phrase “may be” has been used, its meaning is to be understood as a freedom of choice.

All electrical issues not included in this document but concerning the subject matter of the contract shall be subject to the regulations contained in Polish regulations and subject matter standards.

All deviations from the technical requirements contained in this document shall be agreed and accepted in writing by the Client's Electrical Department. Requests for deviation shall be submitted using the template form included in Appendix No. 6.

All issues related to the detailing of the issues described in this document shall be agreed and accepted in writing by the Electrical Department.

In the event that the scope needs to be expanded, the Contractor should request the necessary additional information from the Electrical Department.

The scopes of examination and acceptance tests of electrical devices both at the manufacturer's factory (FAT - Factory Acceptance Tests) and at the installation site (SAT - Site Acceptance Tests):

- a) Shall confirm compliance with all required technical parameters.
- b) The scope of examination and tests shall be agreed each time and accepted in writing by the Electrical Department.

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At the start of SAT tests, all digital devices shall have the latest software version installed.

Electricity can be supplied at the following voltage levels:

- Medium voltage: 10 kV, 6 kV.
- Low voltage: 0,69 kV, 0,4 kV.

The above mentioned variants should be selected according to the results of techno-economic analysis.

If it is necessary to use other supply voltage, the Client should be informed about this, to agree on specific conditions.

3.1. DESIGN CONDITIONS

During the design process, the following rules shall be followed:

- Maintenance safety,
- Provision of high-quality electricity with high power reliability.
- Energy efficiency,
- Attendance – free operation.

Design temperature:

- Maximum design temperature + 40° C,
- Minimum design temperature - 25° C,
- The minimum ambient temperature for selecting heating tapes - 29° C.

Ambient conditions of designed equipment, machines, apparatuses, etc., e.g. temperature, humidity, etc. described in manuals, declarations, etc. issued by manufacturer or their authorised representatives shall be respected.

3.2. SAFETY DESIGN CRITERIA

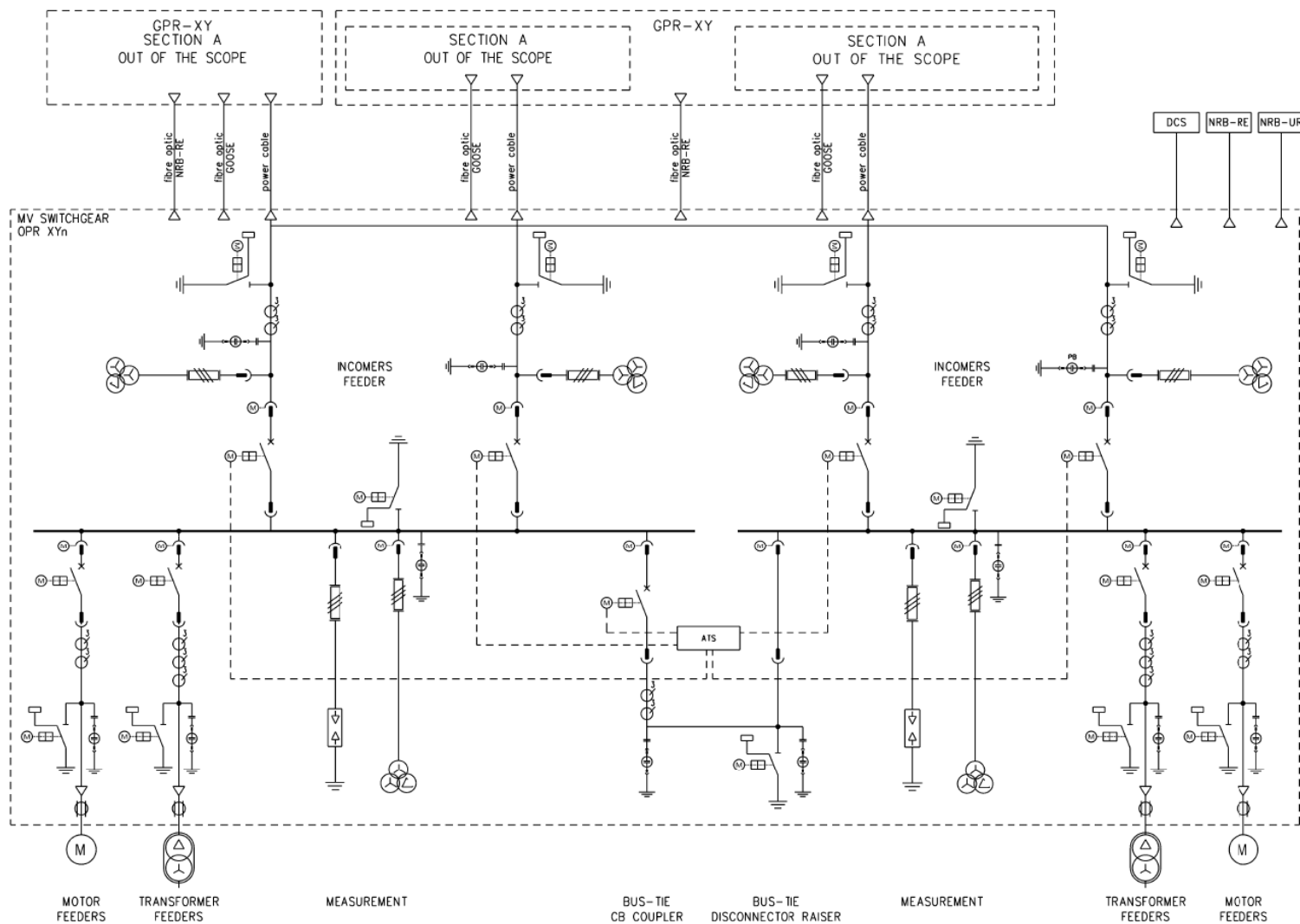
- a) Used material, equipment, apparatus, etc. shall not contain any Polychlorinated Biphenyls (PCB).
- b) Where cables, conduit, or piping penetrate fire resistant wall the opening shall be sealed with an approved sealant with the required rating.
- c) Where it is necessary, non-insulating couplings are used to connect pneumatic transfer piping, a non-insulated bonding wire jumper shall be installed across the coupling to maintain electrical continuity and avoid electrostatic charges.
- d) Any rotating device and equipment with movable parts should be provided with a LOTO lockable disconnect switch.
- e) Where frequent shut-down for maintenance or operations is required, the disconnect shall be located in close vicinity to the equipment controls.
- f) For equipment with a height exceeding the standardized human arm reach range, suitable access platforms shall be provided.
- g) In electrical rooms, water and sewage installations shall not be installed, except in the battery room for the purpose of supplying water to the emergency safety shower installation.

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3.3. NOMINAL PARAMETERS OF POWER SUPPLY SYSTEM FOR PRODUCTION

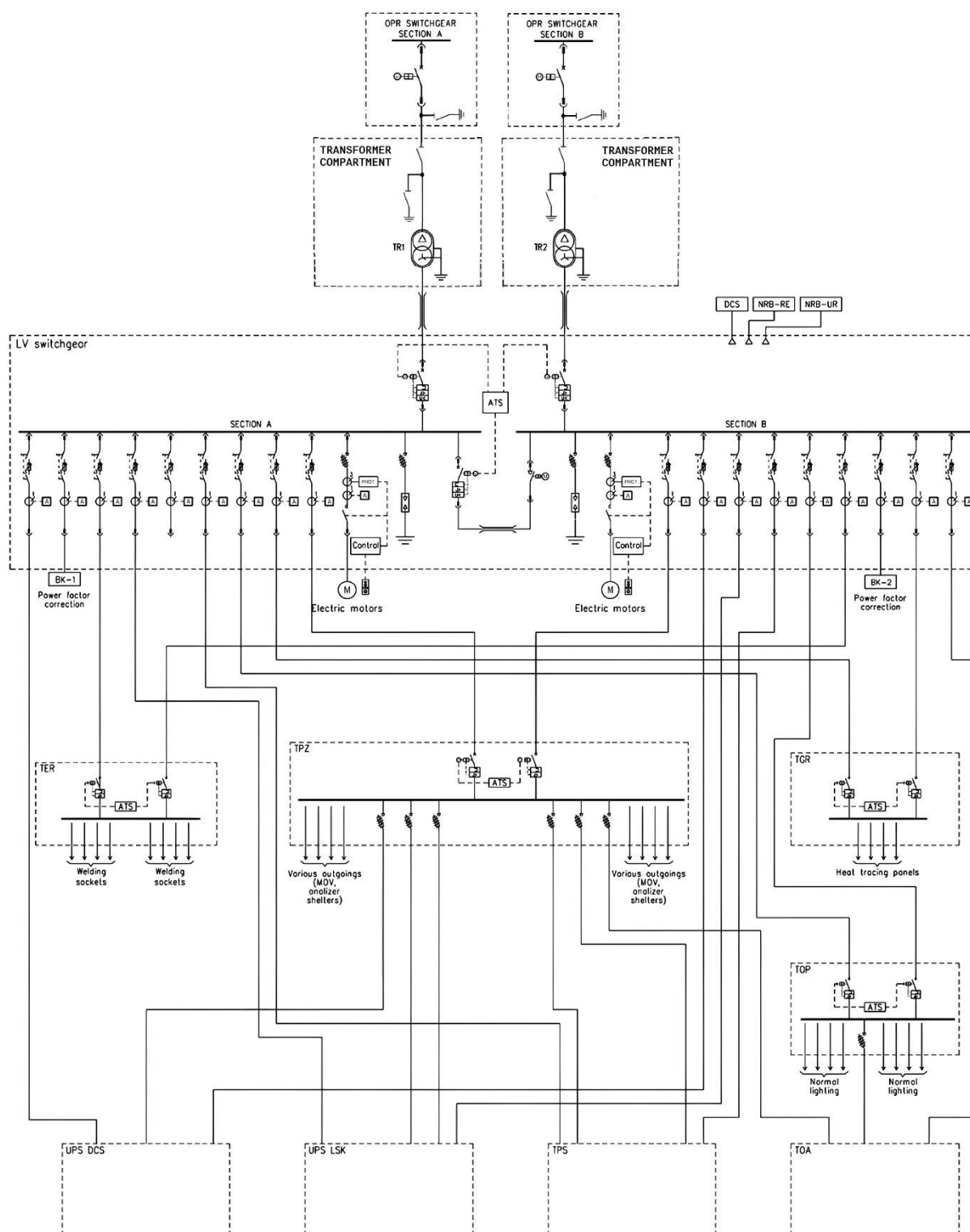
UNITS AND TECHNOLOGICAL FACILITIES

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Dwg. 1. A sample of MV single-line diagram

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Dwg. 2. A sample of LV single-line diagram

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3.3.1. Medium Voltage Network

Nominal voltage	I	10 000 V, +/- 5%
	II	6 000 V, +/- 5%
Nominal frequency	50 Hz, +/- 2 %	
Short circuit capacity uses		
– To select equipment for switchgear – To start up motors	I	Shall be calculated according to technical and economic assumptions
		Shall be calculated according to technical and economic assumptions
– To select equipment for switchgear – To start up motors	II	40 kA/1s or higher
		15 kA
Type of system	I	Neutral point grounded through resistance, which limits the single – phase short circuit current
	II	Neutral point grounded through resistance, which limits the single – phase short circuit current to ca. 186 A

3.3.2. Low Voltage Network

Nominal voltage	I	400/690 V, +/- 5%
	II	230/400 V, +/- 5%
Nominal voltage		
Nominal frequency	50 Hz, +/- 2%	
Short circuit capacity uses		
– To select equipment for switchgear – To start up motors	I	Shall be calculated according to technical and economic assumptions
		Shall be calculated according to technical and economic assumptions
– To select equipment for switchgear – To start up motors	II	80 kA
		28 kA
Type of system	TN-S system	

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3.3.3. Guaranteed voltage network, AC current

Nominal voltage	230 V +/- 1% statically +/- 5% dynamically
Nominal frequency	50 Hz +/- 0,1% for bank of batteries operation +/- 2% for by-pass operation
Network arrangement:	TN-S system
Note: A need to use 400/230 V three-phase nominal voltage shall be consulted with the Client	

3.3.4. Guaranteed voltage network, direct current network to feed protection, control and annunciation systems of MV and LV switchgear

Nominal voltage	110 V +10 / -15%	Voltage should be chosen according to technical and economic considerations
	220 V +10 / -15%	
Type of system	IT	Network system should be chosen according to technical and economic considerations, e.g. TN-S

3.3.5. Guaranteed voltage network, direct current system for emergency lighting standby supply system

Nominal voltage	220 V +10 / -15%
Type of system	TN-S system

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3.4. SCOPE OF ELECTRICAL EQUIPMENT DELIVERIES

3.4.1. Contractor's obligations

3.4.1.1. Contractor is responsible for:

- a) Detailed design and delivery of documentation in accordance with agreement made.
- b) Delivery of equipment in accordance with agreement made.
- c) Defining the assumptions for testing, acceptance and commissioning of the entire subject of the contract. The assumptions specified by the Contractor for testing, acceptance and commissioning of the entire subject of the contract require the approval of ORLEN S.A.
- d) Participation in testing and starting up of the whole of the object of the Contract, which shall be confirmed by appropriate ORLEN S.A. approved acceptance certificates.

Contractor is obligated to provide in offer a list of training courses that are necessary for correct operation and maintenance of the object of the Contract. Scope of trainings requires ORLEN S.A. approval. Training courses which mentioned above are scope of Contractor. Training courses after completion, shall be confirmed by issuing appropriate certificates.

Each piece of delivered electrical equipment shall be properly protected against atmospheric exposure for the anticipated conditions of transportation, point of destination and place of temporary storage.

3.4.1.2. Contractor shall deliver the following technical documentation for:

- a) Power and control cables, etc.
- b) Electrical motors and relevant intermediate junction boxes and motor control stations.
- c) Lighting systems.
- d) Lightning protection and grounding systems.
- e) Heat tracing systems.
- f) Telecommunication intercom system including exchanged equipment.
- g) Auxiliary materials and structures.
- h) HV/LV switchgears/substations, motor control centres, electrical equipment, motors and transformers (as option).
- i) UPS systems.
- j) Capacitor banks.
- k) Batteries & rectifiers.
- l) Any other facilities, equipment/materials, etc. Lying under the scope of contractor.

Contractor shall deliver equipment and material index indicating process equipment package (e.g. Compressor unit). Detailed equipment and materials list shall be handed over during design development process.

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3.5. EXPLOSION HAZARDOUS AREAS CLASSIFICATION

3.5.1. General information

- 3.5.1.1. Classification documentation of explosion hazardous areas shall be issued in line with Client's OHS Department requirements.
- 3.5.1.2. The classification documentation, once approved, shall be used for the selection of equipment and systems intended for use in explosion hazardous areas and the implementation of minimum health and safety requirements related to the possibility of an explosive atmosphere in the workplace.
- 3.5.1.3. Without approved classification documentation of a given object and adjacent areas, electrical equipment cannot be operated in explosion hazardous areas.

3.6. ELECTRICAL EX-PROOF EQUIPMENT

Equipment and materials shall be conformed to the Polish Standards and complying with CENELEC Standards. IEC Standards need to be used if CENELEC are not issued in the specific scope. All electrical materials will be marked with the CE stamp, delivered with EU Declarations of conformity and EU/WE type examination certificates.

3.6.1. The Construction of Electrical Ex-Proof Equipment

Electrical equipment designed to be operated in explosion hazardous areas shall be manufactured in accordance with the requirements as contained in Ex-proof design certificates or test certificates, EU/WE type examination certificates issued by notified bodies, EU declarations of conformity, manuals issued by manufacturers or their authorised representatives and in the standards - taking into account detailed ORLEN S.A. applicable requirements.

3.6.2. Selection of Electrical Ex-Proof Equipment

- 3.6.2.1. Electrical equipment designed to be operated in potentially explosive atmospheres shall be selected in accordance with the requirements indicated in EU/EW type examinations certificates issued by notified bodies, EU declarations of conformity, manuals issued by manufacturers or their authorized representatives and in the regulations taking into account detailed ORLEN S.A. applicable requirements mentioned in this documents.
- 3.6.2.2. Electrical equipment or its equivalent manufactured in accordance with Category 3 shall not be selected.

3.6.3. Installation of electrical equipment and systems in explosion-proof execution

- 3.6.3.1. Installations and supervision of installation of electrical equipment and systems in explosion-proof execution shall be carried out by persons with necessary expertise to the extent required by producers, records of explosion-proof documentation, explosion-proof certificates, relevant Polish standards and regulations.
- 3.6.3.2. The expertise of persons engaged in installing and supervising the installation of electrical equipment and systems in explosion-proof execution shall be confirmed by relevant certificates.

3.6.4. Release for Operation of Electrical Ex-Proof Equipment

- 3.6.4.1. In order to obtain an approval for operation of electrical equipment, the following instructions shall be followed:

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CONTRACTOR'S OBLIGATIONS:

3.6.4.2. The Contractor shall deliver the following to ORLEN S.A. - Project Manager/Investment Coordinator:

- a) Ex-proof electrical equipment specification prepared on the basis of rated nameplates of installed apparatus, equipment, systems, etc., using the template from provided in Appendix No. 3. The said specification shall contain the following data: tag numbers, type of equipment, symbol of certificate, Ex-proof mark, manufacturer, quantity, etc. according to the form delivered by ORLEN S.A., with attached completed set of:
 - Ex-proof design certificates i.e. EU/WE type examination certificates issued by notified bodies and EU Declarations of Conformity issued by producers for electrical apparatus, equipment, electrical systems along with the necessary appropriate addenda or supplements.
 - The mentioned certificates, declarations and appropriate addenda or supplements should be provided in English. Translations of these certificates and declarations should have confirmation of compliance with the original.
- b) Explosion Protection Document, acc. to Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (ATEX 158).
- c) Operating Manuals set for electrical equipment, apparatuses, machines, etc. issued by producers or their authorised representatives – each manual issued in Polish language version, English language version and the manufacturer's language version.
- d) Declaration issued by the Design Office confirming the implementation of a complete set of safety requirements in the design studies, included in the in EU/EC type examination certificates, EU declarations of conformity, user manuals.
- e) Contractor's declaration confirming the correct functioning of the complete set of safety requirements included in the EU/EC type examination certificates and operating instructions for the installed electrical devices, equipment, etc., signed by the Contractor's representative.

NOTE:

Delivering a set of English language version certificates along with necessary addenda or supplements that state the Ex-proof design of electrical equipment or electrical systems delivered is a condition to install Ex-proof equipment at the plants. The method of preparing the Ex-proof electrical equipment specification, as well as its scope and division, shall be agreed in each case with the Client's Electrical Department.

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ORLEN S.A. OBLIGATIONS:

3.6.4.3. Project Manager/Investment Coordinator of ORLEN S.A.

- a) Checks the Ex-proof electrical equipment specification prepared on the basis of data from rated nameplates of installed apparatuses for the conformity and completeness.
- b) Provides to the End User a set of operating instructions, manuals for installed equipment, systems etc. issued by producers or their authorised representatives issued in Polish language version and English language version.
- c) Submits the following documents to Electrical Department Ex-proof electrical equipment specification prepared on the basis of data from the nameplates of installed electrical equipment, after signing by the Contractor, the Investment Supervisor and the Project Manager of ORLEN S.A., together with the attached complete EU/EC type examination certificates, EU declarations of conformity and complete post-assembly/as-built documentation including all equipment mentioned in the Specification.
- d) Provides the End User with a complete specification of explosion-proof electrical equipment, approved by the Electrical Department, based on the data included on the nameplates of the installed devices, equipment, etc .

3.6.4.4. Investment Supervision Department of ORLEN S.A.:

- a) Receives from the Project Manager/Investment Coordinator of ORLEN S.A. Ex-proof electrical equipment specification based on the data from rated nameplates of installed equipment, along with completes EU/WE type examination certificates, EU declarations of conformity.
- b) Supervises the correctness of devices installation, electrical equipment etc.
- c) Verifies the completeness of:
 - Specification of explosion-proof electrical equipment based on data from nameplates. It is unconditionally required to prepare specifications for explosion-proof devices, electrical equipment, etc., based on the data on the nameplates of the installed devices, equipment, etc.
 - Set of operating instructions issued by producers or their authorised representatives, before passing to end user.

3.6.4.5. Electrical Department of ORLEN S.A.:

- a) Verifies, in the scope of electrical branch Ex-proof electrical equipment specification prepared on the basis of rated nameplates of installed equipment, systems, etc. along with submitted certificates, addenda and supplements thereto.
- b) If the following is found conformity of EU/WE - type examination certificates, EU Declarations of conformity with the above mentioned specification of installed electrical machines, apparatuses, equipment, etc., the Manager of Electrical Department or other authorised person shall approve the listed electrical devices, equipment, etc. in explosion-proof design, as specified, for operation.
- c) In case if above mentioned are found not in conformity, incomplete, etc. Electrical Department shall apply to ORLEN S.A. - Project manager/Investment Coordinator for making them complete or revising.

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3.7. ELECTRICAL SYSTEMS IN EXPLOSION HAZARDOUS AREAS

- a) Electrical equipment dedicated to operate in potentially explosive atmospheres shall be selected in accordance with the requirements as contained in Ex-proof design certificates or electrical equipment test certificates and in the regulations taking into account detailed ORLEN S.A. applicable requirements.
- b) TN-S electrical systems that feed the consumers in potentially hazardous atmospheres shall be provided with devices to perform the operation of disconnecting phase conductors together with neutral conductor. Tripping of the protective devices shall also disconnect the phase and the neutral conductors.

3.8. FIRE PROTECTION

- a) Self-extinguishing or fireproof-jacketed cables and conductors resistant to chemical exposures (hydrocarbons) shall be used, where necessary.
- b) The separate fire protection system consists of the manual fire alarm (pushbuttons) shall be installed on the plant areas. These must be connected to the relevant fire alarm centre, location of which will be indicated by Client.
- c) Fire-fighting protection monitoring system shall be used.

Obligatory regulation of European Union should be applied after obtaining prior Client acceptance, in case when economic reasons suggest solutions different from the mentioned ones.

3.9. ELECTRICAL SHOCK PROTECTION

3.9.1. General requirements

- 3.9.1.1. The electric shock protection for MV nominal voltage systems is made through automatic switch-off and grounding system.
- 3.9.1.2. Electric shock protection from indirect contact in low-voltage installations should be provided by automatic switch off of power supply along with the use of additional equalising connections.
- 3.9.1.3. In outgoings for socket outlets, heat tracing circuits or other equipment requiring additional protection, such protection shall be used by means of residual current circuit breakers with a rated differential activation current of maximum 30 mA.
- 3.9.1.4. Groups of circuits shall not be protected solely by a single residual current device where the RCD has a rated residual operating current of 30 mA or less.
- 3.9.1.5. Selection of residual current devices:
 - a) The rated current of the RCD shall be equal or greater than maximum load current of the circuit, considering coordination with the overcurrent protective devices.
 - b) Type AC RCDs may be use only in circuits supplying resistive loads that generate sinusoidal residual current only, such as heat trace circuits and resistive heating elements (e.g. water heaters, electric heaters). The use of type AC RCDs shall not be permitted in circuits with equipment generating pulsating or direct currents.
 - c) Type A RCDs shall be used as the standard solution in all electrical circuits for detection of sinusoidal residual currents and pulsating direct residual currents. This includes circuits supplying equipment incorporating electronic circuits (e.g. computers, LED lighting, motors with simple control/drive electronics). An exception may be made for circuits where specific technical requirements, such as the presence of DC residual currents or high-frequency residual currents, justify the use of Type F or Type B RCDs.

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3.10. OVERVOLTAGE PROTECTION

- a) In MV installations, particular consideration should be given to the possibility of its temporary operation in a system without grounding resistor.
- b) Electrical installation overvoltage protection should be co-ordinated with overvoltage protection of other installations requiring overvoltage protection, e.g. installations of guaranteed voltage, telephone, teletechnical and aerial installations.
- c) Surge protection using surge arresters should cover individual busbar sections of medium and low voltage switchgears. Usually consumers will not be equipped with additional overvoltage protection devices, unless Manufacturer explicitly points its out.
- d) Surge arresters should be switched on via fuses. Fuses should switch off damaged surge arresters without disturbing the continuity of power supply to the consumers.
- e) Damage of surge arresters should be indicated. The fault signal should be sent to the NRB-RE system.

3.11. ELECTROSTATICS PROTECTION AND ELECTROMAGNETIC COMPATIBILITY

- a) Electrostatic protection and electromagnetic compatibility shall meet the requirements of the applicable standards.
- b) At loading and unloading stations for bulk trucks, trailers, railway tank cars, etc. there should be used appropriate grounding systems, connected to electronic devices for monitoring of grounding continuity, shall meet the requirements of Client's Instrumentation discipline.

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4. DETAILED REQUIREMENTS

4.1. POWER SUPPLY SYSTEM FOR PRODUCTION UNITS AND TECHNOLOGICAL FACILITIES. ELECTRICAL STATIONS AND SUBSTATIONS

4.1.1. General requirements and information

- 4.1.1.1. Incomers MV feeders and MV cable lines shall meet the requirements acc. to required equipment, supplied electricity measurement, power factor requirements, harmonic distortion in respect of Electricity Supply Technical Requirements issued by the Electrical System Operator.
- 4.1.1.2. Substations (OPR) supply production installations with electric energy with rated voltage of 6 kV. If it is necessary to supply a production installation with voltage of 10 kV it is necessary to additionally consider a 30/10 kV station.
- 4.1.1.3. Depending on importance of an installation for continuity of a technological process, power substations (OPR) are supplied with:
- two independent power supplies, or
 - three power supplies.
- Each power supply unit should ensure full power demand for an entire switchgear.
- 4.1.1.4. Electrical substations (OPR) supply the LV switchgear, which supply the production installation with electrical power at a rated voltage of 0,69 kV and/or 0,4 kV.
- 4.1.1.5. The plant substations and main LV switchgear are equipped with the control automatics systems:
- Automatic Change Over (ACO),
 - Scheduled Power Supply Change Over (SPSCO).
- 4.1.1.6. The overall power supply schematic is shown in Drawing No. 2

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4.2. MEDIUM-VOLTAGE AND LOW-VOLTAGE SWITCHGEARS

4.2.1. General requirements

- 4.2.1.1. The switchgear should be powered from a cable line or busbars with the same cross-section of all conductors or busbars. The power distribution system in the switchgear should be based on a single, sectioned busbar system. All busbars should have the same cross-section along their entire length and in relation to each other. Particular sections of the switchgear should be loaded evenly.
- 4.2.1.2. Each MV and LV switchgear with at least two sections should be equipped with separate coupling feeders: coupling (SW) and riser (SO), installed in separate cabinets.
- 4.2.1.3. All devices installed in the switchgears shall be accessible when the doors are opened.
- 4.2.1.4. A common protective device shall not be used for different groups of loads.
- 4.2.1.5. Control and protection systems in switchgears should be adapted to cooperate with SCO/SOB systems (SCO - Underfrequency Load Shedding System, SOB - Black-out Defense System). SCO/SOB systems will be implemented using NRB-RE system devices. This applies to the circuit breaker/contactors position status signals, one phase current measurement signals, voltage measurement signal and the Switch-Off control signal. Details related to the selection of a given switchgear feeder should be agreed each time with the client.
- 4.2.1.6. The LV switchgear should be powered in the TN-S system fed from the transformer. If the busbars casing is used as a PE bus in the switchgear, it is required to connect the busbar casing with the internal PE bus of the LV switchgear with an additional bus. The internal PE bus of the switchgear should be connected to the facility's grounding installation in at least two places.
- 4.2.1.7. Each switchgear shall be marked with permanent, fixed, engraved labels, made in accordance with the diagram.
- 4.2.1.8. The scope of delivery of medium and low-voltage switchgear shall include:
 - a) Equipment in the in terms of voltage detection.
 - b) Basic and additional electrical insulating equipment.
 - c) Safety and rescue equipment and personal protective equipment (PPE).
 - d) Transport trolley for circuit breakers.
 - e) For the low-voltage switchgear, a cabinet should be provided containing earthing modules, at least one of each size of withdrawable modules used in the switchgear.
 - f) For low-voltage switchgear - a test trolley for outgoing modules (cassettes) enabling testing of all sizes of these modules built-in the low-voltage switchgear.

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4.2.2. Requirements for Automatic Change Over

4.2.2.1. The Control automatics (ACO and SPSCO) systems shall be realised by means of separate microprocessor automate installed in a dedicated cabinet, located as close as possible to the incomer feeder and coupling. Installation of the Ethernet switches for IEC 61850 GOOSE communication in the ACO cabinet is permitted, subject to agreement with the ACO automation system manufacturer.

4.2.2.2. Automatic Change Over (ACO) times for switchgears:

Switchgear type	Delay ACO from decline of voltage	ACO Limit time	ACO Starting voltage
-	[s]	[s]	[xUn]
MV switchgear with two feeders	1,0	3,0	0,4
Cooperating with the aforementioned LV switchgear	1,5	3,5	0,5
MV switchgear with three feeders	0,8	3,0	0,4
Cooperating with the aforementioned LV switchgear	1,7	3,5	0,5

4.2.2.3. Automatic Change Over (ACO) for medium-voltage switchgears with three power supply units works on a two-stage basis and has the following switch times:

1 stage	0,8 sec.
2 stage	If stage 1 responses correctly, is blocked.
	If stage 1 responses incorrectly, is delayed as compared with stage 1 by response-times of circuit breakers.

4.2.2.4. Part of low-voltage switchgears is equipped with Automatic Change Over (ACO) working with time dependent on switching devices applied.

4.2.2.5. To realise automatics, interlocking and other connections between outgoing feeders in GPR and incoming feeders in the OPR, were possible, must to be used communication standard compliant with PN-EN 61850 (IEC 61850). Realisation method of connections between feeders of switchgear OPR shall be each time agreed with Electrical Department.

4.2.2.6. Microprocessor automate for automatic systems ACO/SPSCO shall realize functions:

- Automatic Change Over (ACO) synchronous with simultaneous impulse transmission activated by an external initiation signal.
- Automatic Change Over (ACO) synchronous with short power supply interruption, activated by an external electric signal opening the circuit breaker of supply line.
- Automatic Change Over (ACO) synchronous with short power supply interruption activated when the circuit breaker of the basic supply is mechanically opened.
- Automatic Change Over (ACO) slow, activated when the circuit breaker of the basic supply line is mechanically opened.

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e) Automatic Change Over (ACO) slow, activated by voltage decay at the bus bars with the closed circuit breaker of the basic supply line.

f) Scheduled Power Supply Change Over (SPSCO) uninterrupted synchronous.

Additional functions:

a) HMI operator display with synoptic status of switchgear main feeders.

b) Events recorder.

c) Permanent and Transient interlocks.

d) Local communication port.

e) Communication protocol IEC 61850.

f) Communication protocol IEC 60870-5-103 for communication to supervisory system (NRB-UR).

4.2.2.7. Interlocks for Automatic Change Over (ACO) and MV incoming cable feeder protection:

a) Local Reserve or Circuit Breaker Feeder Protection (CBFP), implemented within 1 section, working in case of switch off basic or reserve incoming feeder or switch off tie-in breaker.

b) Incoming Feeder and outgoing Feeder interlock, for time needed to switch-off outgoing feeder.

c) Sectional protection (Incoming feeder protection – up stream substation outgoing feeder protection) to speed up work of automatics or incoming feeder protections.

4.2.2.8. In case of using a generator set, the Automatic Change Over (ACO)/Scheduled Power Supply Change Over (SPSCO) functions shall be implemented by means of a five-breaker ACO system.

4.2.3. Requirements for protection systems in MV switchgears

4.2.3.1. In outgoing and incoming feeders of MV switchgear, earth-fault protection 50G/51G cooperating with zero-sequence current transformer – Ferranti type shall be applied. In the MV switchgear coupling, earth-fault protection 50G/51G cooperating with a Holmgreen connection shall be applied. The use of earth-fault protection 50G/51G in this unit is permitted only as a back-up protection to 50G/51G. The tripping of earth-fault protection in MV switchgear units shall be conditional upon simultaneous activation of the 3U₀ protection.

4.2.3.2. MV incoming feeder microprocessor protection shall be equipped with following protection functions:

a) 3-phase overcurrent directional protection [50/51].

b) Earth fault directional overcurrent: primary [50N/51N] and backup [50N/51N].

c) Watt-metric Earth Fault [32N].

d) Phase under/over voltage [27, 59].

e) Voltage controlled overcurrent [51V].

f) Under/over frequency protection [81 U/O].

g) Output relays latching [86].

h) CB control.

i) Test of output relays.

j) Measurements.

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- k) Event recorder.
- l) Disturbance recorder.
- m) Fault recorder.
- n) Remote communication port (RS 485).
- o) External serial port for local communication.
- p) Communication protocol IEC 61850, GOOSE for communication to other protections of switchgear and realisation of interlocking functions.
- q) Redundant link for communication PRP (Parallel Redundancy Protocol),
- r) Protocol IEC 60870-5-103 for communication with supervisory systems (NRB-UR).

4.2.3.3. MV bus tie feeder microprocessor protection shall be equipped with following protection functions:

- a) 3-phase directional overcurrent [50/51].
- b) Earth fault directional overcurrent: primary [50N/51N] and backup [50N/51N].
- c) Watt-metric Earth Fault [32N].
- d) Phase under/over voltage [27, 59].
- e) Voltage controlled overcurrent [51V].
- f) Under/over frequency [81 U/O].
- g) Output relays latching [86].
- h) CB control.
- i) Test of output relays.
- j) Measurements.
- k) Events recorder.
- l) Disturbance recorder.
- m) Fault recorder.
- n) Remote communication port (RS 485).
- o) External serial port for local communication.
- p) Communication protocol 61850, GOOSE for communication to other protections of switchgear and realisation of interlocking functions.
- q) Redundant link for communication PRP (Parallel Redundancy Protocol).
- r) Protocol IEC 60870-5-103 for communication with supervisory systems (NRB-UR).

4.2.3.4. MV measurement feeder microprocessor protection shall be equipped with following protection functions:

- a) Phase under voltage [27].
- b) Phase over voltage [59].
- c) Zero-sequence overvoltage [59N].
- d) Negative-sequence overvoltage [47].
- e) Positive-sequence overvoltage [27D].

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- f) Under/over frequency [81 U/O].
- g) Rate of change of frequency [81 R].
- h) Under voltage blocking.
- i) Measurements.
- j) Peak value measurements.
- k) Events recorder.
- l) Disturbance recorder.
- m) Remote communication port (RS 485).
- n) External serial port for local communication.
- o) Communication protocol 61850, GOOSE for communication to other protections of switchgear and realisation of interlocking functions.
- p) Redundant link for communication PRP (Parallel Redundancy Protocol).
- q) Protocol IEC 60870-5-103 for communication with supervisory systems (NRB-UR).

4.2.3.5. MV Motor feeder microprocessor protection shall be equipped with following protection functions:

- a) Short-circuit protection [50/51].
- b) Earth-fault protection: primary [50N/51N] and backup [50N/51N].
- c) Thermal overload protection [49].
- d) RTD / thermistor inputs [49/38].
- e) Unbalance protection [46].
- f) Extended start-up protection [48].
- g) Locked rotor protection [51LR-50S].
- h) Star-up's number limit [66].
- i) Motor protection for motors with rated power equal to or higher than 2000 kW shall be equipped with differential protection [87].
- j) Prediction diagnostic, in scope of:
 - detection of damage of phase to phase insulation, damage phase to earth insulation, deterioration of stator windings coil insulation,
 - detection of stator windings coil short-circuit of induction motor,
 - detection of damages of rotor cage bar.
- k) Events recorder.
- l) Disturbance recorder.
- m) Remote communication port (RS 485).
- n) External serial port for local communication.
- o) Communication protocol IEC 61850, GOOSE for communication to other protections of switchgear and realisation of interlocking functions.
- p) Redundant link for communication PRP (Parallel Redundancy Protocol).

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q) Protocol IEC 60870-5-103 for communication with supervisory systems (NRB-UR).

4.2.3.6. MV outgoing transformer feeder microprocessor protection shall be equipped with following protection functions:

- a) 3-phase directional overcurrent [50/51].
- b) Overload [49].
- c) Earth fault directional overcurrent: primary [50N/51N] and backup [50N/51N].
- d) Watt-metric earth fault [32N].
- e) Phase under/over voltage [27, 59].
- f) Voltage controlled overcurrent [51V].
- g) Winding over-temperature protection.
- h) Output relays latching [86].
- i) CB control.
- j) Test of output relays.
- k) Measurements.
- l) Events recorder.
- m) Disturbance recorder.
- n) Fault recorder.
- o) Remote communication port (RS 485).
- p) External serial port for local communication.
- q) Communication protocol IEC 61850, GOOSE for communication to other protections of switchgear and realisation of interlocking functions.
- r) Redundant link for communication PRP (Parallel Redundancy Protocol).
- s) Protocol IEC 60870-5-103 for communication with supervisory systems (NRB-UR).

Additionally – a three-phase backup protection supplied from separate current transformers and a separate 100 V DC auxiliary power supply.

4.2.4. Requirements for protection systems in LV switchgears

4.2.4.1. Protections in circuit breakers in incoming feeder and in the bus tie coupling shall be equipped with the following functions:

- a) Overload protection.
- b) Short-circuit protection.

4.2.4.2. Microprocessor-based protection devices in LV motor feeders shall be equipped with the following functions:

- a) Overload protection.
- b) Short-circuit protection.
- c) Undercurrent protection.
- d) Phase loss protection.

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- e) Phase unbalance protection.
- f) Stalled rotor and prolonged start protection.
- g) Protection against exceeding the permissible number of starts.
- h) Thermistor motor protection.
- i) Communication interface (RS485).
- j) Measurement of phase currents and voltage.
- k) Event log.
- l) Fault recorder.

4.2.5. Construction of a medium-voltage switchgear

4.2.5.1. Medium-voltage switchgears should be built on the basis of:

- a) 12 kV indoor, double-segment, free-standing distribution feeders, certified in terms of arc-protection – class AFLR.
- b) Equipment with short-circuit capability, as determined by endurance of rated one-second long current of 40 kA or higher.
- c) The degree of protection of the housing – at least IP41.
- d) Feeder width – minimum 750 mm.

4.2.5.2. Medium-voltage switchgear should be designed in accordance with the following rules:

- a) Rated current of the entire switchgear busbars and primary circuits in the feeder, coupling and riser feeder, designed with a 20% spare, calculated on the basis of the installed power of the switchgear.
- b) Spare feeders, fully equipped for transformer and motor outputs, with a Spare of not less than 10% of the total number of switchgear feeders, with an even division between given sections into transformer and motor feeders.
- c) Spare feeders not equipped with secondary circuits with a spare of not less than 10% of the total number of switchgear feeders.
- d) No spare is required for switchgears dedicated to powering a single drive with a rated power equal to or higher than 3 MW.
- e) Spare space for possible expansion of the so-called construction spare, with a spare of not less than 10% of the total number of switchgear feeders.

4.2.5.3. Medium-voltage switchgears should be equipped with:

- a) Withdrawable circuit breaker units with electric drive, equipped with a vacuum circuit breakers.
- b) Withdrawable units with electric drive for riser feeder and voltage measurement feeders.
- c) Effective countermeasures to reduce the effects of arc faults.
- d) In outgoing and incoming feeders, for the purpose of primary earth-fault protection (50G/51G), zero-sequence current transformer – Ferranti type shall be applied, while in the coupling a Holmgreen connection shall be implemented.

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- e) Voltage transformers installed in voltage measurement feeders, mounted in a way that allows inspection of transformers and replacement of protection devices, without the need to turn off a given section of the switchgear.
- f) Locking system preventing incorrect manipulations.
- g) Electric drive of the earthing switch, integrated with mechanical interlocks for each switchgear feeders.
- h) Primary voltage indicators (reactance and capacitance).
- i) Continuous measurement of current in the outgoings of each distribution feeder.
- j) Surge arresters equipped with trip counters with ability to send information to NRB-UR system, installed in voltage measurement feeders in a way that allows the replacement of surge arrester protection without the need to turn off a given section of the switchgear (e.g. installed in withdrawable units).
- k) Automation, control, security, signalling and measurement systems.
- l) Systems for cooperation with the NRB-RE supervision system for remote control of circuit breakers in incomer feeders.
- m) Systems for cooperation with DCS and NRB supervision systems for remote monitoring of the status of switches, registration of events and disturbances, and electricity balancing.
- n) Each incomer feeder in MV switchgear shall be equipped with an emergency shutdown button, operating on:
 - switching off the circuit breaker in a given incomer feeder,
 - permanent interlock of ATS system in MV switchgear.
- o) Functionality enabling the switching off transformer feeders from the emergency shutdown buttons located in transformer chambers and on the facade of incoming feeders of LV switchgears and MV transformer feeder.
- p) Functionality enabling the switching off motor feeders from the emergency shutdown buttons located on the facade.
- q) Position indicators: the withdrawable unit of the circuit breaker, the position of the circuit breaker and earthing switch in the feeder, the disconnecter in the transformer chamber (for the transformer feeder).

4.2.5.4. Circuit-breakers for medium-voltage switchgears should be chosen for:

- a) 12 kV rated voltage.
- b) Rated current min. 1250 A.
- c) Rated breaking symmetrical short-circuit equal to or higher than 40 kA/1s.
- d) Charging supply voltage 110 V DC.

4.2.5.5. Medium-voltage switchgears shall be provided with a standardised power supply one-line diagram to be placed on the front plate along with a description of the apparatus installed in a feeder.

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4.2.6. Design of Low-voltage Switchgears

4.2.6.1. Low-voltage switchgears shall be designed, using distribution cubicles:

- a) Indoor, free-standing, modular, with a rear cable compartment.
- b) Withdrawable or stationary units, depending on the type of loads.

4.2.6.2. LV switchgears partitioning form – 4b.

4.2.6.3. The degree of protection of the housing – at least IP41.

4.2.6.4. Low-voltage switchgear should be designed in accordance with the following principles:

- a) Rated current of switchgear busbars and primary circuits in the feeder, coupling and riser feeders, designed with a 20% spare, calculated on the basis of the installed power of the switchgear.
- b) Spare cubicles fully equipped for motor outgoing, with spare not less than 10% of the total number of LV motor cubicles supplied from the switchgear, with an even division between given sections.
- c) Spare cubicles fully equipped with non-motor outgoing, with a spare of not less than 10% of the total number of switchgear cubicles other than motor cubicles, with an even division between given sections.
- d) Spare unequipped cubicles (empty drawers) for motor outgoing with a spare of not less than 10% of the total number of LV motors, powered from the switchgear, with an even division between given sections.
- e) Spare unequipped cubicles (empty drawers) for non-motor outgoing with a spare of not less than 10% of the total number of switchboard cubicles other than motor cubicles, with an even division between given sections.
- f) Spare space for possible expansion of the so-called construction spare, with a spare of not less than 10% of the total number of switchboard cubicles.

4.2.6.5. Each of the busbar sections of the low-voltage switchgear should be equipped with surge arrester protected by fuses. Fuses should switch off damaged surge arresters without disturbing the continuity of power supply to the receivers.

4.2.6.6. Each incomer feeder in LV switchgear shall be equipped with an emergency shutdown button, operating on:

- switching off the circuit breaker in a given incomer feeder,
- switching off the transformer feeder supplying a given LV switchgear in MV switchgear,
- permanent interlock of ATS system in LV switchgear.

4.2.6.7. Switchgears shall be suitable for working with supervisory systems (DCS/ESD, PLC, NRB, etc.).

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- 4.2.6.8. Supply, coupling, distribution cubicles of low-voltage switchgear shall be equipped with:
- Withdrawable air circuit breaker for rated currents greater than or equal to 800 A.
 - Molded case circuit breaker installed in the withdrawable unit for rated currents less than 800 A.
 - Automatic switching equipment.
 - Automatic control and protection systems to switch over power supply units.
 - Analog three phase current and voltage measurement system.
 - Power network meter – except in bus tie coupling.
 - Synoptic cassettes on the front panel.
- 4.2.6.9. Outgoing distribution feeders for motors with nominal power higher than 2kW should be equipped with:
- Fuse switch disconnectors with power fuses.
 - Air insulated contactor.
 - Electronic overload protection.
 - Current measurement system.
 - Signalling systems for motor status and operation.
- 4.2.6.10. Outgoing distribution feeders for motors with nominal power lower than 2kW should be equipped with:
- Motor protection circuit breaker.
 - Air insulated contactor.
 - Current measurement system.
 - Signalling systems for motor status and operation.
- 4.2.6.11. Each motor's outgoing panel shall have a rear cable compartment with a width to ensure a free and safe access to main terminals and auxiliary circuit terminal blocks. The panels' auxiliary circuits shall be led out to the auxiliary circuit terminal block in the cable compartment.
- 4.2.6.12. Other outgoing cubicles of the low-voltage switchgear should be equipped with:
- Withdrawable air circuit breaker for rated currents greater than or equal to 800A.
 - Withdrawable compact circuit breaker for rated currents less than 800 A but greater than or equal to 400 A.
 - Fuse switch disconnecter, circuit breaker or molded case circuit breaker for rated currents less than 400 A.
- 4.2.6.13. Each outgoing module should be marked with a permanent tag containing the rated current of the fuse and its type, as well as, for motor feeders, the rated current of the fed motor.
- 4.2.6.14. Charging systems of the circuit breakers in the feeder cubicles and the coupling should be powered by 230 V AC.
- 4.2.6.15. In places where it is impossible to use indoor or container switchgears and the loads supplied from these switchgears are not critical for the production plant, it is allowed to install field switchboards (outdoor).
- 4.2.6.16. The use of field switchboards (outdoor) should always be agreed with the Electrical Department.

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4.2.6.17. Field switchboards (outdoor) should meet the following requirements:

- a) Enclosure must be provided to protect against external factors such as water, snow, UV radiation, etc.
- b) The degree of protection of the housing should be at least IP65.
- c) Appropriate anti-condensation heating of the switchboard interior should be used.
- d) The switchboard should be equipped with a roof to protect it from rain and preventing snow accumulation.
- e) Enclosures used should allow easy access to the interior of the switchboard without the need to use tools.
- f) If the infrastructure allows it, the voltage loss signal on the switchboard buses should be transmitted to the NRB system.

4.2.6.18. In addition to LV switchgear and field switchboards, auxiliary boards are used. All of the auxiliary boards should be designed, as single-section, without withdrawable unit. The following is a list of auxiliary boards fed from the main LV switchgear:

- a) TOP: normal lighting distribution panel, designed to supply lighting on the production plant and TOA panel. Powered by two different sections, with automatic change over (ACO).
- b) TOA: emergency lighting distribution panel, powered during normal operation from the normal lighting distribution panel (TOP), but during a loss of main voltage, automatically switched to power from a battery bank charged from a 220 V DC rectifier.
- c) TPS: direct current distribution panel, designed to supply protection circuits and control in medium and low-voltage switchgear. Powered during normal operation from two buffer power supplies. Each of them is supplied from two different sources - LV switchgear or TPZ and cooperating with a 110 V DC battery bank.
- d) TGR: low-voltage heating distribution panel, located in the electrical switchgear room, supplying distribution boxes for heating panels, winter heating and technological. Supplied from two different sections of the main switchgear, with an automatic change over (ACO).
- e) TER: low-voltage repair outlet distribution panel, located in the electrical switchgear room, supplying repair outlet sets. Supplied from two different sections of the main switchgear, with automatic change over (ACO).
- f) TPZ: low-voltage alternating current distribution panel, located in the electrical switchgear room. It is supplied from two different sections of the main switchgear, with automatic change over (ACO). The following loads are supplied from the TPZ:
 - UPS DCS and LSK: Bypass/electrical bypass line in TP panel,
 - SDM cabinet non-critical loads, so-called bus D,
 - TPS, TOA: Backup power supply for the installation's 110 V DC, 220 V DC rectifiers,
 - Other circuits needed for normal operation of the production plant. e.g. anti-condensation heaters of motors,
 - Internal installations of buildings (outlets, internal lighting of cabinets, electrical heating of rooms).
- g) TKL: HVAC distribution panel, located in the electrical switchgear room. It is supplied from two different sections of the main switchgear, with automatic change over (ACO).

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4.2.6.19. LV auxiliary boards should be designed in accordance with the following principles:

- a) Rated current of buses of auxiliary boards, power cables and equipment in the cubicles supplying a given panel designed with a 20% spare.
- b) Spare outgoings fully equipped, with a spare of not less than 10% of the designed number of consumers.
- c) Spare space for possible expansion, the so-called construction spare, with a spare of not less than 10% of the designed quantities of consumers.
- d) Equipped with a dedicated spots for convenient installation of portable earthing devices.
- e) Cable feeders from auxiliary boards shall be terminated via terminal strips.
- f) Minimum partitioning form – 2b.
- g) All devices installed in auxiliary boards shall be accessible after opening the doors.
- h) Common protective devices shall not be used for different groups of loads, e.g. socket circuits together with lighting or heating circuits.

4.2.7. Nomenclature of switchgears, electrical boards and other electrical equipment

- 4.2.7.1. The following naming rules, apply to newly constructed installations.
- 4.2.7.2. Nomenclature of switchgear and auxiliary boards is derived from the name of the supply switchgear, not from the location.
- 4.2.7.3. Prefixes OPR and OPT apply only to MV main switchgear (OPR) and LV main switchgear (OPT), which is located in a different building than OPR).
- 4.2.7.4. OPR 6kV switchgear shall be named based on the number of the GPR switchgear supplying it, e.g. GPR-R2, should supply OPR-R21, OPR-R22, OPR-R23, etc. switchgear. Other example names of GPR: GPR-P1, GPR-S1, GPR-O1.
- 4.2.7.5. The LV main switchgear shall be named based on the number of the OPR switchgear supplying it, e.g. OPR-R21, should supply switchgear R21-N1, OPT-R211N1, OPT-R212N1, etc.
- 4.2.7.6. If the LV main switchgear, together with the transformers supplying it, is located in the OPR building from which it is supplied, then in its name, do not use the prefix OPT, but the suffix N1, N2, etc. e.g. R21-N1.
- 4.2.7.7. The naming of the subsequent switchgear fed from the LV switchgear should be based on changing the suffix NX to NXY, e.g. LV sub-switchboards fed from R21-N1 switchgear should be named R21-N11, R21-N12, etc., and those fed from OPT-R211N1, should be named R211-N11, R211-N12, etc.
- 4.2.7.8. The naming of auxiliary boards and other equipment supplied from LV sub-switchboards shall include the name of the supplying switchboard and the name of supplied equipment, e.g. R211N11-TPZ, R211N11-TGR.

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4.2.7.9. Examples of naming switchgear, auxiliary boards and other electrical equipment are shown in the table below:

Device type	Nomenclature
6 kV switchgear	OPR-R21
0,4 kV switchgear in the same building as the OPR	R21-N1
0,4 kV switchgear in a separate building from OPR, together with transformers	OPT-R211N1
0,4kV switchgear fed from the above	R211-N11
Low-voltage alternating current distribution panel	R21-TPZ, R211-TPZ
Low-voltage heating distribution panel	R21-TGR, R211-TGR
Heat tracing distribution panel on plant	R21-TGR-HTP, R211-TGR-HTP
Low-voltage repair outlet distribution panel	R21-TER, R211-TER
Normal lighting distribution panel	R21-TOP, R211-TOP
Emergency lighting distribution panel	R21-TOA, R211-TOA
Direct current distribution panel	R21-TPS, R211-TPS
HVAC distribution panel	R21-TKL, R211-TKL
NRB-UR cabinet	R21-NRB-UR, R211-NRB-UR
NRB-RE cabinet	R21-NRB-RE, R211-NRB-RE
Transformer 6/0,4 kV	R21-T1, R21-T2, R211-T1, R211-T2

4.2.7.10. The method of naming the elements of the guaranteed voltage system is presented in Appendix No. 4.

4.2.8. Colours of the facades of the feeders of medium and low-voltage switchgear

4.2.8.1. The facade colours of the individual feeders of MV switchgear (OPR) are presented below:

Feeder Type	Colour	RAL
Outgoings	Grey	7032
Primary and reserve incomers	Red	3000
Couplings	Yellow	1016
Voltage measurement	Green	6018

4.2.8.2. The colours of the facades of the feeders of low-voltage switchgear (OPT) are presented below:

Feeder Type	Colour	RAL
Outgoings	Grey	7031
Primary and reserve incomers	Red	3003
Couplings	Yellow	1021

4.2.8.3. Colour scheme for auxiliary boards TPZ, TOA, TOP, TGR, TER, TKL - RAL 9003, white.

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4.3. CAPACITOR BANKS

- a) Power factor correction should be performed by capacitor banks that automatically maintain the required power factor.
 - For MV grids, the power factor should be maintained at the level of $\text{tg } \varphi = 0,4 / \cos \varphi = 0,93$ MV capacitor batteries should be built at the level of GPR switchgear - outside the scope of this study.
 - For low-voltage grids, the power factor should be kept at $\text{tg } \varphi = 0,2 / \cos \varphi = 0,98$.
- b) Calculations and/or measurements of distortion introduced by current and voltage harmonics should be made, the point of measurement should be explicitly agreed upon with the Client. If the maximum permissible value of harmonics has been reached, harmonic distortion reduction filters should be installed. The contractor should meet the requirements for measuring systems: electricity, permissible power factor, permissible level of higher harmonics, etc.

4.3.1. Low-voltage capacitor banks

4.3.1.1. Basic requirements

- a) Power compensation of 0,4 kV low-voltage loads must be carried out with compensators operating in a tracking system.
- b) Capacitor banks must be connected to the corresponding sections of the low-voltage main switchgear.
- c) Compensation must lead to a power factor $\cos \varphi = 0,98$.
- d) Regulation of reactive power compensation must be automatic.
- e) Capacitor batteries must be suitable for operation in networks where higher harmonics occur.
- f) The ratings of capacitor batteries must correspond to the power ratings of the power transformers supplying the low-voltage switchgear and the reactive power demanded by the switchgear for which they are selected. The manufacturer must perform all calculations necessary for battery selection, based on the ratings of the transformers and the power balance of the LV switchgear.

4.3.1.2. Design requirements

- a) The capacitor bank shall have a metal enclosure, suitable for operation in an enclosed rooms, outside the explosion hazardous area.
- b) Cabinets are to have hinged doors at the front and hinged doors at the rear or removable covers.
- c) Enclosures need to be connected by a common busbar system. The busbars need to be fixed so as to withstand, without damage, the dynamic stresses and thermal effects caused by maximum short-circuit currents. The ground rail need to be installed along the entire length of the capacitor bank set.
- d) Cable and bus duct terminals are to be located at the rear of the cabinets. Cable terminals and bus duct terminals are to be located so as to facilitate the routing and connection of cables or bus ducts.

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4.3.1.3. Technical requirements

- a) If the emission of harmonics, as defined by EN 50160, sent to the grid by power equipment is exceeded, higher harmonic suppression chokes must be installed in the capacitor bank.
- b) The battery must be equipped with a power factor controller, which will be installed on the door of the capacitor bank cabinet.

4.3.2. Low-voltage active filter

4.3.2.1. Basic requirements

- a) Power compensation of 0,4kV low-voltage loads must be carried out with compensators operating in a tracking system.
- b) Active filters must be connected to the corresponding sections of the low-voltage main switchgear.
- c) Compensation must lead to a power factor $\cos \varphi = 0,98$.
- d) The active filter must fully compensate for capacitive reactive power.
- e) Reactive power compensation control must be automatic.
- f) Active filters must be suitable for operation in networks where higher harmonics occur.
- g) The rating of the active filter must correspond to the reactive power demanded by the switchgear for which it is selected. The contractor must perform all calculations necessary for the selection of the active filter, based on the power balance of the LV switchgear provided by the Client. The contractor must perform all necessary measurements of power quality parameters for the selection of the active filter and its parameterization.

4.3.2.2. Design requirements

- a) The active filter shall have a metal enclosure, free-standing, suitable for use in a closed room, outside an explosion hazard area.
- b) Active filter cabinets must have a hinged door on the side from which the unit is operated or maintained.
- c) Cabinets must have hinged doors or removable covers on the back and sides.
- d) Cable and rail terminals must be located at the rear of the cabinets.
- e) Cable and bus terminals must be located so as to facilitate the routing and connection of cables or bus bars.

4.3.2.3. Technical requirements

In the event that the emission of interference, as defined by EN 50160, sent to the network by electrical equipment is exceeded, the settings of the active filter must be changed. The configuration and parameterisation of the active filter is the full responsibility of the Contractor.

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4.4. POWER TRANSFORMERS

4.4.1. Power transformers requirements

4.4.1.1. Distribution transformers parameters

Connection group	Dyn5
Rated voltage	6300/400 V, 6300/690 (MV/LN) 10500/400 V, 10500/690 (MV/LV)
Voltage regulation	Primary side tap changers, in de-energized condition, in the range of $\pm 2 \times 2,5\%$
Short circuit voltage	normally 6%
Insulation	Cast-resin, of F class

4.4.1.2. Transformers shall be selected from standard / typical range as follow (... 630, 1000 to 1600, kVA) shall be used. According to technical and economic assumptions higher values of nominal power of transformers may be consulted with a Client.

4.4.1.3. Power transformers should be placed in a casing with a degree of protection IP 20.

4.4.1.4. In the transformer chamber, a disconnector with an earthing switch, shall be installed on the transformer MV side.

4.4.1.5. Transformer shall be protected with the following protections:

- a) Instantaneous overcurrent protection phase to phase against internal short circuit in the transformer.
- b) Earth fault protection.
- c) Winding temperature protection.
- d) Main and standby time delay overcurrent protection against LV external network short circuits currents.

4.4.1.6. Distribution transformers shall be equipped with double PT100 thermistors that are installed in each phase of secondary side windings.

- a) The thermistors shall be connected to a terminal strip.
- b) The winding temperature protection shall be a two-stage one, where: the first stage sends a warning signal, the second stage sends a signal to switch off. The first stage and second stage temperature overrun signals shall be transmitted to DCS system.
- c) The transformer cooling requirements and temperature protection settings shall be as indicated in manufacturer's recommendations.
- d) The auxiliary circuits of the winding temperature protection shall be fed with the substation guaranteed voltage.
- e) The temperature protection relay shall be installed on the transformer housing, on the chamber's entrance side.

4.4.1.7. The neutral point of the transformer secondary side shall be directly grounded, without the use of test joints.

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4.4.1.8. Top connection to the power transformer shall be used:

- primary side by cables or bus ducts,
- secondary side by bus ducts in a TN-S system.

4.4.1.9. Transformer earthing terminals shall be installed on the MV side of the transformer in the form of flat copper bars, suitable for the connection of portable earthing devices.

4.4.1.10. Surplus of transformer power cable shall be provided and placed under the transformer compartment.

4.4.1.11. The transformers shall be suitable for hidden reserve operating conditions, i.e. each of the two transformers shall be able to take over 100% load of the switchgear.

4.4.1.12. The transformer load shall not exceed 50% of their rated powers when operated in the normal mode.

4.4.1.13. Power transformers MV/LV shall be situated in transformer chambers and located on the north side of the designed facilities.

4.4.1.14. In the transformer chamber, in an easily accessible place, there should be placed an emergency shutdown button for the transformer, which will turn off its feeder in the MV switchgear and permanently lock the ATS system in the LV switchgear.

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4.5. POWER GENERATORS

4.5.1. Power generators - general requirements

The power generator used at the ORLEN site should be brand new, completely equipped with components to ensure proper operation, manufactured within a maximum of 12 months prior to the date of delivery to the station. The Automatic Change Over (ACO)/Scheduled Power Supply Change Over (SPSCO) for power generator changeover shall be implemented by means of a five-breaker ACO system, installed in the LV switchgear. Power generators shall meet the following requirements:

- a) Engine-driven (internal combustion), equipped with compression-ignition (diesel) engines.
- b) Three-phase alternating current (AC).
- c) Emergency (standby), automatically started in the event of a loss of the electric power supply, meeting the requirements of the ESP (Emergency Standby Power) rating in accordance with ISO 8528, i.e. intended for emergency supply operating during mains failure, with operating time of 200 h/year.
- d) Stationary, operating in island mode (off-grid).
- e) Dedicated for supplying sensitive loads (including IT systems, UPS and PLC), ensuring high voltage and frequency stability.
- f) Intended for operation in industrial environments (refineries/petrochemical plants). Corrosion class C3 is required.
- g) Suitable for supplying electric motors, including operation during motors start-up.
- h) Minimum operating time of the power generator at 100% load without refuelling of min. 8 hours.
- i) Start-up and load acceptance time maximum 30 s.
- j) Automatic and manual start-up using the control panel on the equipment of the generator set.
- k) At the commissioning stage, the power generator shall be equipped with a full fuel tank. Fuel in the delivered generator must be of the "winter" type.
- l) The Contractor shall be responsible for conducting Factory Acceptance Test (FAT) and Site Acceptance Tests (SAT), including the provision of relevant test reports. Perform the tests in accordance with the scope agreed with the Purchaser.

4.5.1.1. Environmental requirements

- a) Maximum short-term ambient temperature: +40 °C.
- b) Highest daily average temperature: +35 °C.
- c) Highest average annual temperature: +20 °C.
- d) Lowest ambient temperature for stationary power generators: -25 °C.

4.5.1.2. Nominal parameters:

- a) The generator in normal operation of loads should ensure continuity of power supply at maximum energy demand. Rated power of the generator selected on the basis of power balance, detailed design. Also take into account 20% power spare with $\cos\Phi=0,8$ in continuous operation mode.
- b) Rated frequency: 50 Hz.

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- c) Range of relative frequency variation in steady state: $\leq 1,5\%$.
- d) Rated voltage: 230/400 V.
- e) Steady-state voltage deviation: $\leq 2,5\%$.
- f) Load acceptance time: maximum 10 s.
- g) Time range with overload 10% not less than 1 hour within 12 hours operation.
- h) Required load power factor range: $0,7 \div 1$.
- i) Phase load irregularity: up to 20%.
- j) Type of diesel fuel: diesel fuel with parameters in accordance with Directive 98/70/EC.
- k) Maximum noise level at 100% load from a distance of 1 m: 90 dB(A).
- l) Rated voltage of the starting battery in accordance with the manufacturer's documentation.

4.5.1.3. Construction requirements

- a) IP rating of the generator: IP 23.
- b) IP degree of protection of the junction box: IP 55.
- c) IP degree of protection of the control panel: IP 51.
- d) Starting system: electric, automatic.
- e) Cooling system: liquid-air.
- f) Voltage and frequency regulator: electronic.
- g) Control and control-measuring apparatus: required, in accordance with the manufacturer's guidelines.
- h) The control panel have to include at least the following elements:
 - synoptic diagram with indicators and control switches,
 - automatic on/off control,
 - operating parameters monitoring system,
 - operating mode selection switches,
 - control selection switches, testing switches,
 - alarm indicators,
 - measuring instruments, power supply for all measuring devices of the current set,
 - protections.
- i) The generator must have signalling of conditions that threaten proper operation: signalling of oil condition, coolant condition, buffer power supply damage, low fuel level, failed start up.
- j) The generator must be able to transmit signals to the DCS, NRB-RE and NRB-UR computer supervisory systems, in accordance with the requirements specified in the relevant signalling sections.
- k) The generator must be equipped with a total operating time counter.
- l) The generator must be equipped with an engine block heating system.
- m) The generator must be equipped with a visual indication of the fuel level.
- n) The generator must be equipped with a buffer power supply for starting batteries.

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- o) The generator must have the ability to operate, in service mode, with a minimum load of 10% of rated power.
- p) The generator should be adapted to work with a 400/230V AC switchgear. Start/stop of the generator shall be implemented by the 400/230V switchgear's ACO.
- q) The fuel filler for the generator tank should be lockable with a key and should be located on the wall of the container on the road side or in another place that allows refuelling during operation without shutting down the generator.
- r) The generator shall have a check valve system to prevent fuel from draining from the fuel system into the tank after operation.
- s) Generator made in containerized housing (intended for outdoor setting) must be equipped with thermal insulation on the ground side.

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4.6. CABLE LINES AND CABLE ROUTES

4.6.1. Cable lines requirements

- 4.6.1.1. Where necessary, power cables, control cables and signalling cables should be flame retardant and self-extinguishing.
- 4.6.1.2. Cables to be laid for equipment installed beyond explosion hazardous areas shall not pass through those areas.
- 4.6.1.3. Power cables for electric motors that driving technological machines that reserve each other shall be fed from different switchgear sections and shall be routed on independent cable routes, separated from each other by a safe distance.
- 4.6.1.4. Cables in explosion hazardous areas shall be laid:
 - Underground in concrete cable trenches wholly filled with sand,
 - Above-ground on cable racks, pipe racks in cable trays or on ladders.
- 4.6.1.5. Cables for guaranteed voltage system e.g. for emergency equipment, shall be laid in independent and marked routes protected against expected mechanical, thermal and chemical damages.
- 4.6.1.6. All cable entries through walls shall be permanently sealed. Plant cable entries from underground location to auxiliary junction boxes shall be sealed with sealing compound appropriate to expected mechanical, thermal and chemical damages.
- 4.6.1.7. Cables located across the roads and in places where danger of mechanical damage exists shall be protected with Client's approved conduits.
- 4.6.1.8. Cables running underground or aboveground to:
 - LV motor, including motor operated valves, shall be terminated in separate terminal boxes. The connections between the intermediate terminal boxes and motor terminal boxes shall be made by means of suitable flexible cables, with conductors of at least Class 5.
 - MV motor, it is recommended to be connected directly to motor terminal boxes.
- 4.6.1.9. For newly designed substations and substation buildings, cable rooms with a minimum room height of 2,2 metres shall be provided.
- 4.6.1.10. Obligatory Regulations of European Union should be applied after earlier obtaining prior acceptance of Client in the case when economic reasons suggest solutions different from above mentioned ones.

4.6.2. Selection of electrical cables, electrical conductors and equipment

- 4.6.2.1. MV rated voltage power installations for process units and technological objects shall be executed by means of single or three core, power cables, of the following characteristic:
 - copper cores,
 - cross linked polyethylene cores insulation,
 - electric field of radial distribution type,
 - common return copper core,
 - longitudinal and radial moisture protecting seal,
 - external sheath of self-extinguishing or fireproof polyethylene, or self-extinguishing or fireproof polyvinyl,
 - resistant to corrosion caused by chemical exposures (hydrocarbons).

Power cables for motors powered by frequency converters shall be symmetrical and shielded.

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4.6.2.2. LV rated voltage power installations for process units and technological facilities shall use three, four or five core, power cables of the following characteristic:

- copper cores,
- cross linked polyethylene cores insulation,
- identical sections of phase and protective cores (except for Power cables for motors powered by frequency converters),
- external sheath self-extinguishing or fireproof polyethylene, or self-extinguishing or fireproof polyvinyl,
- resistant to corrosion caused by chemical exposures (e.g. hydrocarbons).

For LV consumers of nominal power equal to or greater than 160 kW, one-core cables may be used/.

Power cables for motors powered by frequency converters shall be symmetrical and shielded.

4.6.2.3. Controlling, signalling, measuring installations on the level of 230 VAC or 110 VDC (e.g. connections with Local Control Stations) installed in process units and technological facilities shall use multi-core signalling cables of the following characteristic:

- copper cores,
- cross linked polyethylene cores insulation,
- with a common shield,
- identical sections of signal and protective cores, external sheath of self-extinguishing or fireproof polyethylene, or self-extinguishing or fireproof polyvinyl,
- resistant to corrosion caused by chemical exposures (e.g. hydrocarbons).

4.6.2.4. Controlling, signalling, measuring installations on the voltage level of 24 VDC (e.g. connections with DCS, NRB) installed in process units and technological facilities shall use multi-pair telecommunication cables of the following characteristic:

- copper cores,
- cross linked polyethylene cores insulation,
- individual cable core pairs shall be stranded and protected by individual shields,
- with a common shield,
- external sheath self-extinguishing or fireproof polyethylene, or self-extinguishing or fireproof polyvinyl,
- resistant to corrosion caused by chemical exposures (e.g. hydrocarbons).

4.6.2.5. For the selection of cables the rated current of the fed consumers should be considered, taking into account the installation conditions, short circuit criteria (initial symmetrical short-circuit current - I_k , duration of short circuit current) and following maximum voltage drops:

- 5 % at full load conditions, 15% at starting conditions for motors,
- 5% for power feeders,
- 3% for lighting feeders,
- 2 % for branch-circuits.

4.6.2.6. For the selection of power supply cables feeding OPR switchboards from GPR switchboards, the short-circuit duration shall be assumed as $t_z=1$ s. For all cables supplying loads from OPR switchboards, $t_z=0,5$ s shall be assumed.

4.6.2.7. Cables and wires for safety installations routed in fire hazardous areas shall be of construction assuring at least thirty minutes resistance to fire.

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4.6.2.8. Cables laid in explosion hazardous areas, entirely or partly, shall have the following minimum cores cross sections:

- Power cables - 2.5 mm²,
- Control, signalling cables - 1.5 mm²,
- Telecommunications cables - 1.0 mm².

Usage of cables with cores of smaller cross-sections requires written consent of Client.

4.6.2.9. The method of laying power cables in the ground should be carried out in accordance with currently applicable regulations, taking into account the impossibility of laying cables in layers.

4.6.2.10. Cables shall have improved level of insulation, i.e.:

Cable type	Rated voltage [kV]	Cable rated voltage [kV]
Medium voltage power cables	10	8,7/15 kV
	6	6/10 kV
Low voltage power and controlling, signalling cables	0,4/0,23	0,6/1 kV
Telecommunications cables		0,3/0,5 kV

4.6.2.11. The power-cables for electric motors to be laid in explosion hazardous areas shall have a long-term current carrying capacity of no less than 125 % of the motor rated current at a 5% maximum voltage drop.

4.6.2.12. Signalling, control and telecommunication cables shall have at least 10% spare cores. There is recommended that the maximum number of cores in any one cable does not exceed 24 pieces.

4.6.2.13. The number of wires in the control cables for MV remote control station or LV remote control station shall be standardised.

4.6.2.14. The outer sheath of the power and control cable shall be black.

4.6.2.15. The colours of the wires inner insulation of the cable shall be as listed below.

a) Five-core cable for three-phase alternating current (AC) installation:

- U (L1 phase wire): brown,
- V (L2 phase wire): black,
- W (L3 phase wire): grey,
- N (neutral wire): blue,
- PE (protective wire): yellow-green.

b) Single-core cable for three-phase alternating current (AC) installation:

- U, V, W (phase wire L1,2,3): black.

c) Three-core cable for single-phase alternating current (AC) installation:

- L (phase wire): brown,
- N (neutral wire): blue,
- PE (protective wire): yellow-green.

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d) Three-core cable for single-phase direct current (DC) installation:

- positive (+) wire: red,
- negative wire/neutral (-/N): blue,
- protective wire (PE): yellow-green.

e) Control cable:

- control wire: black,
- protective wire (PE): yellow-green.

4.6.2.16. Marking of cable lines.

a) All cables shall be marked at both ends of the cable with securely attached stainless steel plates containing the following information:

- cable designation according to the cable list in the technical documentation,
- the relation of the cable: from where (designation of the distribution board, number of the feeder) - to where (technological designation of the consumer),
- type of cable, number of cores, its cross-section and rated voltage,
- year of laying of the cable.

b) Cables laid in the ground shall be equipped with permanent markers at distances of not more than 10 m along their entire length and at the joints and in characteristic places, e.g. at the crossing, duct and protective tubes entries.

c) Cables laid on cable trays/cable ladders shall be equipped with permanent markers at cable terminations and electrical devices, and at distances of not more than 10 m along their entire length in such locations that the identification of the cable is unambiguous.

d) Cables laid in ducts and tunnels shall be equipped with permanent markers at distances of not more than 20 m.

e) The marking of cable/wire cores inside the cabinets should include the relation of the cable core: from where (designation of the strip terminal/device terminal) - to where (designation of the strip terminal/device terminal).

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4.6.3. Requirements for cable trays and cable ladders

4.6.3.1. The elements of cable trays shall be:

- a) Designed with a surplus not less than 30%.
- b) Made of hot-dip galvanized steel sheet for corrosion aggressiveness class C5 (according to the PN-EN ISO 1461 standard, the average thickness of the zinc coating should be at least 45-85 μm depending on the thickness of the steel used).
- c) Mounted in a manner assuring durability of anti-corrosion protection used.
- d) Instrumentation and telecommunication cables should be laid separately from power cables.
- e) Emergency lighting circuit cables should be laid separately from normal lighting circuits.
- f) Alternate current cables should be run separately from direct current cables.
- g) Properly protected from corrosion when introducing cables and wires to cable trays and/or ladders.
- h) When cables and conductors are entering into cable trays and/or ladders, a method ensuring that the reliability of the applied anti-corrosion protection shall be used.
- i) Cables trays or cable ladders shall be protected against destructive external influences, such as: atmospheric precipitation, sunlight radiation and unintentional mechanical or thermal damages by using appropriate protective covers.

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4.7. ELECTRICAL DRIVES

4.7.1. Electric Motors

4.7.1.1. The following electric motors shall be used:

- a) Squirrel-cage directly started-up three-phase induction motors with insulated winding of at least F temperature insulation class. Insulation for medium voltage motors shall be executed in VPI technology (Vacuum Protected Insulation).
- b) Motors shall be totally enclosed fans cooled, with minimum IP 54 protection class. This IP requirement shall not apply to motors protected by ATEX pressurized enclosures.
- c) Only when for economical or technical reasons, air cooling is not feasible e.g. for larger motors, these shall be closed circuit water-air cooled with integral coolers.
- d) If motors in explosion-proof execution are used then flameproof increased safety, motors shall be used i.e. flameproof motor, increased safety motor terminal boxes, otherwise it is recommended to use motors in pressurized enclosure.
- e) The motors should be provided with suitable executed temperature sensors, vibrations sensors, etc.
- f) The maximum noise level shall be 85 dB(A) and shall be confirmed in accordance with PN-EN ISO 1680 Acoustic. Test code for the measurement of air-born noise emitted by rotating electrical machines, measured at 1-meter distance.
- g) Main terminal box should be at the top of motor case with the ability to rotate every 90 degree, or at a place as agreed with Client. Terminal box should be made of thick cast iron, cast steel or steel sheets of minimum 3 mm thickness.
- h) Separate auxiliary terminal boxes with sensors for measurement of bearings temperature, windings temperature or vibrations (as necessary). Each terminal box should be made of cast iron, cast steel or steel sheets of minimum thickness 3 mm.
- i) Motors with a power exceeding 500 kW and above 3000 rpm, or two-pole motors, should be equipped with slide bearings, others with roller bearings.
- j) The bearing temperature, at the determined rated motor parameters, should not exceed 70°C, at the maximum ambient temperature of + 40°C.
- k) When roller bearings are used for motors, minimum 100°C operating temperature of bearings shall be used.
- l) If the low-voltage motor is equipped with PTC sensors to measure the winding temperature, these shall be connected to the protection device.
- m) If the motor is equipped with anti-condensation heaters, they shall be connected to the power supply system and shall be switched on after the motor has been switched off.

4.7.1.2. MV motors, rated voltage: 6 kV, 10 kV shall be equipped with temperature sensors for measuring bearings temperature, windings temperature and anti-condensation heaters.

- a) Terminals of sensors for the measurement of windings temperatures, bearings temperatures or vibrations shall be installed in separate terminal boxes. Doubled (one spare) resistance sensors of Pt 100 type shall be used.
- b) One double sensor to measure temperature of the front bearing and one double sensor to measure temperature of the back bearing. Bearing temperature sensors shall co-operate with Distributed Control System (DCS).

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- c) Bearing temperature sensors terminal clamps shall be led into a separate terminal box. The Ex-proof execution of temperature sensors and sensors terminal box shall meet the requirements of Client's Instrumentation discipline.
- d) One doubled (one spare) sensor per each winding phase. Winding temperature sensors terminal clamps shall be led into a separate terminal box. Winding temperature sensors shall co-operate with the motor protection system.
- e) The motor winding temperature measurement system consisting of temperature sensors, connecting wires, auxiliary terminal boxes, shall be designed in accordance with requirements for "increased safety" type execution.
- f) Anti-condensation heaters. The connection terminals of the anti-condensation heaters should be led to a separate junction box.
- g) Vibration sensors shall be executed in accordance with Client's Mechanical discipline requirements. The vibration sensor terminals shall be led into a separate terminal box.

4.7.1.3. Low voltage motors with a rated power equal or higher than 160 kW shall be equipped with:

- a) One doubled (one spare) sensor to measure the temperature of the front bearing and one doubled sensor (one spare) to measure the temperature of the back bearing. The bearing temperature sensor terminals shall be led into a separate terminal box. Bearing temperature sensors shall co-operate with process control system (DCS).
- b) The Ex-proof execution of bearings temperature sensors terminal box shall meet the requirements of ORLEN S.A. instrumentation discipline.
- c) One PTC sensor per each winding phase. Winding temperature sensors terminal clamps shall be led into a separate terminal box. Winding temperature sensors shall co-operate with the motor protection system.
- d) The motor winding temperature measurement system consisting of temperature sensors, connecting wires, auxiliary terminal boxes, shall be designed in accordance with requirements for "increased safety" type execution.
- e) The vibration sensor terminals shall be led into a separate terminal box. The vibration sensors shall be designed in accordance with ORLEN S.A. mechanical discipline requirements.

4.7.1.4. Low voltage motors with a rated power equal or higher than 30 kW shall be equipped with:

- a) One PTC sensor per each winding phase. Winding temperature sensors terminal clamps shall be led into a separate terminal box. Winding temperature sensors shall co-operate with the motor protection system.
- b) The motor winding temperature measurement system consisting of temperature sensors, connecting wires, auxiliary terminal boxes, shall be designed in accordance with requirements for "increased safety" type execution.

4.7.1.5. Electric motors shall be appropriate for operation during the period of five years between two consecutive scheduled maintenance activities.

The manufacturer shall define the conditions admitting any motor for 5-year operation period by indicating indispensable periodical diagnostics which are possible to be executed during normal operation at the installation site.

The following shall be indicated in the operating and maintenance manual:

- a) Conditions admitting electrical motor for five-year approximately 40000 h or longer period of continuous operation between two subsequent turnarounds.

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b) Approval conditions for the motor operation in five-year inter-repair cycles by indicating necessary periodical diagnostic tests that are possible to perform in operation under load at the motor installation place.

c) Manufacturer's drawings with dimensions for: arrangement of holes for fixing bolts, shaft height, overall dimensions, limiting outline, etc.

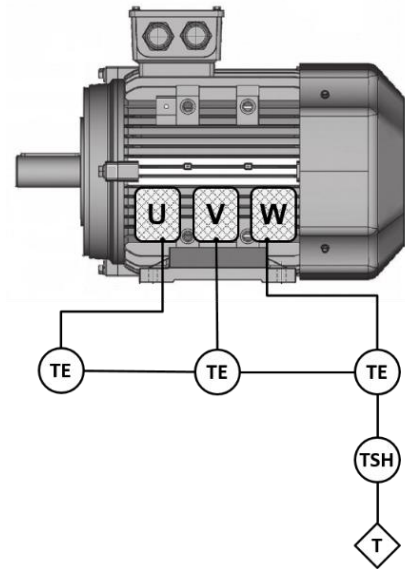
4.7.1.6. Recommended for temperature protections for electric motors of F insulation class equipped with sensors for measuring the temperatures of bearings and/or windings are presented in the table below.

Temperature Protection Settings	WARNING	OFF
BEARINGS	80°C	95°C
WINDINGS	115°C	125°C

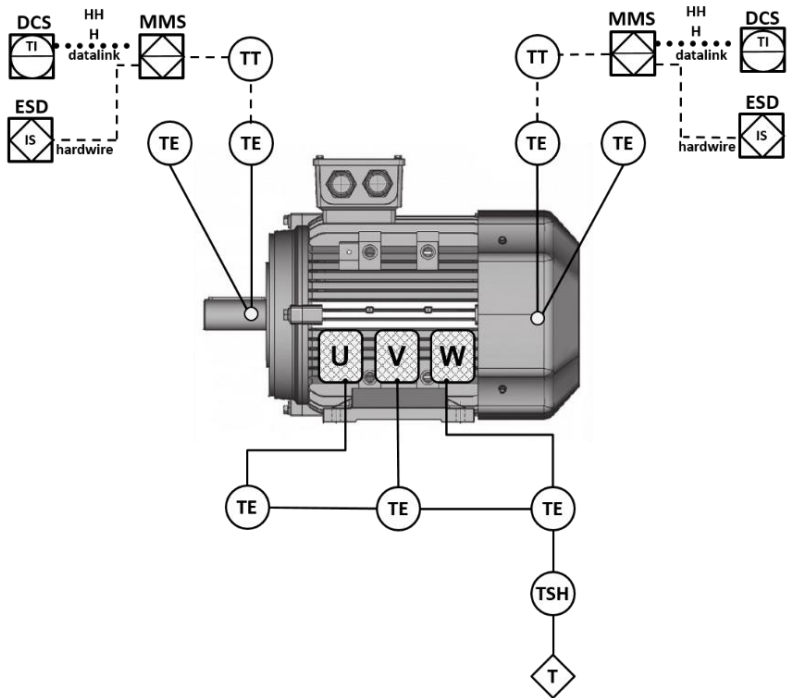
Table 1. Recommended temperature protection settings for bearings and windings of electric motors

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a) Low voltage motors with rated power equal or over 30 kW

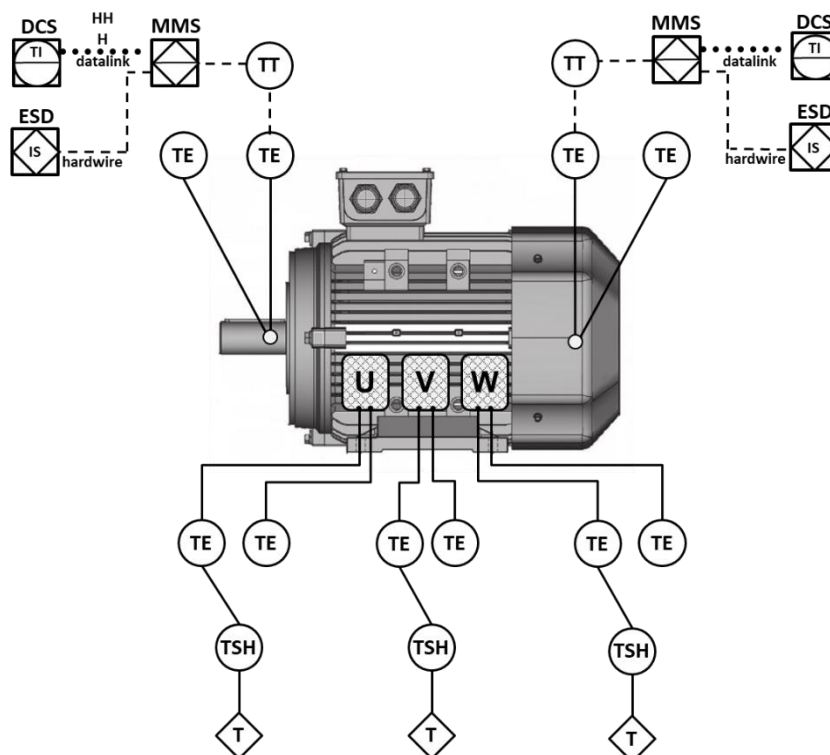


b) Low voltage motors with rated power equal or over 160 kW



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c) Medium voltage motors



Dwg. 3. Temperature measurement method for electric motor's bearings or windings

Where: **TE**-temperature sensor; **TSH** – set point overrun annunciation (I°); **T** – OFF if temperature set point exceeded (II°); **TT** – temperature transmitter; **TI** – temperature indicator; **H** – set temperature overrun alarm; **U, V, W** – motor's stator windings.

Winding temperature measurements on MV motors shall be protected against MV short circuit with special short circuit protection devices, which provide a ground connection - at the motor. This or other solution for the same protection shall be agreed with Client.

4.7.2. Selection of Electric Motors

The following assumptions should be taken into account when selecting electric motors.

4.7.2.1. Self-start-up of Process Plant.

4.7.2.2. Electric motors of rated power:

- Higher than 160 kW should be fed from medium voltage network on level of 6kV, 50 Hz. Respectively, in case of using the network of 10 kV, 50 Hz, electric motors with rated power of 400 kW.
- Higher than 0,25 kW up to equal 160 kW should be fed from low voltage network (0,4 kV; 50 Hz). Respectively, in case of using the network 0,69 kV, 50 Hz, electric motors with rated power higher than 0,25 kW to 400 kW.
- Below or equal 0,25 kW shall be fed from low voltage network (0,23 kV; 50 Hz).

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4.7.2.3. Design short circuit current of power system for motor start-up:

- a) MV Switchgear 6 kV bus-bar - initial symmetrical short circuit current, I_k equal or higher than 15 kA, acc. to PN-EN 60909.
Respectively, bus-bar 10 kV – initial symmetrical short circuit current, I_k shall be calculated according to technical and economic assumptions, according to PN-EN 60909.
- b) LV Switchgear 0,4 kV bus-bar - initial symmetrical short circuit current, I_k equal or higher than 28 kA; according to PN-EN 60909.
Respectively, bus-bar 0,69 kV –initial symmetrical short circuit current, I_k shall be calculated according to technical and economic assumptions, according to PN-EN 60909.

4.7.2.4. The motor start-up current to rated current ratio shall not exceed the following values:

- a) For MV motors.
- Rated voltage 6 kV:
Motors rated power lower than 1000 kW 5,8
Motors rated power higher than or equal to 1000 kW 4,0
 - Rated voltage 10 kV: shall be chosen acc. to technical and economic assumptions.
- b) For LV motors.
- For 0,4 kV motors, rated power lower than or equal 160 kW 6,0-8,0
 - For 0,69 kV motors, rated power lower than or equal 400 kW Shall be chosen acc. to technical and economic assumptions

If it is not possible to meet the above requirement, the following should be agreed: improvement of the parameters of the motor used, a soft-start system or a frequency converter system.

4.7.2.5. Motor self-start-up (reacceleration).

If a voltage failure occurs, motor self-start-up shall be possible:

- a) In systems with MV switchgears, with two feeders, for maximum time of Automatic Change Over /ACO/:

Motor type	ACO setting	ACO limit time
-	[s]	[s]
Medium voltage	1,0	3,0
Low voltage	1,5	3,5

- b) In systems with MV switchgears, with three feeders, for maximum time of Automatic Change Over /ACO/:

Motor type	ACO setting	ACO limit time
-	[s]	[s]
Medium voltage	1,2	3,0
Low voltage	1,7	3,5

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4.7.2.6. Automatic change over starts from the value:

- 40 % nominal rated voltage for MV switchgear,
- 50 % nominal rated voltage for LV switchgear.

In case of ACO failure, electric motors driving technological machines shall be switched off via electrical protection systems (Automatic Self Switch off /ASS/) after 6 sec.

4.7.2.7. Electrical motors control circuits shall be equipped with a system sustaining status-on, in short-time voltage outages, caused by network automatics. Such a system shall cooperate with DCS system.

4.7.2.8. Assurance of correct co-operation with other electrical consumers that are fed from the same network under normal and emergency operating conditions.

4.7.2.9. Contractor shall obtain from the motor manufacturer and deliver exact motor heating up and cooling downtime constants in order to correctly set the medium voltage motor protection. Based on the thermal model, the protection should be configured as to the number of starts on a cold and warm motor. Unless otherwise specified by the motor manufacturer, the preferred number of starts: 3 cold, 2 warm.

4.7.2.10. The root-mean-square values of motor vibration velocity shall be as follow:

- a) Shaft height $56 \leq h \leq 132$ – 1,1 mm/s.
- b) Shaft height $h > 132$ – 1,5 mm/s.

The motor manufacturer shall indicate the measured motor vibration root-mean-square value in shop testing certificate. For motors supplied by variable frequency converters, the above vibration ranges apply over the entire speed control range.

4.7.2.11. Motor softstarter systems or frequency converters shall be used if limitation of starting current value of motor driving the machine is required.

4.7.2.12. Client stipulates the right for final inspection of the motors, which are important for the process at premises of motor manufacturer or motor driven machine unit manufacturer.

4.7.3. Connections for Electric Motors

4.7.3.1. Medium voltage motors shall be fed from medium voltage switchgear using cables that are directly connected into the motor main terminal box.

- a) Motor terminal boxes shall be compatible with the cable and cable accessories selected and so located as to ensure an easy access to terminals.
- b) The way of cable entering into terminal box shall consider the impact of mechanical vibrations on the reliability of the electric motor connection.

4.7.3.2. Low voltage motors, including motor operated valves, shall be fed from low voltage switchgears using cables and motors intermediate terminal boxes.

The intermediate boxes – electric motor interconnection shall be done by means of insulated flexible cable.

Motor terminal boxes shall be compatible with the cable and cable accessories selected and so located as to ensure an easy access to terminals.

4.7.3.3. The motor stand shall be so located as to ensure that installation and disassembly operations are easy to perform.

4.7.3.4. Feeders supplying motors should be made on the basis of withdrawable units (low voltage motors) or withdrawable switch components (medium voltage motors), enabling the location of the unit in three positions: PRACA (RUN), PRÓBA (TEST) and REMONT (RENOVATION).

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4.7.4. Requirements for submersible sets (electric motor - pump) in explosion-proof execution

- 4.7.4.1. Type of explosion-proof execution: Ex db h (minimum requirements: category II 2G according to ATEX and EPL Gb level).
- 4.7.4.2. The explosion group and temperature class of the device should be selected accordingly to the medium creating the hazardous area.
- 4.7.4.3. Technical solutions containing intrinsically safe circuits (Ex i) should not be used.
- 4.7.4.4. The permissible dry-running time of the pump not less than 15 minutes, otherwise the pump should be protected against dry running (appropriate mechanical seal in the pump, in accordance with the requirements of EN 80079-37).
- 4.7.4.5. If the set operates via a frequency converter, when connecting the power supply, the requirements given in the pump operating instructions for the interaction between the frequency converter and the pump unit shall be applied. The explosion-proof motor must be suitable for operation with the frequency converter. The inverter must be selected in accordance with the requirements given in the genset motor manual.
- 4.7.4.6. Technical solutions to be used with:
 - a) Motor winding temperature sensor.
 - b) Humidity sensor.
 - c) Separate power and control cables (sensor terminals).
- 4.7.4.7. All factory-installed sensors in the pump should be connected to the pump control circuits in accordance with the instructions for use of the set.
- 4.7.4.8. The wiring supplied with the unit must be resistant to chemicals.
- 4.7.4.9. Unused conductors in multi-core cables should be grounded or properly insulated with appropriate terminations, in accordance with the requirements of EN 60079-14.
- 4.7.4.10. Hydraulic hoses working in explosion-hazardous areas made of non-metallic materials should have appropriate antistatic properties.
- 4.7.4.11. Control cables (sensor connection) should be routed in a separate cable tray.
- 4.7.4.12. If the set operates via a frequency converter, when connecting the power supply, use appropriate wiring in accordance with the parameters given in the pump manual regarding the operation of the converter and the pump unit.

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4.7.5. Cooperation of the electric motor with the soft-start system

- 4.7.5.1. The need to install a soft-start system is to be agreed with Client.
- 4.7.5.2. The selection of soft-start systems should take particular account of:
 - a) Certificates, validation statements or acceptances issued by appropriate Testing Station, Notified Bodies, which define conditions for co-operation of a soft-start system with an Ex-proof motor operated in explosion hazardous area.
 - b) Motor self-start after a voltage failure, shall fulfil requirements concerning reacceleration time for production process maintenance.
 - c) Informing DCS or NRB system about own operation and failures of soft-start system.
- 4.7.5.3. The soft start system should be installed in the low-voltage switchgear or in separate cabinets with a protection level of at least IP 20.
 - a) Installation in separate cabinets is the preferred solution.
 - b) Adequate ventilation should be designed, as well as air conditioning with fault signalling to the NRB-UR system to ensure temperatures in accordance with the manufacturer's requirements.
 - c) The soft-start system shall be connected via apparatus allowing the soft-start input and output to be disconnected
 - d) The way of mounting soft-starts shall be agreed with Client.
- 4.7.5.4. In case of installing a soft-start system for MV drives, the Contractor shall apply to the Electrical Department for necessary additional coordination.

4.7.6. Cooperation of the electric motor with the frequency converter (Variable Speed Drives)

- 4.7.6.1. The need to install frequency converter system is to be agreed with Client.
Contractor is obligated to determine the needs with respect to the use of frequency converters. Each frequency converter system should have a reserve, which is to enable the correct operation of the production installation, with full efficiency, in the event of the unavailability of a drive with an adjustable speed. In the absence of such a reserve, exemption confirmation from the Client must be obtained.
- 4.7.6.2. Especially, the following aspects should be considered while selecting frequency converters:
 - a) Certificates, validation statements or acceptances issued by appropriate Testing Station, Notified Bodies, which define conditions for co-operation of frequency converter system with an Ex-proof motor operated in explosion hazardous area.
 - b) Motor self-start after a voltage failure, shall fulfil requirements concerning reacceleration time for production process maintenance - the logic for this functionality should be implemented as a programmable function in the frequency converter.
 - c) Informing DCS or NRB system about own operation and failures.
- 4.7.6.3. Motors intended for co-operation with frequency converter should be adapted by motor manufacturer for rotating speed control by means of frequency change. Parameters confirming the above adaptation should be placed both on motor rating plates and in operating & maintenance manuals.
- 4.7.6.4. Frequency converters systems shall be installed inside cabinets with a protection degree IP 20 class, at least.

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- 4.7.6.5. Suitable ventilation and air conditioning shall be designed together with the failure signalization do NRB-UR system for frequency converters units to provide temperature required by manufacturer.
- 4.7.6.6. Frequency converters shall be connected through equipment enabling to disconnect the systems input and output.
- 4.7.6.7. An emergency stop button should be installed on the facade of the frequency converter cabinet.
- 4.7.6.8. The communication port for service purposes shall be accessible without the need to open the control cabinet.
- 4.7.6.9. Cables connected to frequency converters, i.e. power cables between frequency converter and motor, signalling cables, control cables shall be shielded. The cable type and the method of its installation should meet the requirements of the device manufacturer.
- 4.7.6.10. Metal local control station and EMC cable glands shall be applied. Where junction boxes are installed between the motor and frequency converter, these shall also be of metal construction and equipped with EMC cable glands.
- 4.7.6.11. In rooms with built-in frequency converters, an ambient parameters meter (temperature and humidity) should be installed, which should transmit the measurements to the NRB-UR system.
- 4.7.6.12. The way of mounting frequency converter should be agreed with ORLEN S.A.

4.7.7. Requirements for medium voltage converters (MV)

- 4.7.7.1. Systems of medium voltage frequency converters have to be designed with the use of a separating transformer at supply of a converter according to the following requirements.
- 4.7.7.2. Control circuits, cabinet interior lighting and fan power supply shall be supplied via an isolation transformer.
- 4.7.7.3. The auxiliary circuits for the frequency converters shall be supplied from the 110V DC TPS Panel.
- 4.7.7.4. During selection of a frequency converter it is necessary to consider in particular:
 - a) EU/WE type examination certificates, attestation statements or admissions issued by relevant notified bodies, instructions, EU/WE conformity declarations, instructions attached by producers to devices - determining conditions for cooperation of frequency converters with cable lines, electric motors including working in hazardous areas and devices of a supplying power station.
 - b) A frequency converter should meet requirements in the range of Electro Magnetic Compatibility (EMC) determined in directives and standards of the European Union.
 - c) Drive system with a frequency converter should meet requirements of directives 2014/35/EU and 2014/30/EU.
 - d) A frequency converter should be installed in an air-conditioned room (ambient temperature 25°C and with a system of forced ventilation, in enclosure made by producers or their authorised representatives, in particular it is necessary to consider in particular connection of input circuits and output circuits of a converter through apparatuses enabling possibility of disconnection e.g. dis-connector or power dis-connector.
 - e) A direct frequency converter 6kV/6kV (10kV/10kV) - without the use of step-up or step-down transformers.
 - f) A converter shall be equipped with input and output dis-connector or power dis-connector, enabling safely measure of cables and devices.
 - g) A frequency converter shall have independent supply of high current circuits and circuits of control and signalling.

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- h) Spare parts shall be accessible for minimum 10 years.
- i) A frequency converter system shall be designed, made and installed in accordance with this specification, provided that a Bidder does not specify, in an option, a more optimal converter system.
- j) A converter shall have high pulse resistance against switch surges and atmospheric surges. Value of BIL (Basic Impulse Level) should be above 25 kV.

4.7.7.5. Requirements in the range of signalling and control. Drives shall be controlled as follows:

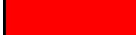
- a) Remote control in cooperation with the systems: DCS/ESD (signals: START, STOP, PERMISSION, CONTROL OF ROTATION SPEED) e.g. through a current loop 4-20 mA.
- b) Local control from a control station located near a motor (signals: START, STOP, AUTO, MANUAL, READINESS).

4.7.7.6. System of signalling operation status of a variable speed drive shall indicate the mode of operation:

- a) Local signalling: on a front panel of a box containing a frequency converter there shall be diode lamps signalling the mode: RUN, ELECTRICAL READY, PERMIT, ALARM (durable designation in Polish language: PRACA, GOTOWOŚĆ ELEKTRYCZNA, ZEZWOLENIE, ALARM) and the diodes signalling the availability of the auxiliary voltage.
- b) Remote signalling includes the following signals transmitted to:
 - The system: DCS, through voltage-free contacts (NC): WORK, READINESS, FAILURE, MOTOR ROTATIONAL SPEED e.g. through a current loop 4-20 mA.
 - The system: NRB-UR, through RS 485 serial interface, protocol IEC 60870-5-103 or Modbus RTU.

4.7.7.7. Informing of the systems: DCS and SCADA (NRB - minimum 3 binary signals, (details to be arranged in the stage of executive project) about work and faults of a drive system.

4.7.7.8. Colour of signal lights on the facade of the converter cabinet:

INDICATION LAMP				
PERMISSION	ELECTRICAL READY	ALARM	MOTOR RUNNING	AVAILABLE AUX. VOLTAGE
BLUE	WHITE	RED	GREEN	ORANGE
				

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4.7.7.9. Colour of buttons on the facade of the converter cabinet:

BUTTON			
RESET (IF APPLICABLE)	EPG (IF APPLICABLE)	START (IF APPLICABLE)	STOP (IF APPLICABLE)
BLACK	RED	GREEN	RED

4.7.7.10. A control and signalling system shall ensure self-starting of motors after failure of supply voltage.

4.7.7.11. A converter shall have legible signalling of states of operation and failures as well as a possibility of reading basic configuration parameters of the system and its particular components:

- locally - indication of operation statuses on lamps, meters and display, in the range no less than it is stipulated in a design for an existing system, permanent labelling in Polish and display for among others reading available measured parameters, alarms and records of events,
- remotely - signalling to computer system (voltage-free contacts, signalling 4-20mA and RS 485 with IEC 60870-5-103 protocol or MODBUS RTU to NRB UR system),
- alarm history (recording of events with real-time stamp).

4.7.7.12. A converter should have an option of reading data after complete disconnection of supply. Data from registration of disturbance should be accessible at least within 100 hours from complete disconnection of supply voltage.

4.7.7.13. Requirements in the scope of cooling:

- Enclosure of a frequency converter shall be equipped with an appropriate ventilating system compliant with the standard PN-EN 60146-1-1, protecting from overheating of semiconductor elements of the converter at various values of speed and load which may occur.
- A frequency converter system shall have an air-forced cooling system. Converter cabinets should be adapted to be equipped with ventilation ducts from the top.
- Evacuation of heat generated by converters should be carried out through ventilation of converter systems or other equivalent technical solutions, recommended by producers or their authorized representatives.
- A forced ventilation system should be equipped with all necessary elements, i.e. filter, fan, starter with an overload protection and auxiliary relays, making it possible to lead out of an alarm signals. Replacement of a filter should be possible without a need to switch off devices.

4.7.7.14. Requirements for frequency converters in the scope of electrical parameters:

- Input frequency - 50 Hz.
- AC-AC efficiency with rated load [%] - at least > 90%.
- Input frequency tolerance - at least 49 Hz-51 Hz.
- Output frequency accuracy (without a signal of feedback) +/- 0,5%.
- THDi coefficient of current of supplying switchgear shall be fulfilled within a full scope of regulation of motor's rotational speed and shall be lower than 5%.

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- f) A rate of rise of output voltage $du/dt < 300 \text{ V}/\mu\text{s}$.
- g) Maximum amplitude of surges of output voltage U_{peak} measured between phases and phase-earth needs to be smaller than voltage strength of motor's insulation in a particular drive system.
- h) Resistance to short circuit on an output cable without damage to power circuits as well as signalling and control.
- i) Construction considering maximum short circuit power of a switchgear 6 kV (10 kV) from which a converter is to be supplied.
- j) Resistance to reduction of voltage to 15% within 6 sec. and to complete decline of voltage in a period of up to 300 ms. during disturbance in a supply network.
- k) A converter should have an option of reduction of rotational speed during temporary overload and automatic return to chosen rotational speed after disappearance of temporary overload (without disconnection of drive).
- l) A converter should not transmit to the power supply network and do not emit, to the surroundings, generated disturbances both conducted and radiated.
- m) A method of control of power semi-conductor connectors - scalar and vector control.

4.7.7.15. Requirements in the scope of construction:

- a) Bus-bars of high current connections made of copper and insulated.
- b) Cables of signalling and control put in cable channels, separated from power cables, (observe required minimum distance between cables required by producers of converters). Control and power cables should be screened and screens of cables shall be properly earthed, in accordance with the section on the earthing system.
- c) Built-in discharge resistors ensuring reduction of voltage on condensers to 50 V not longer than within 5 minutes after turning off supply.
- d) Built-in anti-condensation heaters.
- e) All metal parts not participating in conduction of current shall be connected galvanically with each other and connected to a common earthing bus of a frequency converter. The earthing bus-bars of a frequency converter shall be connected to earthing installation of a building structure.
- f) In accordance with IEC 62271-200, MV frequency converters should have a high degree of resistance to internal arcing on all sides of the device structure (arc resistance class in accordance with AFLR). The exception is the installation of the frequency converter against a wall, in which case the side adjacent to the wall does not have to comply with the above-mentioned constructional requirements (arc resistance class in accordance with AFL).
- g) Service access only from the front.
- h) Electronic plate should be varnished on both sides.

4.7.7.16. Other requirements:

- a) Noise level $< 80 \text{ dB(A)}$ in distance of 1m.
- b) Flying start - yes.
- c) Flying start function must be realized in time ensuring drive correct operation for maintenance production process.

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- d) Control panel - yes.
- e) Soft start - yes.
- f) Admissible ambient temperature - from 15 to 25°C
- g) Storage temperature - from -20 to +60°C
- h) Admissible ambient humidity 5% - 95%, without condensation.
- i) Admissible altitude - <1000m.
- j) Slip compensation.
- k) Lifetime of a converter - at least 15 years.
- l) It is necessary to deliver with diagnostic software for the offered frequency converter, making it possible to carry out diagnostics and parameterisation of the frequency converter in online and offline modes.
- m) It is necessary to deliver a documentation of a producer in English and Polish. The documentation needs to be provided in a printed version and electronic version - CD or flash memory.
- n) A frequency converter for supply of a motor built in hazardous areas shall be equipped with protection systems in accordance with requirements of the Ex certificates for a motor.
- o) As part of the delivery, the detailed and as-built designs should include the settings, logic and parameterisation of the frequency converter. All descriptions of signalling and control connectors of frequency converters should be described in Polish.
- p) Closed speed control system.
- q) In case of rotation speed signal failure, frequency converter operation with open layout of regulator unit shall be possible.

4.7.7.17. Safety measures, the following safety measures are required:

- a) Temperature protection of a motor.
- b) Short circuit protection of a motor.
- c) Overload protection of a motor.
- d) Short circuit protection of a converter.
- e) Overload protection of a converter.
- f) Temperature protection of a converter.
- g) Protection against decline of control voltage.
- h) Protection against asymmetry.

4.7.7.18. Marking:

All devices and apparatuses shall be described in accordance with names of apparatuses given in factory documentation of a converter.

Description plates shall be made of material resistant to corrosion and protected from loosening.

All descriptions shall be made in Polish.

A converter shall have a rating plate containing, as a minimum, the following data:

- a) Input parameters: voltage, frequency, number of phases and current.

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b) Output parameters:

- rated voltage,
- rated current,
- rated power,
- rated frequency,
- frequency range,
- number of phases,
- power factor range.

In addition, the minimum speed of the drive system should be indicated in the technical and operating documentation or on the rating plate.

4.7.7.19. Requirements for a separating transformer:

a) A power transformer should have the following parameters:

It is necessary to meet requirements of a producer of frequency converters and requirements of a Purchaser determined in reference to converter system also indicating at least the following arrangement of guaranteed parameters:

Group of connections	Given by a Manufacturer
Rated voltage	6 kV / 6 kV (10 kV / 10 kV)
Regulation of voltage	By means of tap changer in a winding of upper voltage, in voltage-free state, within the scope of $\pm 2 \times 2.5\%$
Short circuit voltage	Given by a Manufacturer
Insulation	Resinous insulation, of class F

- b) A power transformer shall be placed in an enclosure with a degree of protection at least IP 20.
- c) A transformer shall be equipped with necessary types of factory protections and built in a feeder of switchgear 6 kV (10 kV).
- d) A neutral point of a winding of a secondary side of a transformer shall be connected consistently with requirements of a producer of a converter and according to a system of protections agreed with the Client.
- e) A power transformer shall be connected:
 - From the primary side through a cable line or a bus-bar or insulated bus-ducts,
 - From the secondary side through a cable line or a bus-bar or insulated bus-ducts.
- f) A transformer shall be adapted to a drive system with frequency converters and requirements of the process and power system.
- g) A transformer shall be put in a separate box built-in room of a switching station 6 kV (10 kV) (common structure with a converter).
- h) A power transformer shall be equipped with thermal protection made and monitored by a frequency converter.

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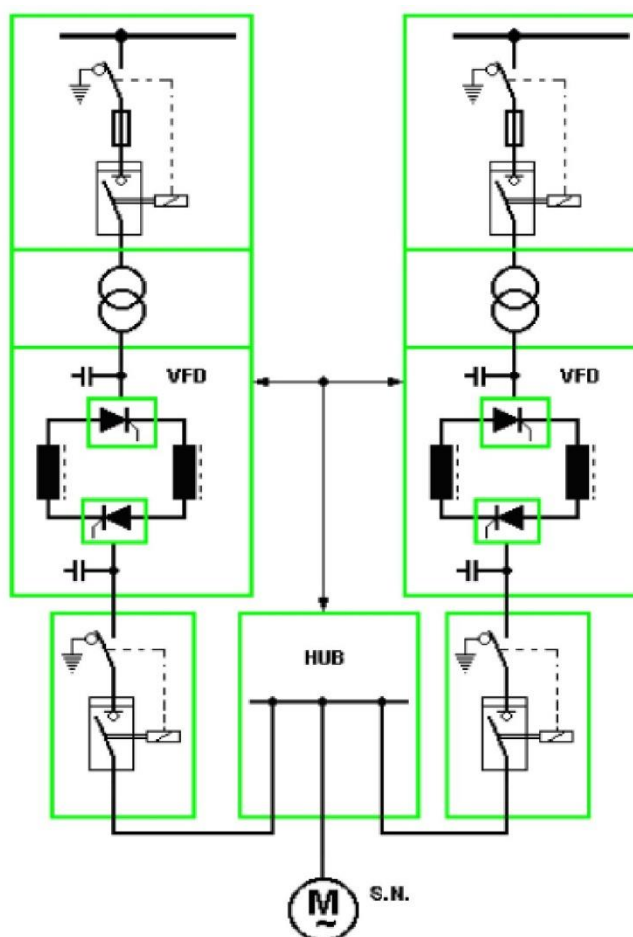
4.7.8. MV and LV frequency converters - critical for production installations and process plants i.e. switching off the critical drive stops the production plant

4.7.8.1. Configuration of a drive system for critical devices needs to be each time consulted with the Electrical Department.

4.7.8.2. Configuration systems with two frequency converters shall meet the following requirements:

- The system should have procedures ensuring security of exploitation activities and repair activities when the system remains in the operation mode. These procedures need to make it possible to safely switch-off and switch-on any unit during work of the system.
- The drive system shall work without breaks in emergency states such as decline of supply from a power transformer and any error of one of the frequency converters.

4.7.8.3. Apart from the foregoing requirements frequency converters of critical drives shall meet requirements of redundant configuration such as below:



Dwg. 4. MV Frequency Converter configuration for a critical application

4.7.8.4. A drive system should operate emergency states, mentioned below:

- Decline of supply from power transformer,
- Any error of one of frequency converters.

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4.7.8.5. Two different solutions are acceptable:

- a) In the normal operation mode frequency converters divide load, 50 % each. In case of a failure in a particular unit, the other takes over 100 % of load, without any disturbance of a propelled motor.
- b) In the normal operation motor is supplied from one of frequency converters, second frequency converter is switched-on in hot-stand-by mode. In case of a failure in one unit, the second unit take 100 % of load in possible shortest time.

Choosing optimal solution shall take into consideration technology requirements (i.e. acceptable inter-switching times and return to set rotation speed).

4.7.8.6. Each Contractor shall perform an analysis to determine the maximum time to reach the required rotational speed, in case flying start and inter-switching in hot-standby system.

4.7.8.7. Each frequency converter must to be supplied from a separate section of a switchgear.

4.7.8.8. Control circuits of a frequency converter have to be supplied from an external UPS system.

4.7.8.9. A Contractor should provide procedures ensuring security of exploitation activities and repair activities when the system remains in the operation mode. These procedures need to make it possible to safely turn off and turn on any single unit during work of the system.

4.7.9. Special medium voltage power systems

- a) An intention to install special medium voltage supply systems e.g. medium voltage power electronic devices (soft- start systems, frequency converters etc.) shall be consulted with the Electrical Department.
- b) Before installation and after the first switching of a medium voltage power electronic device, there should be carried out tests of correctness of selection of a device, in particular correctness of selection should be checked due to a level of harmonic concerns in a place of installation.
- c) A programme of tests of a power electronic device should be consulted with the Electrical Department.
- d) Documentation of electronic devices, documentation of a test (qualifications of people carrying out tests, data of measurement instruments, preparation of measurement results, registration, etc.) and conclusions arising from tests shall be provided to the Electrical Department of Client to admit to exploitation.

4.7.10. General requirements for LV Frequency Converters

4.7.10.1. Each frequency converter shall have the separate systems of power supply, signalling and control.

4.7.10.2. Control circuits, cabinet interior lighting and fan power supply shall be supplied via an isolation transformer.

4.7.10.3. The auxiliary circuits for the frequency converters shall be supplied from the 110V DC TPS Panel.

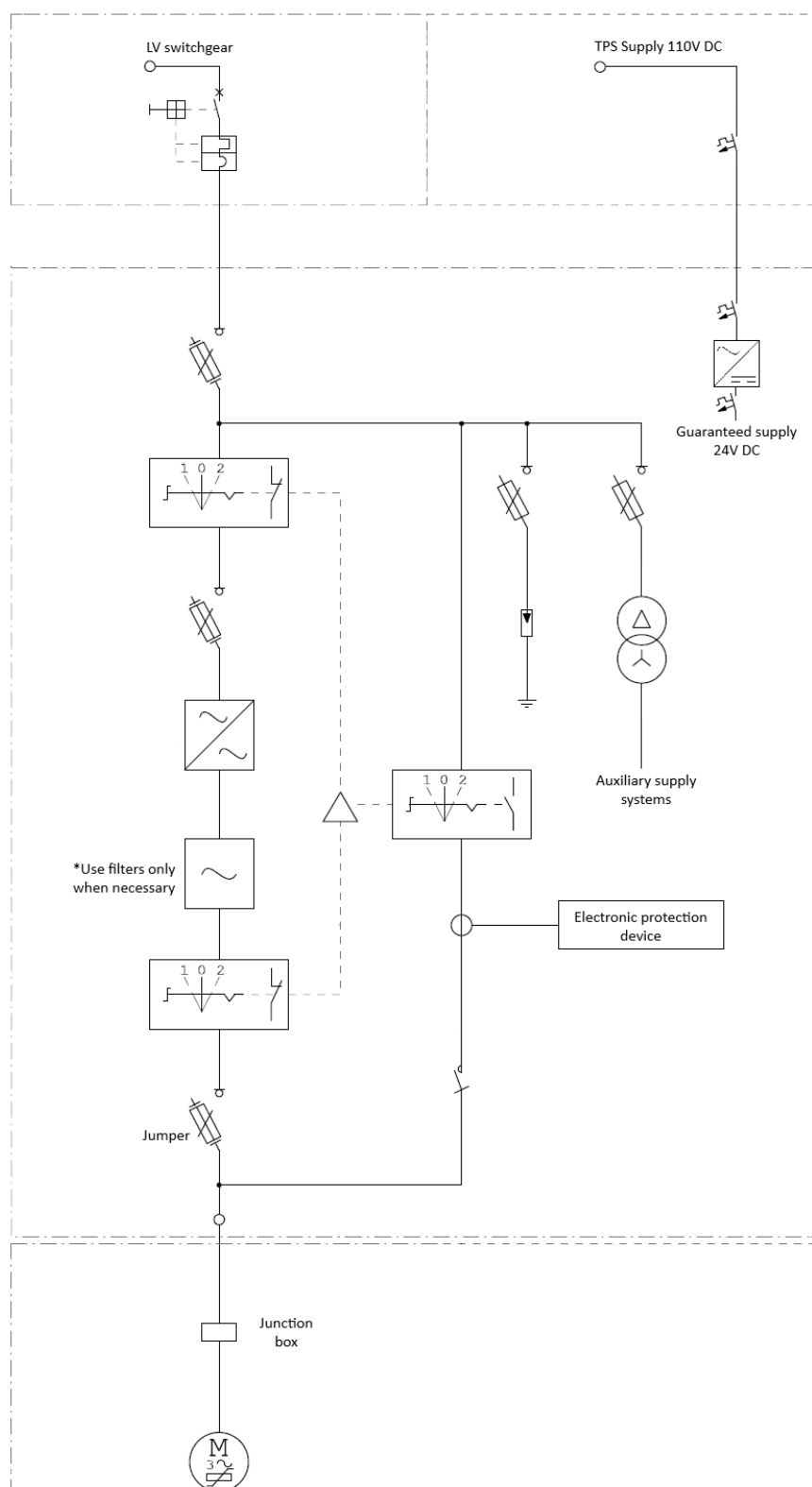
4.7.10.4. Frequency converters shall be installed in a separate cabinet with forced air circulation.

4.7.10.5. Cabinets of frequency converters above 250 kW shall be adapted for mounting ventilation ducts from above of the enclosure.

4.7.10.6. The frequency converters shall be installed in air-conditioned rooms in which the temperature of maximal 25°C is provided.

4.7.10.7. Each system of the frequency converter must have the manual service bypass with signalling of the motor operation state from the converters or from bypass.

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Dwg. 5. LV Frequency Converter configuration for applications with a bypass system

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4.7.10.8. Control of the driving system with frequency converter:

- a) Remote control from DCS (START, STOP, PERMIT, SET POINT CONTROL for 4-20 mA, Modbus RTU).
- b) Local control from the station close to the motor with a switch STOP, 0, START and AUTO, MANUAL.
- c) Control system adapted for automatic restart after instantaneous power failure (START/STOP signals cannot be used).
- d) The motor system shall have the motor winding temperature protection based on double PTC or Pt 100 sensors in the motor winding.
- e) If a safety relay is used, the trip signal should be installed on the enclosure's door or inserted into a programmable input of the drive together with programming of an appropriate message on the operator panel.

4.7.10.9. Indication of the system operation status:

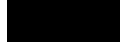
- a) Local (frequency converter cabinet/facade) diodes signalling of operation states: RUN, ELECTRICAL READY, PERMIT, ALARM (durable designation in Polish language: PRACA, GOTOWOŚĆ ELEKTRYCZNA, ZEZWOLENIE, ALARM) and the diodes signalling the availability of the auxiliary voltage. Display for (among other data) readings of measured available parameters, alarms and events history (diode signal panel and the display are to be located on the door of frequency converter, available to End-Users).
- b) Remote indication:
 - DCS system - according to Annex 2,
 - NRB UR system - RS 485 system with MODBUS RTU or IEC 60870-5-103 protocol.

4.7.10.10. Colour of signal lights on the facade of the converter cabinet:

INDICATION LAMP				
PERMISSION	ELECTRICAL READY	ALARM	MOTOR RUNNING	AVAILABLE AUX. VOLTAGE
BLUE	WHITE	RED	GREEN	ORANGE
				

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4.7.10.11. Colour of buttons on the facade of the converter cabinet:

BUTTON	
RESET (IF APPLICABLE)	EPG (IF APPLICABLE)
BLACK	RED
	

4.7.10.12. Cooling and ventilation system for frequency converters above 250 kW:

- Cabinet of frequency converter shall be equipped with an appropriate ventilating system according to standard PN-EN 60146-1-1, protecting from overheating of semi-conductor elements of converter, for different values of speed and load which may occur.
- The frequency converter shall be equipped with a forced ventilation system.
- Evacuation of heat made by drives shall be led out to outside through the ventilation system or other technological equivalent, recommended by a producer of frequency converter or his authorised representative.
- The forced ventilation system shall be equipped with all necessary elements, i.e. filters, fans, start-up system with overload module and auxiliary relays, enabling to transmit warning and failure signals. Filters exchange must be possible without switching-off frequency converter.

4.7.10.13. Requirements for frequency converters in the scope of electrical parameters:

- The frequency converter must be equipped with the event and alarm register with time stamp.
- AC-AC efficiency at full load should be higher than 90%.
- Input voltage tolerance +/- 15%.
- Output voltage maximum distortions - du/dt less than 500 Volt/microsecond.
- Overvoltage maximum preferred amplitude of output voltage $U_{peak} < 750 \text{ V}$, measured phase to phase and phase to neutral conductor or phase to protective-neutral conductor. Maximal value of overvoltage shall be adapted to durability of motor insulation.
- The frequency converter shall be selected for the same maximum short-circuit power as in a supplying substation.
- The frequency converter shall have the input system assuring THD of the input current less than 10% for converters above 75 kW, and less than 50% for the converters below or equal 75 kW. This parameter have to meet the full range of control for any given application.

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4.7.10.14. Requirements in the scope of construction:

- a) When using external output filters, filter temperature monitoring shall be used, either by means of a PTC sensor with a trip signal, at the facade, or taken out to a programmable input of the drive, together with the configuration of an appropriate message on the operator panel.
- b) Protection degree - minimum IP 20.
- c) Access for servicing - only from the front.
- d) Electronic circuits boards shall be varnished on both sides.

4.7.10.15. Other requirements:

- a) Noise level at distance of 1m - below 60 dB(A).
- b) Flying start – yes.
- c) Flying start function must be realized in time ensuring drive correct operation for maintenance production process.
- d) Shall have the provision for co-operation with personal computer as well as applicable visualisation, diagnostic and parametrisation software.
- e) Calculation of tolerance output cables shall be based on maximal value of total root mean square (TRMS) of output current.
- f) Capacitor discharge system. Each device and equipment shall be marked in accordance with numbers specified in drawings attached to factory documentation of frequency converter.

4.7.10.16. Technical parameters of driving system

- a) Driving system with frequency converter shall have the certificate for complete driving assembly (motor and frequency converter) in order to guarantee output voltage of good quality and safety operation.
- b) Driving system with frequency converter should fulfil requirements of EU regarding electromagnetic compatibility (EMC):
 - resistance to an external electromagnetic interference,
 - neither sends to the power supply network nor emits to the environment self-generated interference (conducted and radiated),
 - signalling and control cables have to be laid in cable trays separated from power cables (maintain minimum distances between cables required by manufacturers of frequency converters),
 - Control and power cables are to be shielded. Shields have to be properly earthed in accordance with the section regarding cable lines and cable routes.

4.7.10.17. Marking

- a) Each device and equipment shall be marked in accordance with numbers specified in drawings attached to factory documentation of frequency converter.
- b) Plates with data shall be made of material resistant to corrosion and protected from loosening.
- c) All inscriptions shall be made in Polish.

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- d) The frequency converter shall have a plate with data, mentioned below, as minimum:
- input parameters: rated voltage, rated frequency, quantity of phase, rated current,
 - output parameters: rated voltage, rated current, rated load, rated frequency, quantity of phase, scope of power factor.
- e) Additionally, in technical and maintenance documentation or on a plate with data, shall be specified data as follow:
- minimum speed,
 - maximum output load with minimum and maximum speed,
 - frequency with minimum and maximum speed,
 - voltage with minimum and maximum speed.

4.7.10.18. Additional requirements

- a) Technical documentation in English and Polish languages. Electronic version (CD or flash drive) and a hard copy of documentation should be delivered. The documentation should include:
- documentation from manufacture, as well signalling and control diagrams,
 - protocols of factory examinations confirming the essential technical parameters,
 - guarantee certificate for min. 24-month guarantee period from the date of putting the equipment in operation containing detailed guarantee conditions and address of the Guarantor's company,
 - the list of indispensable parts for 5-years operation.

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4.8. PROTECTION, CONTROL, SIGNALLING AND MEASUREMENT SYSTEMS

4.8.1. The protection, control, signalling and measurement systems requirements

4.8.1.1. The following auxiliary voltage values are allowable:

a) Power supply for: – MV and LV rated voltage motor protection systems. – MV rated voltage motor control systems.	110 V Direct Current
b) Power supply for LV rated voltage motor control systems.	230 V Alternating Current
c) Power supply to motor control systems from the DCS	24 V Direct Current

4.8.1.2. The motor feeding power line shall be equipped with an instantaneous overcurrent protection against short circuits and a motor protection.

4.8.1.3. The protection system for low voltage motors of nominal power higher than 2kW shall be designed using electronic relay functionality:

- a) Time delay overload protection.
- b) Protection against excessive windings temperature rise.
- c) Phase failure or phase asymmetry protection.

Protection shall be equipped with an external signalling module located on outgoing panel of the switchgear.

4.8.1.4. Motor shall be controlled from local control station allocated near the motors installation location.

4.8.1.5. Remote control unit of MV motors shall perform function:

- a) AUTO/MANUAL/0 switch, operating mode switch, positions: automatic operation, local (manual) control, position 0 shall be lockable by means of LOTO system. Signalling of the position of the AUTO/MANUAL switch should be transmitted via a suitable switchboard to the DCS /ESD, PLC systems, etc.
- b) "READY TO START" indication lamp, signal from DCS/ESD, PLC, etc. via switchgear.
- c) START button.
- d) STOP button.
- e) Emergency stop button (if there are no contraindications to its use).

Local control stations for MV motors shall be equipped with an ammeter to measure the motor load current, as well as the ready-to-start status.

4.8.1.6. Local control station of LV motors shall have the following functions:

- a) AUTO/MANUAL switch (on areas where operating from control and safety systems is required), operating mode switch, positions: automatic operation, local (manual) control. The signalling of the position of the AUTO/MANUAL switch shall be transmitted via a suitable switchboard to the DCS /ESD, PLC systems, etc.
- b) STOP-0-START switch function with the possibility to lock a STOP position with LOTO system. START signal shall be a pulse signal and a STOP signal shall be constant.
- c) "READY TO START" indication lamp - signal from DCS /ESD, PLC, etc. via switchgear.

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d) Emergency stop button (if there is no contraindication to its use).

Local control stations for motors with rated power equal or greater than 10 kW shall be equipped with ammeter to measure load current of the motor.

Local control stations for motors with a rated power of less than 10 kW should be equipped with the aforementioned ready to start and running status.

4.8.1.7. The control and signalling systems shall perform the following functions:

- a) Local motor switching-on and switching-off from local control unit,
- b) Local emergency switching-off of a motor or a group of motors (if necessary) using local emergency button,
- c) Stable (LOTO lockable) "OFF" position on site for maintenance purpose.

4.8.1.8. Colour of signal lights and pushbuttons on the LV and MV local control stations:

a) MV motor local control station:

INDICATION LAMP	BUTTON		
READY TO START	START	STOP	EPB
BLUE	GREEN	RED	RED
			

b) LV motor local control station:

INDICATION LAMP		BUTTON
MOTOR RUNNING	READY TO START	EPB
GREEN	BLUE	RED
		

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4.8.1.9. Colour of signal lights and pushbuttons for LV and MV switchgears:

a) The facade of the MV motor cabinet:

INDICATION LAMP		
ALARM	ELECTRICAL READY	STOP FROM DCS
RED	WHITE	YELLOW
		

BUTTON
EPB
RED

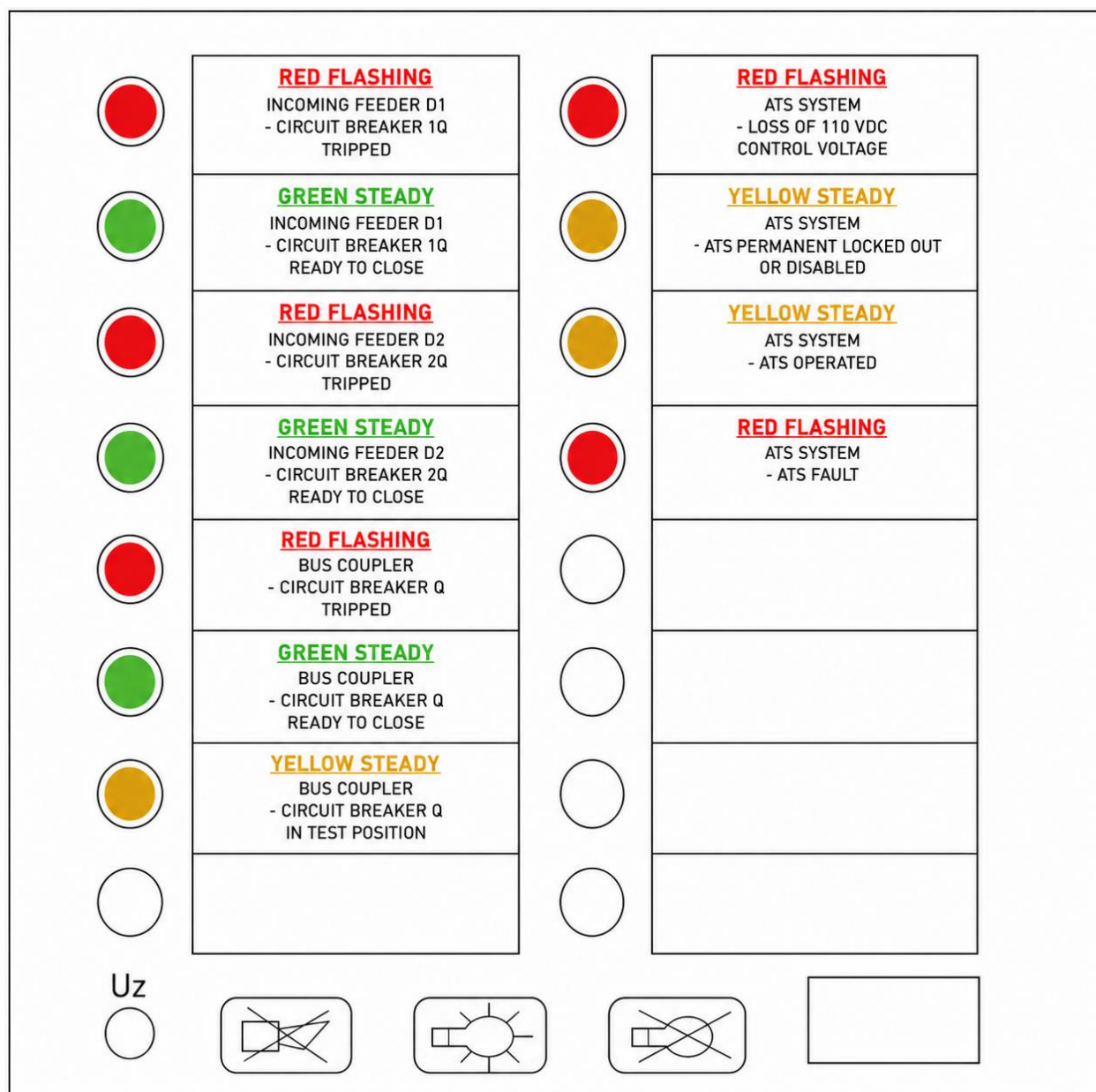

b) The facade of the LV motor cabinet:

INDICATION LAMP		
MOTOR RUNNING	PERMISSION	ELECTRICAL READY
GREEN	BLUE	WHITE
		

BUTTON	
TEST	EPB
YELLOW	RED
	

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c) Example view of the LV switchgear synoptic cassettes:



4.8.1.10. The control and signalling systems should be protected with overcurrent circuit breakers or fuse breakers.

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4.9. SPECIAL LOW-VOLTAGE POWER SUPPLY SYSTEMS

4.9.1. Special low-voltage power supply systems - general requirements

4.9.1.1. Special power supply systems shall be used for the following consumers:

- a) 230 V guaranteed AC voltage supply system for the needs of DCS control system and interlocking system's control & instrumentation equipment.
- b) 230 V guaranteed AC voltage supply system for the needs of local computer networks.
- c) 3x400/230 V guaranteed AC voltage supply system for the needs of electric motors required by technological process.
- d) 110 V guaranteed DC voltage supply system for the needs of protective devices, control and automatics systems.
- e) 220 V DC guaranteed voltage supply system for the needs of emergency lighting.

4.9.1.2. Special power supply systems shall be based on UPS or buffer power supply fed from battery, in normal mode power system is fed from the low-voltage grid, switched uninterruptible to fed from battery banks.

4.9.1.3. Following the process requirements related to long power supply retention periods of more than 60 minutes, one or more power generating sets shall be installed per production unit in order to feed the special power supply systems that are in emergency operating mode, i.e. when there is no electric power from the low-voltage network.

4.9.1.4. The following shall always be agreed upon with the Electrical Department:

- Operation requirements for generating sets connected to separator power system powered from generating set.
- Application system design for power generating sets.
- RFQ for delivery of power generating sets.
- Selection of power generating set manufacturer.

4.9.1.5. Special power supply systems shall ensure an uninterrupted operation of a specific group of equipment in case of bad supply voltage quality-parameters (e.g. voltage decay in the main power supply network, etc.).

4.9.1.6. The basic emergency power supply system for the consumers of:

- a) AC voltage, is UPS unit that with external set of batteries.
- b) DC voltage is a buffer power supply (rectifier) working with a battery bank attached to the terminals of the distribution panel.

4.9.1.7. Power electronic equipment: frequency converters, soft-starts etc. shall be installed in separated cabinets or LV switchgear cubicle, following below mentioned aspects:

- a) Power circuits and control & measuring circuits shall be so installed as to ensure electromagnetic compatibility (required spacing shall be kept, shields for power circuits by placing in separate compartment shall be applied, etc.).
- b) Power circuit shall be connected through disconnectors to safely perform maintenance work.
- c) The temperatures inside cabinets or distribution cubicles shall be kept below 30°C (e.g. through ventilation).
- d) The outside noise level in a distance of 1 meter to the cabinet shall be lower than 60 dB(A).

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- e) Control circuits powered by AC/DC or DC/DC power supplies responsible for critical control functions (loss of control voltage causes the system to stop) should be powered by a system of redundant power supplies, the circuit should allow for the replacement of one of the power supplies during system operation.
 - f) Additional AC/DC and DC/DC power supplies should be provided with contacts to indicate power supply failure - the signal should be added to the collective alarm signal to supervisory systems.
- 4.9.1.8. Contractor shall deliver its electronic power equipment documentation to Client for the approval, no later than at the time of delivering the equipment to site.
- 4.9.1.9. The electronic power equipment documentation shall include:
- a) Operating and maintenance manual in English and Polish language, containing in particular: data of power circuits, auxiliary circuits, etc.
 - b) Design documentation, containing in particular: description of application system, external connections of electronic power equipment, list of parameter settings.
- 4.9.1.10. Documentation shall be delivered in electronic version, (.pdf format) and printed.
- 4.9.1.11. All markings shall be in Polish. In the case of a foreign manufacturer, English-language markings are allowed in addition.
- 4.9.1.12. Each device shall be marked with permanent, fixed, engraved labels, made in accordance with the diagram.
- 4.9.1.13. Signalling to the DCS for special power systems shall be supplied with the internal voltage of the respective system, in accordance with Appendix 2.
- 4.9.1.14. All devices installed in cabinets shall be accessible after opening the doors.

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4.10. GUARANTEED DIRECT CURRENT SYSTEM

4.10.1. Structure of guaranteed direct current systems

4.10.1.1. Buffer power supply systems shall be suitable for feeding guaranteed direct current:

- a) The direct current panel (TPS) - 110 V guaranteed direct current power supply system for protection, control and automation systems. The buffer power supply for this system, should be selected simultaneously to supply DC consumers and to charge the battery bank.
- b) Emergency lighting panel (TOA) - 220 V guaranteed direct voltage power supply system for emergency lighting. Buffer power supply for this system, should be selected only for charging the battery bank.

4.10.1.2. Buffer power supply units shall be installed outside TPS or TOA switchgears.

4.10.1.3. For TPS panels, a continuous grounding control system implemented through buffer power supplies or additional devices built into the TPS panel shall be used.

4.10.1.4. In TPS and TOA switchgears, devices that enable disconnection of the input and output of the buffer power supply should be used.

4.10.1.5. Battery current measurement for TPS and TOA, shall be located in the TPS and TOA switchgear. The current measurement device(s) shall be mounted in a location that allows for replacement in a de-energized state, assuming the presence of voltage on the TPS or TOA switchgear.

4.10.1.6. The collective signalling from the TPS and TOA boards shall be transmitted by hardwire contact to the NRB-UR system and by a red signal light located on the panel façade.

4.10.2. Configuration of the 110 V guaranteed voltage supply system for supplying protection and control systems and automation systems

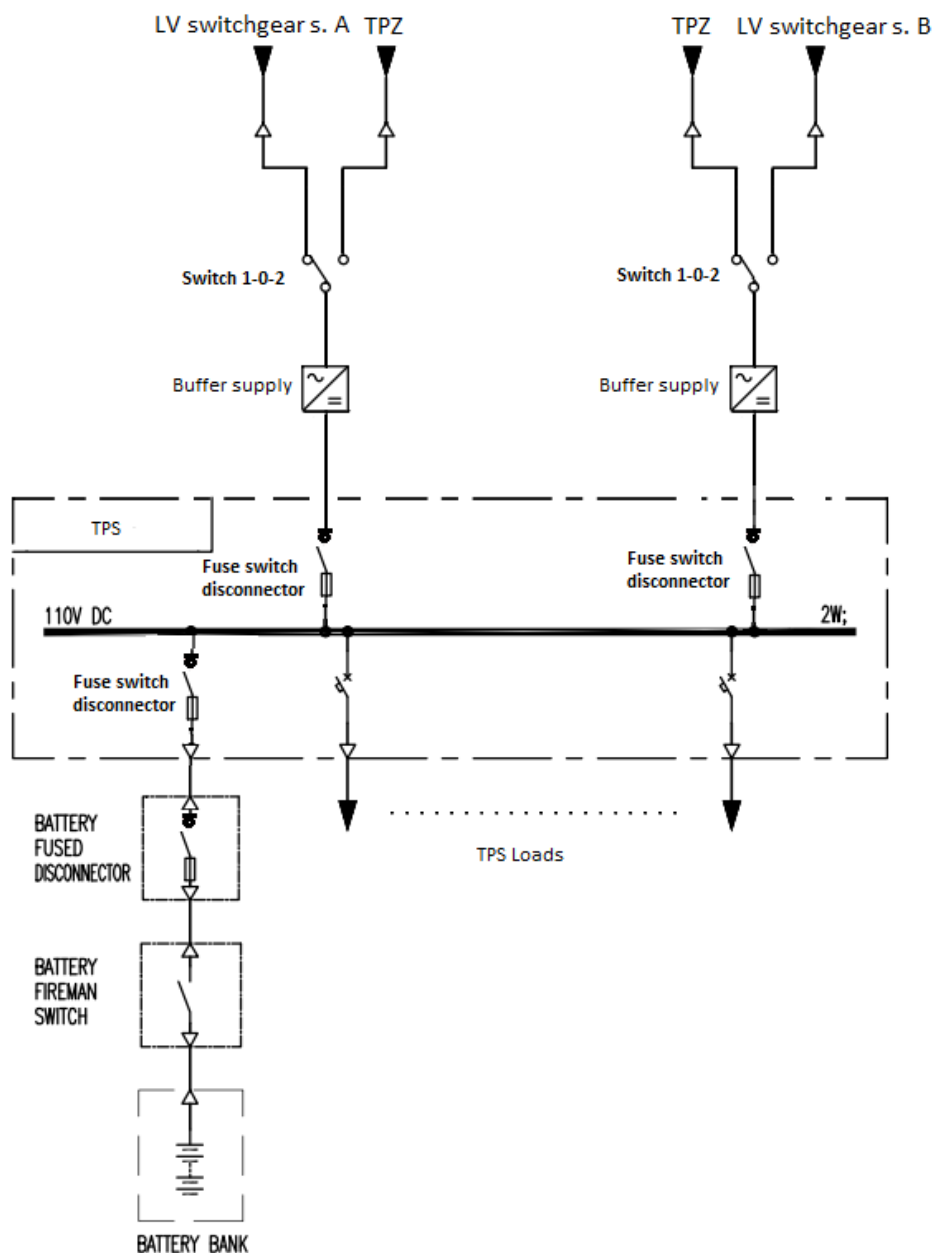
4.10.2.1. The buffer power supply system shall cooperate with 110 V DC battery bank and be supplied from two different sources - LV switchgear or TPZ. Each of them shall supply a common bus of guaranteed voltage of TPS panel.

4.10.2.2. Online insulation monitoring and insulation fault location devices shall be provided.

4.10.2.3. Overcurrent circuit breakers with a trip-indication auxiliary contact shall be used.

4.10.2.4. For each of the two buffer power supplies, use a manually switched power supply consisting of two lines. Preferred I-0-II switch cabinet mounted near the buffer power supply.

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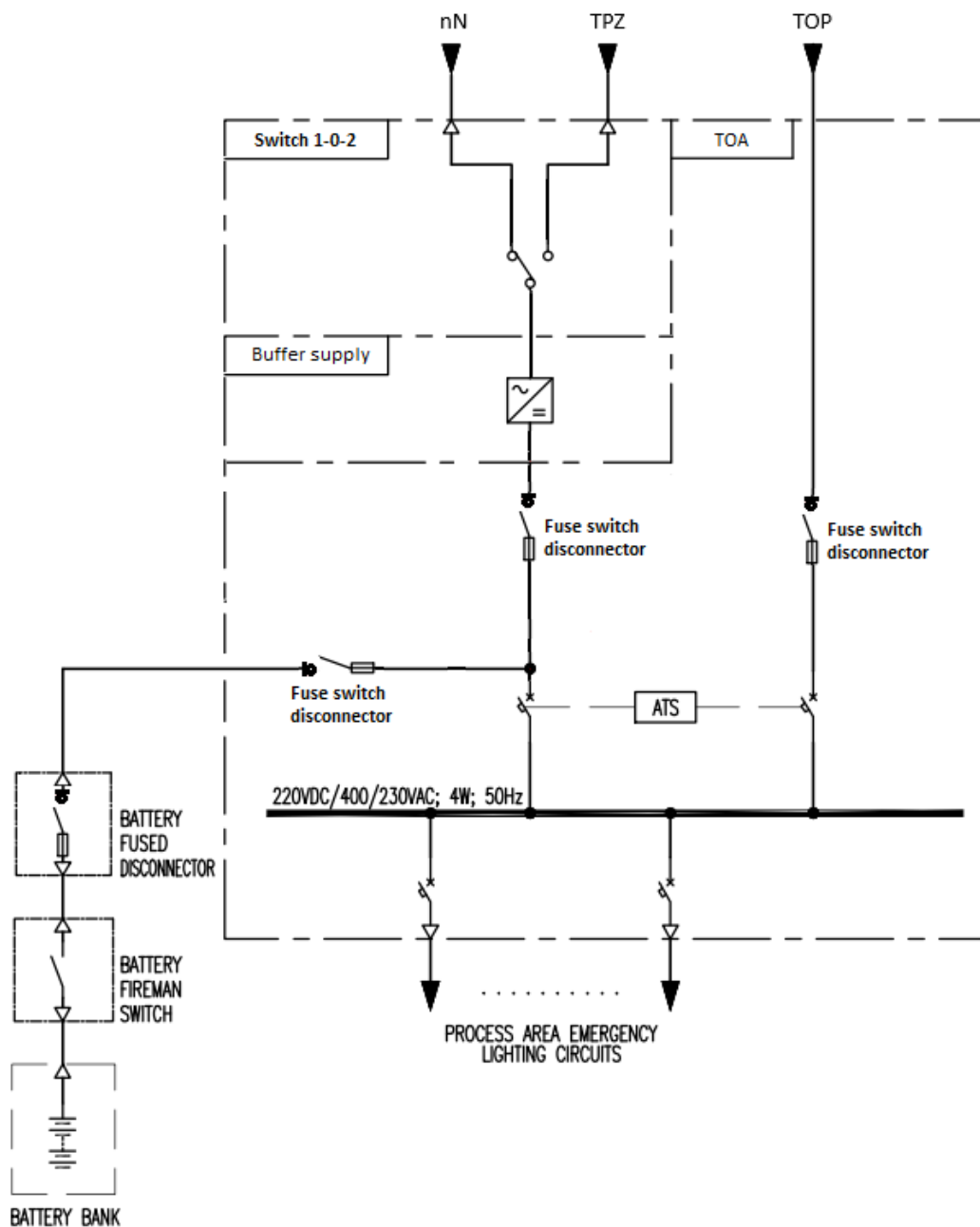
Dwg. 6. Guaranteed voltage supply system for protection and control circuits in medium- and low-voltage switchgear

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4.10.3. Configuration of the 220 V guaranteed voltage supply system for emergency lighting

- 4.10.3.1. One buffer power supply supplied from two sources - LV switchgear and TPZ, supplying the guaranteed voltage bus of the TOA panel.
- 4.10.3.2. Manually switchable power supply for the buffer power supply. Preferred switch cabinet I-0-II mounted near the rectifier.
- 4.10.3.3. Overcurrent circuit breakers with a trip-indication auxiliary contact shall be used.
- 4.10.3.4. A solution is recommended which allows, during normal operation, the use of emergency lighting as primary lighting. For this purpose, the emergency lighting panel (TOA) should be fed:
 - in the normal state, 230 V alternating current supplied from the normal lighting panel (TOP) supplied from the LV switchgear,
 - in the emergency state, 220 V direct current supplied from a dedicated buffer power supply cooperating with the battery bank system.
- 4.10.3.5. The control of the lighting systems supplied from TOA shall be available both during normal operation with supply from TOP and in the event of a power supply failure, during battery operation.

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Dwg. 7. Guaranteed voltage supply system for emergency lighting

4.10.4. Buffer supply units

4.10.4.1. Buffer power supply units shall have the following features and parameters:

- High voltage stability (less than 1% changes) and low rectifier output voltage ripples (less than 0,5%) in the load changes range of 0 to 100%, and low-voltage fluctuations of $\pm 15\%$ in the power supply network.
- Pre-setting of output voltage and battery current limitation.

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- c) Galvanic separation of DC and AC circuits.
- d) Built in short circuit and overload protection.
- e) Readable and easy-to-operate display to indicate all output parameters and alarm conditions of power supply unit operation.
- f) Buffer voltage temperature correction.
- g) External measurement of current of charging batteries.
- h) High reliability.

4.10.4.2. Buffer power supply units shall be equipped with the following systems:

- a) RS 485 communication standard with software to ensure a full PC class computer remote control of power supply unit operation.
- b) Communication module servicing protocols IEC 61850 (fibre or RJ45), IEC 60870-5-103 or alternative MODBUS RTU (RS 485) for cooperation with NRB system.
- c) Thermometer probe (range from -10 °C to +40 °C) including a battery charging voltage temperature adjustment system.
- d) Automatic battery circuit continuity supervision. The battery continuity supervision system shall provide an adjustable interval between consecutive tests, with a setting resolution of not less than 1 hour.
- e) External continuous measurement of charge to and from the battery.
- f) Quick battery recharging.
- g) Contacts for interaction with DCS, NRB systems.
 - 1 no-voltage contacts (NO): alarm cooperating with supervisory system NRB-RE.
 - 1 no-voltage contacts (NC): alarm cooperating with control system DCS.

Each contact should be realised with independent relay. It is not allowed to realise two separated contacts in single relay.

4.10.4.3. The buffer power supply should enable easy expansion of the supplied network system.

4.10.4.4. Buffer power supply units shall meet electromagnetic compatibility requirements as specified in European directives and standards.

4.10.4.5. The THD coefficient determined level of higher harmonic interference of the current consumed by the power supply unit shall be less than 30% for currents up to 100 A and less than 10% for currents above 100 A.

4.10.4.6. Wall-mounted buffer power supplies should be selected.

4.10.4.7. A minimum clearance of 1 m shall be provided above the buffer power supplies to ensure adequate cooling of the equipment.

4.10.4.8. Buffer power supply units shall correctly operate in combination with capacitor units that are connected to common switchgear.

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4.11. ALTERNATE CURRENT UPS SYSTEMS

4.11.1. Structure of guaranteed alternate current systems

4.11.1.1. UPS systems shall be used to deliver guaranteed AC voltage to:

- a) DCS control systems and interlocking of automatics control and measurement systems.
- b) Local computer networks and teletechnical equipment.
- c) Electric motors required by technological process.

4.11.1.2. 7.3.1.2 The internal design of the UPS uninterruptible voltage supply shall provide the ability to:

- a) Disconnect of the primary power supply.
- b) Disconnect the reserve power supply.
- c) Disconnect the external buffer power supply.
- d) Disconnect DC power from an external battery.

4.11.1.3. All UPS systems shall be equipped with TP switchboard, enabling switching operations, including switching on bypass. In the TP switchboard, at least one spare output for each section should be provided.

4.11.1.4. The TP switchboard shall be located in the same room as the dedicated UPS unit and arranged within the same lineup of cabinets.

4.11.1.5. The selection of buffer power supplies for alternate current UPS systems shall be in accordance with the provision of the section concerning buffer power supplies.

4.11.1.6. Configurations different from those presented below shall be permitted only upon prior written agreement with the Electrical Department.

4.11.2. Configuration for UPS system for powering the DCS control system and interlocking ESD control and measurement automation systems

4.11.2.1. A system consisting of two UPS units and a static transfer switch (STS), used as the primary solution for newly designed and modernized production installations.

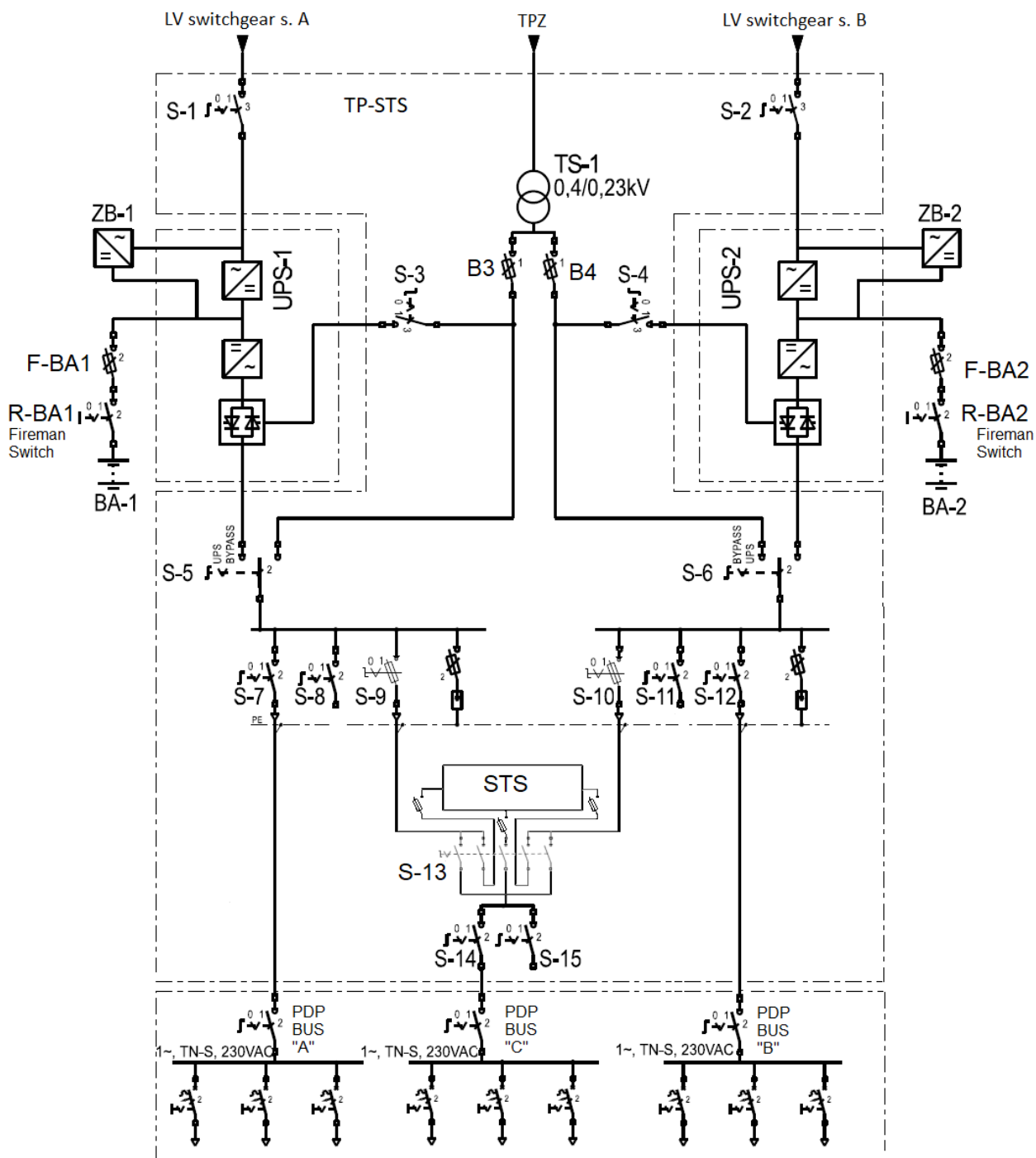
4.11.2.2. Two UPS supply units working independently, supplying two independent busbar sections in power distribution cabinet (bus "A" from UPS1 and bus "B" from UPS2). Through static-switch (STS) third section of guaranteed voltage system is supplied (bus "C").

4.11.2.3. The STS static transfer switch shall be equipped with a bypass system, that is, a multi-position switch that allows uninterruptible manual selection of the power line and isolation of the STS static switch from the bus C supply line. The system must provide full isolation of the STS static switch with a visible gap.

4.11.2.4. Principles of connecting loads included in DCS ESD to guaranteed AC voltage

- Consumers equipped in two supply units should be connected to power distribution cabinet so, as one supply unit was connected to first section (bus "A"), and second supply unit to second section (bus "B") of power distribution cabinet,
- Redundant consumers shall be connected to separated busbar section of power distribution cabinet (bus "A" and bus "B"),
- Consumers equipped with single supply unit and not-redundant shall be connected to third bus section (bus "C") of power distribution cabinet, supplied via static transfer switch (STS) located in TP switchboard.

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Dwg. 8. Guaranteed voltage supply system for DCS/ESD/PLC/KiA system, two UPS units and three guaranteed voltage bus's arrangement

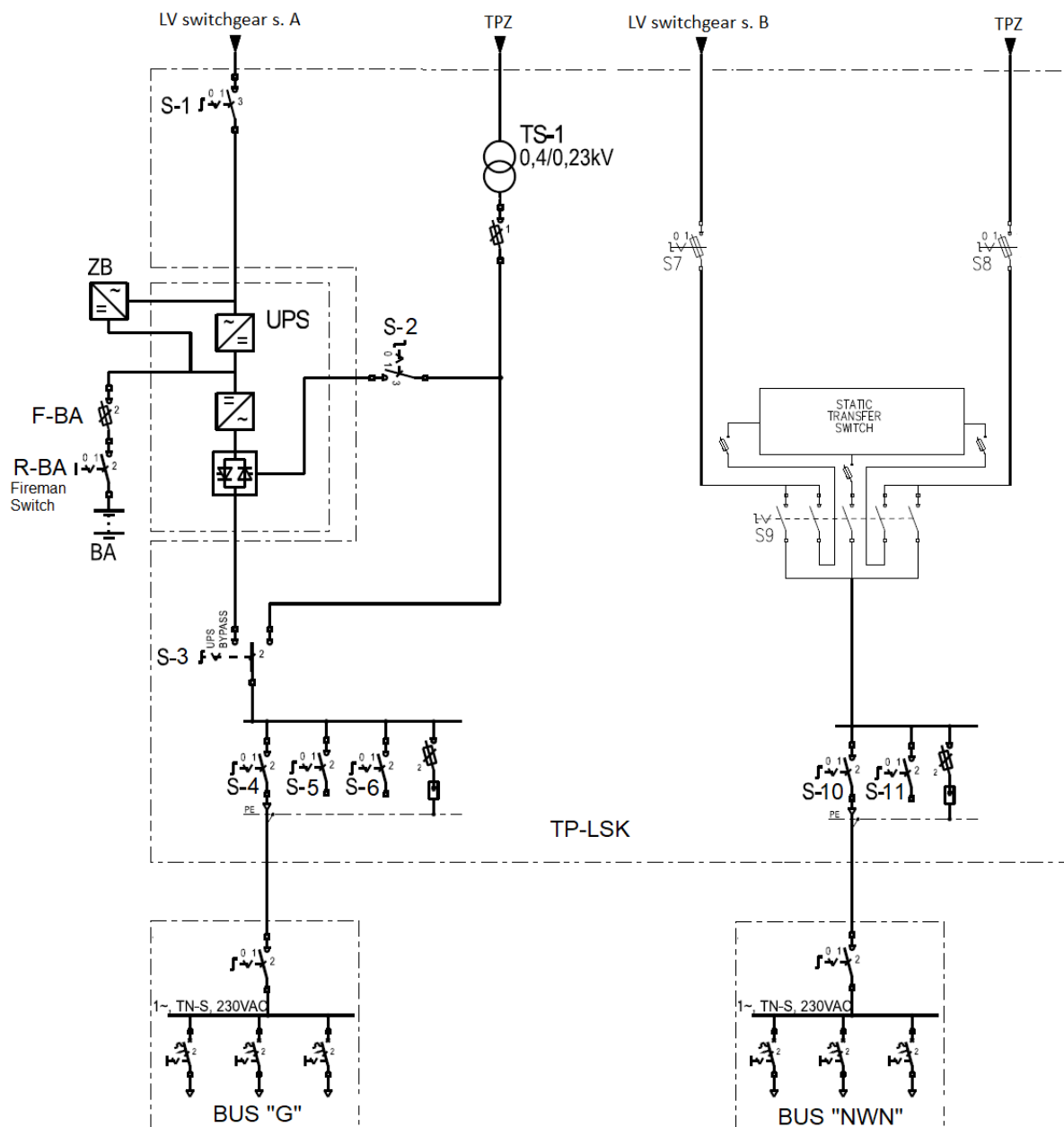
S13 – integrated switch enabling bypass of the STS using supply from UPS1 or UPS2, depending on the switching position. The switch shall provide the following positions, from left to right: 2 – STS bypass from UPS1, STS isolated; 1 – STS bypass from UPS1; 0 – normal operation; 1 – STS bypass from UPS2; 2 – STS bypass from UPS2, STS isolated.

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4.11.3. Configuration for UPS for IT loads (Local Computer Network - LSK) and teletechnical equipment

- 4.11.3.1. UPS supplying a single, guaranteed voltage bus (bus "G"), in addition, the system with static transfer switch (STS) for high reliability voltage supply (bus "NWN").
- 4.11.3.2. Consumers equipped with a single power supply, in this arrangement, are connected to the "G" bus of guaranteed voltage, and devices equipped with two power supplies are connected to the "G" bus and the "NWN" bus.
- 4.11.3.3. Overcurrent circuit breakers with a trip-indication auxiliary contact shall be used.
- 4.11.3.4. Distribution cabinet of "G" and "NWN" buses shall be located in the IT node room.
- 4.11.3.5. The minimum UPS nominal power is specified in the Telecommunications discipline requirements. The selected UPS nominal power shall also take into account the requirements of the loads of the facility.

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Dwg. 9. UPS system dedicated to supply IT consumers (Local Area Network - LAN)

S9 – integrated switch enabling bypass of the STS using supply from UPS1 or UPS2, depending on the switching position. The switch shall provide the following positions, from left to right: 2 – STS bypass from UPS1, STS isolated; 1 – STS bypass from UPS1; 0 – normal operation; 1 – STS bypass from UPS2; 2 – STS bypass from UPS2, STS isolated.

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4.11.4. UPS supply units requirements

4.11.4.1. UPS supply units shall meet electromagnetic compatibility requirements as specified in European parliament and Council directives and other European regulations in relation to resistance to outdoor interference and limitation of level of interference emission to the environment.

4.11.4.2. Each UPS unit shall have the following parameters:

a) Mode of operation	Continuous operation, double conversion (True on line),
b) Efficiency	Higher than 85% for 100% load,
c) Input voltage	1x 230 V or 3 x 400/230 V,
d) Input voltage tolerance	From -15% to +15% of voltage,
e) Rated frequency of input voltage	50 Hz,
f) Input voltage frequency tolerance	from 0,5% to 8% of rated, frequency of input voltage,
g) Output voltage	230 V or 400/230 V,
h) Overload capability of the inverter	125% for 10 min, 500% for 5 s,
i) Output voltage stability	Statically +/- 1% , Dynamically +/- 5%,
j) Output voltage frequency	50 Hz,
k) Output power factor coefficient	> 0,95, independent of load,
l) Stability of output voltage frequency	No less than $\pm 0,1\%$ when battery operated,
m) Input current THD	Less than 10%,
n) Output voltage THD	Less than 3%,
o) Permissible noise level, at 1 m	Less than 60 dB(A),
p) Crest factor	5:1,
q) IP protection degree	No less than IP 20,
r) Autonomous time	Application related,
s) Maximum time of UPS output deenergization	10 milliseconds,
t) Service access	Only front service access,
u) Battery voltage	220 V DC.

4.11.4.3. UPS units with double electric power conversion shall be used. Only those UPS units that are operated in parallel & redundancy arrangement shall be suitable for parallel operation.

4.11.4.4. Each UPS unit shall be provided with a separating output transformer.

4.11.4.5. UPS units shall be equipped with an internal protection against external short circuits and overloads.

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- 4.11.4.6. Inputs and outputs of UPS units shall be protected against voltage surge by means of surge arresters that are compatible with: parameters of UPS units, power supply network for UPS units, and UPS fed equipment.
- 4.11.4.7. Surge arresters with replaceable modules, optical indicator and an auxiliary contact shall be used. Fuse disconnecter switches shall protect surge arresters, allowing replacement of the fuse link without the need to shut down the UPS unit.
- 4.11.4.8. UPS units shall be equipped with operation support systems, e.g. battery monitoring system and software to enable diagnostics of UPS units using computer network.
- 4.11.4.9. UPS units shall be located in ventilated and air-conditioned rooms fitted with a system of redundant air conditioners. Air-conditioning system should be equipped with a redundant operation controller and failure signalling sent to the NRB-UR system. Maximum room temperature + 25°C.
- 4.11.4.10. UPS rooms shall be equipped with an ambient parameters meter (temperature and humidity) which should transmit the measurements to the NRB-UR system.
- 4.11.4.11. Each single UPS unit shall be provided with its own separate batteries set.
- 4.11.4.12. It is recommended to use an external battery laid on rack.
- 4.11.4.13. The battery sets and UPS unit shall be interconnected with a short, if possible, cable distance, using fuses disconnectors.
- 4.11.4.14. Basic requirements for UPS unit:
- a) The UPS unit should have a semiconductor rectifier (with 100% output power) with galvanic isolation to the power inverter (100% output power).
 - b) The UPS unit should be provided with a dedicated semiconductor charger for charging / recharging bank of batteries, complying with the requirements specified in the section concerning buffer power supplies.
 - c) Capacitors should be selected to a temperature from - 40°C to + 105°C.
 - d) Maximum operating voltage for capacitors should be 0,8xUn nominal voltage of capacitor.
 - e) All electrics plates should be varnished on both sides.
 - f) UPS supply units should have a fan failure signal.
 - g) UPS supply system should have cable entries enclosure bottom.
 - h) Internal connections lines should be marked near the connections. Final devices and equipment should be described according to installation documentation.
 - i) UPS supply unit should have the ability to work with disconnected battery.
 - j) Transition of output voltage without synchronisation, in case of inverter failure. Time interval cannot be longer than 14 ms.
 - k) Failure of bypass controller cannot prevent the activation of bypass repair. Battery control failure should not affect inverter operation. Failure of AC inverter cannot interfere with battery charger.

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l) Operation state signalling system:

- Locally - diode signalling system of UPS block scheme of all operation states with permanent marking in polish and the display for readings of available measured parameters, alarms and events history with real time stamp,
- Remote indication to computer system:
 - Two voltage-free contacts (NO): warning, alarm cooperating with supervisory system NRB-RE,
 - Two voltage-free contacts (NC): warning and alarm cooperating with control system DCS.

Each contact should be realised from independent relay. Realisation with two separated contacts in single relay is not allowed.

- m) Communication module servicing protocols IEC 61850 (fibre optic or RJ45), IEC 60870-5-103 or alternative MODBUS RTU (RS485) cooperating with NRB system.
- n) Alarm history with real time stamp (concerns UPS supply units and buffer supply units (battery rectifiers).
- o) UPS supply unit should have dedicated signals of battery recharger failure.
- p) UPS supply unit should be equipped with service terminals allowing testing of UPS under load with supplying consumers via bypass.

4.11.4.15. UPS supply units used in systems supplying DCS control system and interlocking of automatic control & measurement systems and LSK should fulfil requirements as follow:

- a) Each UPS supply unit should have bypass circuit with static-switch and a manually operated service bypass located in TP switchboard. UPS unit bypass circuits should be fed from power network through a separating transformer.
- b) Separating transformers in bypass of UPS units dedicated for DCS/ESD/PLC/KiA systems, shall be designed for:
 - 150% of installed rated power of each UPS unit,
 - 100% rated power of a single UPS for an LSK system.
- c) UPS supply units should be fed from different voltage sources (e.g. various section of LV switchgear), bypass circuits should be fed from a common voltage source (e.g. section of TPZ panel).
- d) UPS supply unit should have ability to cooperate with supervisory systems (e.g. DCS, NRB) in necessary scope.
- e) The power supply to the signalling to the DCS shall be provided by two UPSs from the STS operating on 3 independent sections of guaranteed voltage buses in the power distribution cabinet (bus "A" bus "B" and bus "C"), where:
 - UPS1 and UPS2 feeds signalling from a dedicated protection device mounted on the guaranteed voltage bus it feeds,
 - The signalling from the static switch (STS) should be powered from the protection fed from UPS2.

4.11.4.16. Each UPS supply unit should be equipped with TP switching panel. Switching panel should have the ability to disconnect every UPS supply unit without influence on guaranteed voltage consumers.

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4.11.4.17. Static-switch requirements:

- a) External static-switch STS is required for feeding busbar "C" in Power Distribution Cabinet.
- b) High overload capacity of STS static-switch is required, not less than overload capacity of UPS supply units, which power it. To ensure fast disconnection by protections, in case of short-circuit overload of min. 1500% I_n in 20 millisecond is required.
- c) STS static-switch should be equipped with service bypass, enabling uninterruptible over-switching feeding of consumers on preferred power line. After switching-over of STS static-switch it should be isolated from system, in order to enable conducting service work.
- d) The functionality of parametrization of STS settings by the user is required.

4.11.4.18. Principles for UPS selection:

The required power rating of UPSs should be determined by the preliminary design of the automation, IT or electrical branch according to the application.

The aforementioned design should specify the data for each output of the power distribution cabinet and the data necessary for the selection of the UPS.

- a) The data sheet for each cubicle shall include at least the following information:
 - cubicle number,
 - active power and active power factor calculated for consumers that are fed from the related cubicle,
 - protection devices parameters (sort of protection, type of protection, rated current, etc.),
 - peak current value for consumers connected to the related cubicle,
 - time of flow of the above peak value current,
 - time of critical voltage decay that is characteristic for consumers that are connected to the related cubicle, which causes an emergency technological process shutdown,
 - where consumers with double power supply units are fed from the related cubicle, the number of the cubicle feeding the second power supply units shall be indicated,
 - anticipated increase in active power demand considering expansion of the related cubicle.
- b) The data that is necessary to select an UPS unit shall comprise at least the following information:
 - active power utilised by consumers that are connected to the power distribution cabinet,
 - active power factor for consumers that are connected to the power distribution cabinet,
 - time of critical voltage decay that causes an emergency technological process shutdown,
 - peak current value consumed by consumers that are connected to the power distribution cabinet,
 - time of flow of the above peak value current,
 - level of surge protection required for the power distribution cabinet,
 - anticipated increase in active power demand considering expansion needs,
 - type, rate and the tripping characteristics of the highest rated protection in the power distribution cabinet.

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- c) All outgoing circuits of the power distribution cabinet shall:
- be protected against mechanical damage,
 - meet requirements for a correct operation of protective devices in relation to the purchased UPS units; e.g. meet UPS manufacturer specific requirements permissible drop voltage,
 - be marked to distinguish them from non-guaranteed voltage circuits.
- d) On the basis of the above preliminary designs, the electrical designer should determine the power rating of the UPS, the arrangement of its operation, the power distribution cabinet and the connections to the power supply network, taking into account, among other things, the following:
- power system parameters in point of UPS units' connection,
 - selective operation of protective devices (for each cubicle shall be determined protection sensitivity coefficient, protection safety coefficient of UPS supply unit fed only from battery),
 - protection against electric shock (shall be checked for UPS units powered from the electric power system and for UPS unit powered only from battery),
 - surge protection (appropriate grading of surge protection should be provided),
 - the switch-off of the highest rated protection in the Power Distribution Cabinet as fast as it is possible, no longer than 10ms during autonomic operation of UPS unit.
- e) The power distribution cabinet shall have a high operational and consumers feeding reliability to be achieved by:
- very good insulation parameters of bus bars and outgoings,
 - reliability of switching operations,
 - convenient access to switches and protective devices,
 - cubicle identification uniqueness.
- f) During the design work of the electrical branch, arrangements shall be made with the Client's Electrical Department in the scopes:
- arrangement of UPS units,
 - power distribution cabinet,
 - RFQ for purchase of UPS units,
 - selection of UPS unit manufacturer.

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4.12. BATTERY BANKS FOR GUARANTEED VOLTAGE SYSTEMS

4.12.1. Battery banks requirements

4.12.1.1. Battery banks for cooperation with buffer power supply units shall be selected for rated voltage of the circuit and operating conditions in the range from 85% to 110% of rated voltage value.

4.12.1.2. Battery banks for cooperation with guaranteed power supply shall be selected in accordance with the requirements specified by the equipment manufacturers and following parameters:

a) aging factor	1,25
b) temperature factor (environment temperature)	from +15°C to +25°C
c) final discharge voltage	1,75 V/cell
d) $\cos \varphi$ (with full load of UPS system)	1

4.12.1.3. The number of required cells for each guaranteed voltage system:

- a) 110V DC (TPS), number of cells - 54.
- b) 220V DC (TOA), number of cells - 108.
- c) 230V AC (UPS), number of cells - 108.

4.12.1.4. Battery banks shall consist of lead-acid cells:

- a) Classic batteries – typical solution.
- b) AGM/VRLA - alternative solution, in justified cases.

The acronyms introduced are in conformity with Eurobat guide.

4.12.1.5. Classic batteries shall have the following features:

- a) Lead-acid batteries with liquid electrolyte (positive plate pasted).
- b) The cells shall be of the longest life category, i.e. over 18 years (15 years for cell).
- c) The cell rated voltage shall be 2 V.
- d) A complete set of recombination plugs shall be provided. The recombination plugs shall have a gas recombination efficiency for a preservation voltage higher than 95%. Recombination system shall have a service life not shorter than the service life of the battery.
- e) Battery should be made of material with self-extinguishing properties, should be resistant to mechanical, thermal and electrical exposures. The enclosure should be sealed. The enclosure should be transparent.
- f) The poles should be insulated.
- g) The poles should have adequate sealing, so that the corrosion process on the poles does not cause unsealing of cell / monoblock.
- h) The manufacturer of the battery cells should also be the manufacturer of the grid plates.

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4.12.1.6. AGM/VRLA batteries shall have the following features:

- a) The cells shall be of the longest life category, i.e. over 12 years /LL/.
- b) The cell rated voltage shall be 2 V.
- c) The poles should be insulated.
- d) The cell case shall be made of a self-extinguishing material, and resistant to mechanical, thermal and electrical exposures. The enclosure should be sealed. Handles should be integrated into the housing, fire resistance class in Euroclass System according to UL94 (Underwriters Laboratories Standard).
- e) Permanent battery's preservation voltage at normal temperature shall be in accordance with requirements of battery manufacturer.
- f) Battery manufacturer should be flat grid plates manufacturer too.

4.12.1.7. Batteries shall be provided with an installation, operating and maintenance manual. To the manual should be attached evidence of battery conformity with requirements shown in Eurobat Guide (certificate, declaration, etc.).

4.12.1.8. When selecting batteries, the following autonomy times should be assumed:

- a) Guaranteed voltage systems for automation systems - 30 min.
- b) Guaranteed voltage systems for TPS power supply - 60 min.
- c) Guaranteed voltage systems for TOA power supply - in accordance with current emergency lighting regulations.
- d) Guaranteed voltage systems for IT and telecommunication power supply – 30 min.

The autonomy time may be extended due to technological conditions or the requirements of current regulations.

4.12.1.9. The battery capacity shall take into account the above autonomy times for the rated power of UPS units for DCS and LSK systems. For TPS and TOA systems, the battery capacity shall be based on a power balance including an appropriate margin of at least 20%.

4.12.1.10. The placement of the battery banks shall ensure convenient replacement and handling of individual cells. The cells should be at least on one side accessible from the service aisles.

4.12.1.11. Battery bank shall be placed on a rack in a separate battery room that ensures a good access to battery blocks during operational activities. The battery room should be provided with appropriate temperature conditions throughout the year, in accordance with the manufacturer's instructions, in order to ensure optimal battery life.

4.12.1.12. Battery banks shall allow secure connections between cells, e.g. bolted connections.

4.12.1.13. A nameplate indicating the required safe distance "d", determined in accordance with PN-EN IEC 62485-2, shall be installed in the vicinity of the battery.

4.12.1.14. Battery banks shall not be delivered to site earlier than 6 months prior to their final commissioning (during this period, all operational activities, such as equalizing charges, shall be performed in accordance with the manufacturer's documentation).

4.12.1.15. The nomenclature scheme for each element of guaranteed voltage system and substitute solutions for fireman's switch are shown in Appendix No. 4.

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4.12.2. Battery Rooms

4.12.2.1. Before proceeding with the design, the Design Office shall agree with the Client on the design assumptions.

4.12.2.2. In particular, in terms of the electrical branch, agree on:

- a) Location of the separate battery room and associated auxiliary rooms.
- b) Method of solving existing collisions.
- c) Type of battery bank.
- d) Method of making connections between cells of the battery bank.
- e) Method of setting up the battery bank and auxiliary equipment.
- f) Arrangement of electrical installations in the battery room with the representation of safe distances from the batteries.
- g) Location of water supply and drainage.
- h) Layout of the lighting system (level of illumination, layout of lighting fixtures, etc.).
- i) Connections of electrical installations of battery rooms to external installations.
- j) All other information from the point of view of the function performed by the designed battery room.

4.12.2.3. Battery room

- a) The battery room shall be design in such a way that its areas are classified in the appropriate hazardous area classification documentation as non-hazardous.
- b) Battery room should be located so as to ensure easy transportation of batteries to the battery room.
- c) Battery rooms should be dry, well-ventilated and protected from: exposure to mechanical vibration, freezing, flooding with ground or other water.
- d) The penetration into the battery room or the generation in the battery room of factors that have a detrimental effect on the battery bank (e.g., temperature fluctuations, direct sunlight, etc.) should be avoided.
- e) The floor of the battery room should:
 - withstand the appropriate loads associated with the presence of a point load, such as the load caused by the weight of the battery bank,
 - be resistant to the corrosive environment caused by the electrolyte,
 - be equipped with cuvettes when using batteries with liquid electrolyte,
 - be sloped to ensure free drainage of water,
 - be electrostatically dissipative,
 - have adequate resistance, in accordance with the provisions of IEC 62485.
- f) The ceilings and walls in the battery room must be smooth, without cracks, and painted with a paint coating that does not emit harmful fumes. The paint coating should be resistant to the corrosive environment caused by the electrolyte.
- g) Windows and doors installed in the battery room should be resistant to the corrosive environment caused by electrolyte (windows made of aluminium alloys must not be used).

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h) The width of the service aisles should be adapted to the size of the cells and must not be less than 0,8 m. For operational reasons, the following corridor widths are recommended, which are respectively:

- when batteries are not stacked 0,8 m,
- when stacking batteries 1.0 m,
- the height of service aisles should be no less than 2.0 m.

i) The accumulator room should be secured against unauthorized access.

j) The door of the accumulator room should open outward and be equipped with panic handles. A sign should be placed on the door stating „AKUMULATORNIA - ZACHOWAJ SZCZEGÓLNE ŚRODKI OSTROŻNOŚCI”.

4.12.2.4. Electrical equipment and installations in the battery room

a) The battery room should be free of equipment and installations not directly intended for it.

b) Electrical equipment and installations installed in the battery room should be resistant to the corrosive environment caused by the electrolyte.

c) It is recommended to install in the battery room electrical equipment with a degree of protection, at least IP 56.

d) Lighting fixtures installed in the battery room should be placed in places that allow maintenance of the lighting fixtures from the service corridors, if possible without the use of ladders.

4.12.2.5. Battery rooms shall be equipped with ventilation sufficient to remove hazardous gases. Sizing of ventilation should be done on the basis of the classification of potentially hazardous areas, and its reference number should be referenced in the electrical branch documentation.

4.12.2.6. Accumulator battery racks shall be built up, at most, as single-level, two-stage racks if the weight of a single monoblock exceeds 30 kg. However, if the mass of a single monoblock does not exceed 30 kg, the racks of the battery bank may be built maximum, as two-level, two-stage.

4.12.2.7. The arrangement of monoblock racks shall be selected so as to provide adequate access for transport equipment.

4.12.2.8. The battery room shall be equipped with fixed or mobile cranes that allow the removal of a single monoblock weighing more than 30 kg, if such monoblocks are built in it.

4.12.2.9. In order to ensure optimum battery life, the temperature in the battery room, throughout the year, should be provided in the range of 20°C - 25°C. In addition, the room should be air-conditioned by equipment resistant to sulphuric acid vapour, with fault signalling to the NRB-UR system. Daily $\Delta t^{\circ}\text{C}$ should not exceed 4°C.

4.12.2.10. The battery room shall be equipped with UV protection of the installed batteries.

4.12.2.11. In the battery room, a meter of environmental parameters (temperature and humidity) shall be installed, which shall transmit measurements to the NRB-UR system.

4.12.2.12. The battery room shall comply with all requirements resulting from the classification of hazardous areas, the manufacturer's documentation and relevant standards, prior to the commencement of any use of the battery.

4.12.2.13. Safety showers in battery rooms shall be located and installed in a manner eliminating the risk of flooding or damaging of electrical equipment.

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4.13. SUBSTITUTE SOLUTIONS FOR FIREMAN'S SWITCH

According to the recommendations of the Health and Safety Office Orlen S.A. from 14/08/2014r. regarding Fireman Switches issued on the basis of the guidelines of the State Fire Service No. BZ-III-5560 / 121-2 / 14 of dated 23.07.2014, in facilities where power cut-off may cause stopping an important technological process, or may cause devices that are elements of fire protection to be stopped, it is necessary to use substitute solutions for Fireman's Switch.

4.13.1. Guidelines for substitute solutions for Fireman's Switch

- 4.13.1.1. In order to apply the substitute solution to the Fireman's Switch, individual circuits that switch off particular groups of loads should be used. Each switching system should consist of a control switch and an executive switch.
- 4.13.1.2. All switches controlling the disconnection of batteries and UPS should be located in one hanging cabinet, glazed, additionally protected from weather conditions, accessible from outside the building. The cabinet should be located near the main entrance to the building. Inside the cabinet, cam switches should be installed, protected against accidental shutdowns, with easy access in case of a fire. Each control switch should have a legible and permanent description of circuits being switched off.
- 4.13.1.3. For normal and emergency (backup) lighting circuits, sockets and other auxiliary circuits not related to production, an individual switch-off system shall be used, in accordance with separate regulations relating to Fireman's Switches.
- 4.13.1.4. AC and DC guaranteed voltage circuits (DC systems, 230VAC UPS supplying DCS systems and Emergency lighting boards) should be switched off in the following way:
 - a) Mains power supply should be disconnected in switchgears supplying a building, located in other buildings (remotely from the SCADA system or through operations in the outgoing cubicle of the main switchgear),
 - b) For switching off the systems supplied from external accumulators, individual switch-off systems shall be used for each battery. Each external accumulator battery should have a separate executive switch, with the signalling of the circuit breaker status to the DCS system or, in the absence of DCS, to the control room. The executive switch of the battery should be installed in the battery room in ordinary cabinets or outside the room in fireproof cabinets, between the fuse switch disconnecter and the battery. The coil disabling the given executive switch must be supplied from the point between the executive switch and the fuse disconnecter. Cabinet in standard execution, with transparent doors.
- 4.13.1.5. The nomenclature scheme for each element of guaranteed voltage system and substitute solutions for fireman's switch are shown in Appendix No. 4.

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4.14. COMPUTER SUPERVISORY SYSTEMS

4.14.1. General requirements and information for computer supervisory systems

4.14.1.1. Electrical data acquisition should be performed by computer systems. The NRB system covered by this document should consist of three modules as follows:

- a) NRB - RE dedicated to industrial electricity supply grid operator, Electrical System Operator; shall meet the requirements of Electricity Distribution Services Unit. Used in GPZ, GPR, OPR and OPT switchgears.
- b) NRB - UR dedicated to the End User of the electrical branch of the production installation connected to the local computer network (Ethernet); it should meet the requirements: Electrical Department and End User. Used in OPR and OPT switchgear.
- c) NRB - DCS dedicated to the technological process operator. NRB-DCS system should meet the requirements of the Electrical Department. Used in OPR and OPT switchgear.

4.14.1.2. NRB-RE, NRB-UR, NRB-DCS modules for: servers, RTU, communication connection, user application software should meet the requirements of the Client, i.e., the Electrical Department. Servers, hardware and system software should be in accordance with the requirements of the Client's Information Technology Department.

4.14.1.3. The list of signals to supervisory systems is shown in the presented below:

- Table No. 2 - list of signals transmitted to the NRB-RE system;
- Table No. 3 - list of signals transmitted to the NRB-UR system;
- Appendix No. 2 - list of signals transmitted by wire between the electrical branch, and DCS, ESD, PLC, etc.

4.14.1.4. List of signals dedicated to NRB-UR depends on the implemented equipment, average should be considered about 10-signals for each IED.

4.14.1.5. If it is necessary to install Fault Recording System, the requirements should be agreed with the Client: Electricity Distribution Services Unit and Electrical Department.

4.14.1.6. In the case of switchgear construction based on IEC 61850 standard, the requirements for supervision systems must be agreed with the Electrical Department for each case.

4.14.1.7. Other supervisory systems are also used on the premises of ZP in Plock, which are not included in this document and should be agreed each time with the Departments responsible for them:

- a) NRB Elektra – Used in GPZ, GPR and OPR switchgears supplied with 110kV and 30kV voltage.
- b) NRB-TG – System used at Combined Heat and Power (CHP) and CCGT facilities.
- c) DTS – System used to monitor cable temperatures, for 110kV and 30kV voltages.
- d) ARNE – System used at Combined Heat and Power (CHP) and CCGT facilities.
- e) Energia 4 – Electricity metering system.

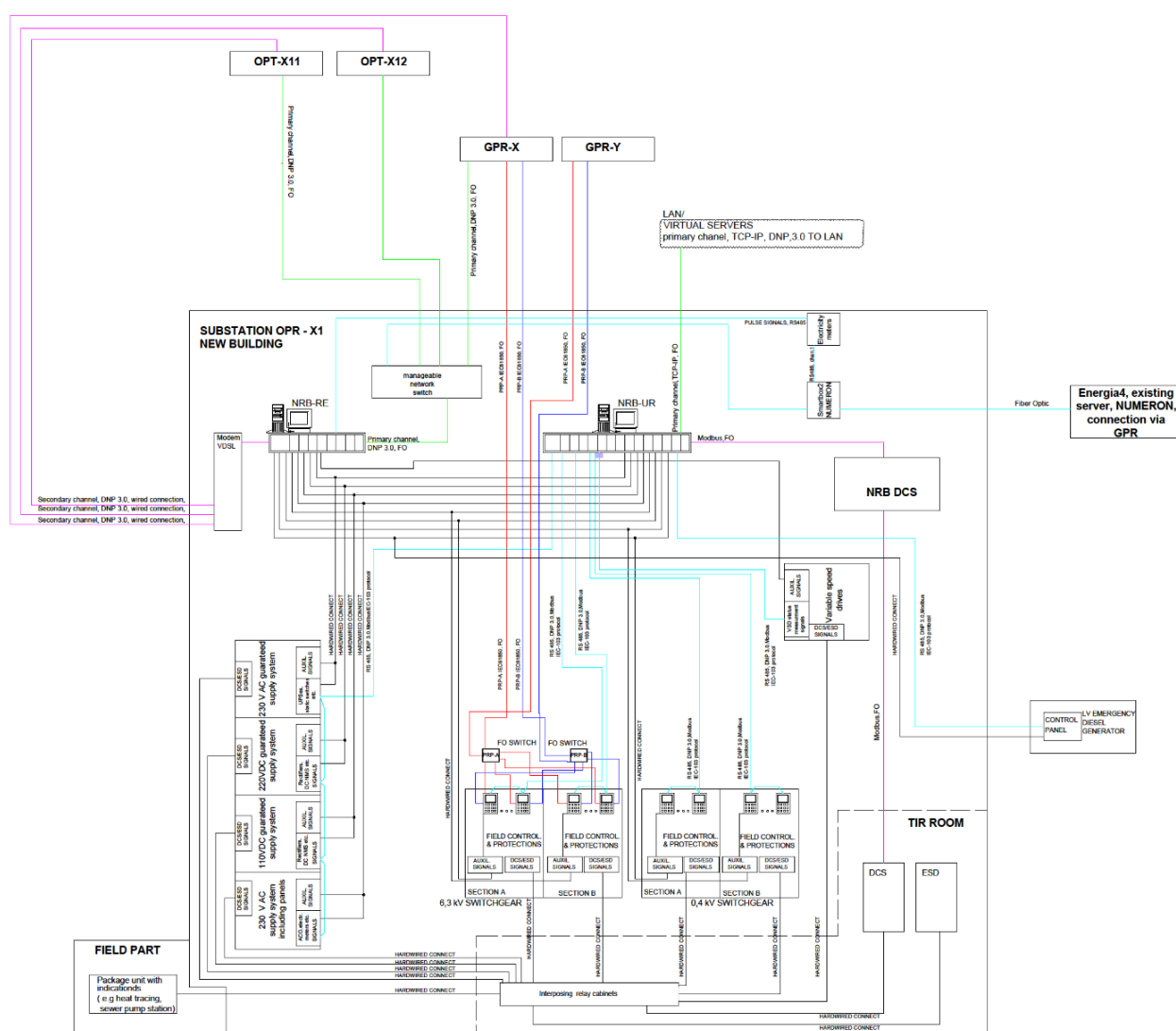
4.14.1.8. Switchgear communication bus system shall ensure a high level of safety. Offer shall include optimization of the switchgear communication bus system with solutions based on fibre or shielded twisted pair.

4.14.1.9. Connection of a switchgear to NRB-RE system - which is a supervision system of the power system - must allow for the transmission of control and monitoring signals.

4.14.1.10. Inputs signals to NRB-RE system will be: potential-free contacts, analogue signals (voltage, current, etc.). Dedicated signals for communication with the NRB-RE system should be independent of the signals collected for other systems (NRB-UR, DCS/ESD).

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- 4.14.1.11. Switchgear supplying include scope correlated with full integration the switchgear data transmission system to NRB system, which is used in existing infrastructure.
- 4.14.1.12. Communication to NRB system shall be executed using supervisory system producer equipment or other producer under condition of fulfilment supervisory system requirements.
- 4.14.1.13. For communication in NRB-UR system, only industrial ethernet switches with enhanced EMC immunity shall be used. The switches shall be designed for operation in industrial automation environments and shall comply with the Client's Telecommunications discipline requirements.
- 4.14.1.14. Details of particular NRB systems e.g. communication and test determination, required each time to be agreed with Electrical Department and Electricity Distribution Services Unit.



NOTES

1. This drawing/document is subject to change. Bidders/contractors to confirm with PKN before submission of final proposal/offer
2. Shown hard wired connection should not be consider as parallel connection, but as signal distribution. Signals for each system are shown in signal list.
3. Number of switches and other network devices along with whole IEC/ISO architecture should be agreed with protection relays provider.
4. Optic connections to the same destination can be done with the same optic cable.
5. Softstarts, Load Commutated Inverter(LCI) or thyristor panels connection philosophy shall be agreed with PKN

Dwg. 10. Diagram of connections to NRB-RE, NRB-UR and NRB-DCS systems for OPR substations

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- 4.14.2.5. The basic communication protocols are DNP 3.0 and IEC 60870-5-103. If the above protocols cannot be used, communication via MODBUS RTU is allowed as an alternative.
- 4.14.2.6. RS-485 communication wiring shall be installed only in a bus topology. Branching and star topology are forbidden.
- 4.14.2.7. Communication buses shall be designed with the following assumptions:
- a) Communication over MODBUS RTU protocol - no more than eight devices should work on the bus.
 - b) Communication using other protocols - it is allowed to use more devices, by agreement with the Electrical Department on each occasion.
 - c) Given bus should contain equipment of the same type.
 - d) For MV and LV electrical switchgear, individual buses, with the exception of incoming feeders, should not pass between sections of the switchgear.
 - e) 120 Ω termination is required at both physical ends of the bus.
- 4.14.2.8. The NRB-UR system shall provide for the transfer of data received from:
- a) Installed ACO/SPSCO and protective relays, analysers and measure devices of grid parameters, UPS power supplies, static-switches, rectifiers, variable speed drives, soft-starts, environmental parameter meters, and other devices equipped with a serial interface, using remote communication to the NRB-UR system.
 - b) The devices listed in the attached list of signals transmitted to the NRB-UR system.
- 4.14.2.9. The NRB-UR system shall also provide binary signalling capability, in accordance with the list of signals transmitted to the NRB-UR system attached to this document.
- 4.14.2.10. Switchgear data connections shall cooperate with the local NRB-UR system unit. NRB-UR system servers should enable data management and data collection, monitoring, signal measurements and visualization, etc.
- 4.14.2.11. Server application will be located on virtual machine of ORLEN S.A. Information and Communication Technology resources.
- 4.14.2.12. The SCADA system application layer shall meet, at a minimum, the following requirements:
- a) A graphic, vector presentation of the current state of the station and network with real-time animation of remote control elements, binary and analogue elements, implemented in synoptic maps and tables.
 - b) Dynamic colouring of lines, strings and busbars.
 - c) Generation of alarms at automatic changes of the system state and when exceeding the analogue values.
 - d) Graphic, vector presentation of archived measurements and the ability to display measurements on-line (high frequency). Scaling charts and the ability to generate several charts on one scale. Presentation of the history of analogue quantities in the form of graphs and tables.
 - e) Counting the effective working time of electric motors with the possibility of generating alarms after exceeding the working time. The limit operating time of the motor must be set by the End User of the system and it must be possible to reset the meter by the End User. Possibility to generate reports with the current list of electric drives supplied from a certain substation with the current operating times and limited times.

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- f) Tabular list of current states of bistable signals and measurements with the possibility of filtering by the address of the element, type of measurements, etc.
- g) Possibility of selective filtering of the event log for individual stations, element, cubicles, types of events. A full history of alarms.
- h) Possibility of placing links to technical documentation.
- i) Priority (categorization) of alarms.
- j) Export of measurement data and event logs to Microsoft Office applications.

4.14.3. Requirements for NRB-DCS system

- 4.14.3.1. Basic functionality of NRB-DCS system is sending measurements from electrical switchgears to DCS system. Due to accepted lack of availability of NRB-DCS system during work of production plant, measurements sending to DCS system cannot take part in logics of control or interlock circuits of production process.
- 4.14.3.2. Controller of NRB-DCS system should be a separated device, independent of NRB-UR controller. It is allowed to retransmit measurements from the NRB-UR controller through a dedicated link.
- 4.14.3.3. Communication between NRB-DCS and DCS system should be realized through fibre optic connections using protocol MODBUS.
- 4.14.3.4. Signals that should be transmitted via the NRB-DCS system:
 - a) Measurement of motor current.
 - b) Voltage measurement in the measurement cabinets of the MV switchgear.
 - c) Measurement of the incoming current of the MV switchgear.
 - d) Temperature measurement of MV motor windings.
- 4.14.3.5. The scope of signals or a type of communication protocol should be agreed each time with Instrumentation Department and Electrical Department.

4.14.4. Requirements for DCS system

- 4.14.4.1. The requirements for the DCS system are defined in the Client's Instrumentation discipline standards. This document covers only scope of signals exchanged between the DCS system and the Electrical discipline.

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4.14.5. List of signals to individual computer supervisory systems

4.14.5.1. Signals transmitted to NRB-RE

Table 2. List of signals transmitted to NRB-RE

No.	Description	Control, Annunciation, Measurement
1	2	3
1.	Medium-voltage switchgears	- Control from NRB level of incoming feeders, couplings feeders of capacitor banks. - Two-bit position signalling for: circuit breakers, disconnectors in transformer chamber, earthing switches, switchgear protractile units. - NRB level circuit-breaker control readiness signalling for: incoming cubicles, coupling cubicles and capacitor banks. - ACO system lack of readiness signalling. - Signalling for motor cubicle OFF by DCS. - Signalling for direct current voltage drop below 0,9 Un in each batteries supplying protection circuits. - Each section signalling: - Warning: Defected overvoltage protection. - Failure: Electrical protection caused trips. - Measurement of phase-to-neutral voltages (L1, L2, L3) in bus bars of both sections. - Electrical measurements using impulse counters.
2.	Low-voltage switchgears and other low-voltage equipment	- One-bit position signalling for: circuit breakers of incomer and coupling cubicles. - ACO system lack of readiness signalling. - Each section signalling. - Warning: - capacitor's bank cut-out, - defected overvoltage protection. - Failure: - voltage interrupts signalling for low-voltage switcher fed panels. - Signalling from UPS units: - warning (plus alarm signal from the buffer power supply units for batteries), - failure. - Alarm signals from buffer power supply units, power controllers, soft start-up systems, frequency converters, static-switches. - Measurement of phase-to-phase voltages (L1-L2, L2-L3) in bus bars of both sections.

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3.	Power Generators	1. Signalling of the position of outgoing circuit breaker/contactors. 2. Run and ready signals.
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4.14.5.2. Binary signals shall be read with a signal resolution of 1 millisecond. NRB shall be provided with appropriate graphic symbols to visualise the above signals.

4.14.5.3. The aforementioned signals may be made available from the NRB system via the company's computer network to other Client's Departments

4.14.5.4. Signals of connections with SCO/SOB systems should be implemented in accordance with the section on MV and LV switchgear.

4.14.6. Signals transmitted to NRB-UR

Table 3. List of signals transmitted to NRB-UR

No.	Description	Control, Annunciation, Measurement
1	2	3
1.	Medium-voltage switchgears	1. Signalling of the position of circuit breakers, withdrawable units and earthing switches in the incoming feeders. 2. Signalling of run status, feeder readiness and permission status. 3. Alarm signalling from feeders (activation, protection operation). 4. Measurements of currents and power in incoming and outgoing feeders. 5. Signalling of status signals of ACO automation (including switching statistics, causes of automatic operation, etc.). 6. Voltage, frequency measurements and energy quality parameters on switchgear sections. 7. Signalling of surge arresters tripping. 8. Status signalling and measurements from frequency converters, soft starts. 9. Calculated state value of motor thermal model from motor feeders. 10. Winding temperature measurements.
2.	Low-voltage switchgears and other low-voltage equipment	<u>Signals sent via the communication protocol:</u> 1. Signalling the position of circuit breakers. 2. Signalling of the position of switches, disconnectors, contactors in the outgoing feeders. 3. Signalling of status signals of ACO automatics (including switching statistics, causes of automatic operation, etc.) 4. Signalling of run status, feeder readiness and permission status*. 5. Measurements of voltage, frequency and parameters of electric energy quality on switchgear sections. 6. Measurements of currents and power in incoming and outgoing feeders. 7. Measurements of thermal states in motor feeders. 8. Measurements of motor speed, motor current, frequency, power for drives supplied by frequency converters.

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		9. Signalling of status signals (including work, readiness, permission, alarm, activation and protection operation) from the switchgear feeders. 10. Status signalling and measurements from buffer supply units, UPS, Static-Switch, frequency converters, power controllers, soft-starts, capacitor banks. 11. Temperature and humidity measurements from environmental parameter analysers. 12. Signalling of the position of the withdrawable units of the switchgear*. * - if it is not possible to send signals via the communication protocol, the signals should be sent in binary form. <u>Signals sent via binary inputs to the object controller:</u> 1. Auxiliary panels: • Signalling of the position of circuit breakers in the incoming cubicles of auxiliary panels: TOP, TOA, TER, TGR, TPZ. • Signalling the tripping of the ACO on the above-mentioned switchboards. • Collective alarm signalling from panels TOA, TOP, TPS, TGR. 2. Signalling of failure of GOOSE switches. 3. Signalling of voltage failure in the NRB-UR cabinet. 4. Signalling of air conditioning failure. 5. Signalling the status of circuit breakers in feeder cubicles and coupling directly from the device. * - if it is not possible to send signals via the communication protocol, the signals should be sent in binary form.
3.	Power Generators	1. Signalling of the position of outgoing circuit breaker/contactors. 2. Run and ready signals*. 3. Measurements of voltage, current and power. * - if it is not possible to send signals via the communication protocol, the signals should be sent in binary form.

4.14.6.1. Measurements shall be read with resolution not lower than 10 sec.

4.14.6.2. List of signals to NRB-UR system and graphic symbols to visualise shall be agreed with Client.

4.14.7. Signals transmitted to DCS

4.14.7.1. List of signals transmitted to DCS /ESD, PLC, etc. is included in Appendix No. 2.

4.14.7.2. DCS shall be provided with appropriate graphic symbols to visualise the aforementioned signals.

4.14.7.3. Signals from the electrical branch of the production plant shall be made available to the staff through the company's computer network to the NRB system.

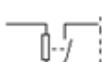
4.14.7.4. The list of signals transmitted to DCS /ESD, PLC etc. system and symbols to visualise the signals shall be agreed with Client.

4.14.7.5. Simplified wiring diagrams with DCS are shown in the following drawings.

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GROUP I - drives not controlled from DCS(PLC)

CONVENTIONAL LV/MV SWITCHGEARS

MV/LV SWITCHGEAR	IRC	DCS/PLC		
		SIGNAL	TYPE	DEFINITION
110V DC OR 230V AC		PERMIT/STOP	CONTACT	CLOSED=PERMIT OPEN=STOP
110V DC OR 230V AC		RUN	CONTACT	CLOSED=RUN OPEN=NOT RUN
110V DC OR 230V AC		AVAILABLE	CONTACT	CLOSED=AVAILABLE OPEN=FAULT

INTELLIGENT LV/MV SWITCHGEARS

MV/LV SWITCHGEAR	IRC	DCS /PLC/		
		SIGNAL	TYPE	DEFINITION
110V DC OR 230 V AC		PERMIT/STOP	CONTACT	CLOSED=PERMIT OPEN=STOP

COMMUNICATION LINK - FIBER OPTIC (FOR THE SWITCHGEAR) CONVERTER SWITCHGEAR SERIAL COMMUNICATION NETWORK WITH MODBUS RTU CONVERTER DCS SERIAL COMMUNICATION NETWORK WITH MODBUS RTU		SIGNAL	TYPE	DEFINITION
		RUN	CONTACT	CLOSED=RUN OPEN=NOT RUN
		AVAILABLE	CONTACT	CLOSED=AVAIL. OPEN=FAULT

Additionally: current value or other parameters

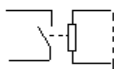
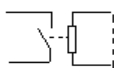
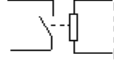
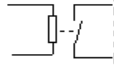
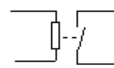
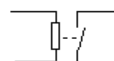
Transmission of status signals through the communication link is allowed only for insignificant consumers that do not affect the continuity of the production process.

Dwg. 12. Signals interposing. Drives not controlled by DCS (PLC)

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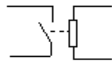
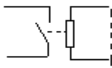
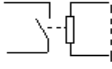
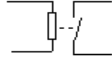
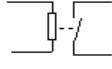
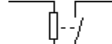
GROUP II - drives controlled from DCS

LV SWITCHGEAR

<u>LV SWITCHGEAR</u>	IRC	DCS /PLC/		
		SIGNAL	TYPE	DEFINITION
230 V AC OR 110V DC		PERMIT/STOP	CONTACT	CLOSED=PERMIT OPEN=STOP
230 V AC OR 110V DC		START	PULSE	 min. 2 sec
230 V AC OR 110V DC		STOP	PULSE	 min. 5 sec
230 V AC OR 110V DC		RUN	CONTACT	CLOSED= RUN OPEN= NOT RUN
230 V AC OR 110V DC		AVAILABILITY	CONTACT	CLOSED=AVAILABLE OPEN= FAULT
230 V AC OR 110V DC		AUTO/HAND	CONTACT	CLOSED= AUTO OPEN= HAND

Additionally: current value, power rot. speed control - 4-20mA loop

MV SWITCHGEAR

ITCHGEAR	IRC	DCS /PLC/		
		SIGNAL	TYPE	DEFINITION
110V DC		PERMIT/STOP	CONTACT	CLOSED=PERMIT OPEN=STOP
110V DC		START	PULSE	 min. 2 sec
110V DC		STOP	CONTACT	CLOSED=PERMIT OPEN=STOP
110V DC		RUN	CONTACT	CLOSED=RUN OPEN=NOT RUN
110V DC		AVAILABILITY	CONTACT	CLOSED=AVAILABLE OPEN=FAULT
110V DC		AUTO/HAND	CONTACT	CLOSED=AUTO OPEN=HAND

Additionally: current value, power rot. speed control - 4-20mA loop

Dwg. 13. Signals interposing diagram. DCS controlled drives

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GROUP III - ESD/DCS controlled drives

<u>MV, LV SWITCHGEAR</u>	IRC	ESD/DCS		
		SIGNAL	TYPE	DEFINITION
110V DC LUB 230 V AC		PERMIT/STOP	CONTACT	CLOSED=PERMIT OPEN=STOP
110V DC LUB 230 V AC		START	PULSE	 min. 2 sec
110V DC LUB 230 V AC		STOP	PULSE	 min. 5 sec
110V DC LUB 230 V AC		STOP (note *)	CONTACT	CLOSED=PERMIT OPEN=STOP
110V DC LUB 230 V AC		* - Two separate contacts from TÜV certified relay		
110V DC LUB 230 V AC		RUN	CONTACT	CLOSED=RUN OPEN=NOT RUN
110V DC LUB 230 V AC		AVAILABILITY	CONTACT	CLOSED=AVAILABLE OPEN=FAULT

Dwg. 14. Signals interposing. ESD controlled drives

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4.15. LIGHTING SYSTEM

4.15.1. General requirements

- 4.15.1.1. Exterior-mounted luminaires shall have a minimum protection level of IP 65. The use of enhanced sealing (protection against water jets under pressure) is required to ensure the declared lifetime of LED light sources.
- 4.15.1.2. The maximum voltage drop from the transformer bus to the lighting fixture shall not exceed 5% (maximum 1% from the transformer to the lighting panel in the substation and maximum 4% further up to the luminaire).
- 4.15.1.3. Lighting circuits shall be protected with circuit breakers rated up to 16A.
- 4.15.1.4. The lighting for process units, pumping station, as well as main roads, internal and access roads, manoeuvring yards, rooms for personnel, control rooms, storage and handling tanks, etc. shall be realised by maximising the use of fixtures with electro-luminescent diodes.
- 4.15.1.5. Lighting fixtures should be mounted in such a way that their easy servicing is possible. Lighting fixtures of local lighting installation for communication roads, stairs, platforms, etc. shall be so installed as to ensure lighting source replacement without using a ladder.
- 4.15.1.6. All lighting fixtures (regardless of the installation zone) shall be fitted with light sources with a minimum lifetime of 50 000 h, for the L80B10 parameter at an ambient temperature of Ta=25°C. This parameter shall be confirmed by the manufacturer's test report (e.g. LM-80/TM-21).
- 4.15.1.7. Minimum luminous efficiency shall be 140 lm/W.
- 4.15.1.8. It should be taken into account that the Client may increase the number of luminaires due to specific local conditions (no more than 10% of the total number of luminaires).

4.15.2. Normal lighting

- 4.15.2.1. Normal lighting is the lighting intended for the type of room, space, equipment or activity under normal operating conditions.
- 4.15.2.2. The supply of lighting circuits is to be made directly from the normal lighting panel - TOP, without the use of lighting sub-distribution panels located on the plant.
- 4.15.2.3. Signalling from the TOP panel to control systems in accordance with the tables in Annex 2 and in the section regarding NRB systems and a local collective alarm signalization on the panel's facade is to be installed.
- 4.15.2.4. The normal lighting installation should be made as a single-phase, TN-S system, using 3 core cables .
- 4.15.2.5. All lighting of the production installation or technological facility should be independently switched on or off from the control room. Internal lighting of objects in the process area, e.g. pump stations or other dimly lit areas should be switched locally.
- 4.15.2.6. Twilight or/and astronomical switches should be used for automatic switching of the lighting of external roads and yards (if necessary).
- 4.15.2.7. The division of luminaires into groups illuminating a specific part of the technological installation, e.g. technological apparatus, pumping station, etc. should be applied. A group of luminaires should be supplied from the same voltage phase and switched on or off using a single switch.

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4.15.3. Emergency lighting

4.15.3.1. Emergency escape lighting:

- a) Emergency escape lighting shall be used inside buildings according to both of CHT's definitions for "escape lighting" and "evacuation lighting". Types of rooms and buildings in which this type of lighting shall be used are listed in the mentioned document "The Regulation of the Minister of Infrastructure on technical conditions to be met by buildings and their location" and "Regulation of the Minister of the Interior and Administration of June 7, 2010 on fire protection of buildings, other structures and areas".
- b) An authorised designer, in consultation with a fire protection expert, shall select the buildings and rooms that should be equipped with this type of lighting.
- c) Unless the designer or fire protection expert decides otherwise, the use of the so-called "dark" mode of operation is recommended.
- d) CNBOP-certified luminaires with built-in batteries should be used for this type of lighting.
- e) Number of luminaires according to the calculated illuminance levels determined by the relevant regulations and standards.
- f) If more than 10 luminaires of this type are used in a building, the use of control and monitoring panels is recommended in order to test the installed luminaires efficiently. The need for such a control panel must be agreed upon in each case with the Electrical Production Support Engineer responsible for the area.
- g) The supply of emergency escape lighting circuits is to be carried out directly from the normal lighting panel - TOP.

4.15.3.2. Standby lighting:

- a) Standby lighting is to be used in all technical rooms e.g. in the electrical switchgear building, including electrical rooms, PiA, IT and control rooms and in all other locations where any measurement, maintenance, service work, etc. is to be carried out inside or outside the buildings and the access roads to these locations. This includes platforms, walkways, ladders, stairs, etc.
- b) This lighting does not require CNBOP certification unless the designer or fire safety expert fire protection expert decides otherwise.
- c) The supply of lighting circuits is to be made directly from the emergency lighting panel - TOA, without the use of lighting sub-distribution panels located on the plant.
- d) Number of luminaires according to the calculated illuminance levels for normal lighting:
 - 50% of the illuminance, calculated for normal lighting, in all technical rooms, e.g. in the electrical switchgear building, including in the electrical rooms, PiA, IT and control rooms,
 - at least 10% of the illuminance, calculated for normal lighting, in other areas, but not less than 15lx, with an illuminance uniformity of $\geq 0,1$.
- e) Signalling from the TOA panel to the control systems in accordance with the tables in Annex 2 and in the section regarding NRB systems should be installed, as well as local collective alarm signalling on the panel facade.

4.15.3.3. Additionally, in the rooms mentioned in clauses above, CNBOP illuminated safety signs should be used with built-in batteries for marking emergency exits.

4.15.3.4. The emergency lighting backup time shall be at least 60 minutes. Extension of the emergency lighting backup time may be based on an analysis of the actions necessary for safe shutdown of the process plant. This time should be agreed between the Contractor and the Client.

4.15.3.5. Luminaires with electro-luminescent diodes, suitable for AC and DC current, should be used.

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4.15.3.6. A solution is recommended which allows, during normal operation, the use of emergency lighting as primary lighting. For this purpose, the emergency lighting panel (TOA) should be fed:

- in the normal state, 230 V alternating current supplied from the normal lighting panel (TOP) supplied from the LV switchgear,
- in the emergency state, 220 V direct current supplied from a dedicated buffer power supply cooperating with the battery bank system.

4.15.3.7. The requirements for the use of light source types are identical to those for normal lighting.

4.15.4. Control for lighting system

4.15.4.1. Normal and standby lighting for level 0 m shall be switched on/off:

- automatically by a twilight or astronomical switch,
- manually by a pushbutton installed in the control panel located in the unit control room.

4.15.4.2. One common signal will switch on/off all circuits for the level 0m of the same unit and for bigger units this functionality shall be divided into few smaller parts of the unit.

4.15.4.3. Normal and standby lighting for above 0m level shall be switched on/off:

- manually by a pushbutton (one per area) installed in the control panel located in the unit control room,
- manually by pushbuttons placed on the unit at each entry/exit from/to a higher level of e.g. platforms, stairs, ladders etc.

4.15.5. Aviation obstruction lighting

4.15.5.1. Requirements for aviation obstruction lighting:

- a) The aviation obstruction lighting installation shall be made as a single-phase, TN-S system.
- b) The lighting fixtures enclosure shall have a minimum degree of protection of IP67 and shall be resistant to UV radiation.
- c) Cable to luminaire connections shall have a minimum degree of protection of IP68.
- d) Junction boxes made of glass fibre reinforced polyester shall be used.
- e) The lifetime of LED light sources shall be at least 100 000 h for a parameter, not less than L80B50 at an ambient temperature of $T_a=25^{\circ}\text{C}$.
- f) The control and power supply system for obstruction lighting shall be protected by type I+II surge protective devices.
- g) For installation in hazardous explosive areas, an aluminium connection box with the required inspection opening, tempered glass type. In accordance with EN 60079-1 and IEC 60079-1, the equipment inside the enclosure may be arranged as needed, provided that at least 40% of the area of each section remains free.

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4.16. ELECTRIC HEATING

4.16.1. Heat tracing installation

4.16.1.1. Each technical design of heating circuits should include:

- a) Full selection of designed components.
- b) The plan of the installation of the heating circuits shown on isometric drawings.
- c) Single-line diagrams and detailed diagrams of heating circuits connection.
- d) Installation plans - cable routes and arrangement of terminal boxes on the installation.
- e) Bills of materials and cables.
- f) Instructions for installation, operation and maintenance.

4.16.1.2. The general division between the instrumentation and electric branch in the scope of electric heating is as follows:

- a) Electrical branch:
 - Heating of pipelines and components permanently associated with them, such as valves or flange connections.
 - Tanks heating.
 - Electric supply for the above mentioned devices and instrumentation heating devices to the first instrumentation distribution box.
- b) Instrumentation branch:
 - Heating of impulse lines.
 - Heating of instrumentation apparatus.
 - Other elements listed in the technical requirements of instrumentation branch.

4.16.1.3. The inter-branch division between the instrumentation and electrical branches should be agreed separately for each installation with the maintenance services of each installations and with the Electrical Department, as it may differ slightly in different areas.

4.16.1.4. Electrical Heat Tracing System (including distribution boards, terminal boxes, junction boxes, heat tracing systems, tapes and cables) shall meet the requirements of Ex-proof execution.

4.16.1.5. Electric heating for pipelines located under pipe sleepers and on main piperacks should be performed at least in accordance with the requirements of zone Ex IIC T3.

4.16.1.6. Self-regulating heating tapes should be used where possible.

4.16.1.7. Requirements for self-regulating heating cables:

- a) Steam blowout resistance (with power off): at least 180°C.
- b) The maximum lengths of the heating loops must not exceed 80% of the maximum lengths recommended by the manufacturer, for miniature overcurrent circuit breakers with maximum rated current of 16 A.

4.16.1.8. TN-S system shall be used for electrical heat tracing supply.

- a) Heat tracing distribution boards on plant (HTP) shall be fed from auxiliary low voltage distribution panel (TGR) located in the substation by means of 3-phase, 5-wire cables.
- b) Terminal distribution boxes (JB) shall be fed from above mentioned HTP distribution boards by means of 1-phase, 3-wire cables.

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- c) Separate bus bars shall be provided inside HTP distribution board for winterising and for process heat tracing if both systems are required.
- d) All devices protecting heating circuits must be equipped with auxiliary contacts to signal the position of the main contacts.
- e) A fault signal from each section of the HTP heating switchboard shall be transmitted to the TGR low voltage distribution panel and indicated with LED lamp on the TGR front panel. Additionally, the common fault signal shall also be indicated locally with LED lamp on the facade of the HTP board.
- f) The common alarm signal from all HTP switchboards and the common alarm signal from the TGR panel shall be combined into a signal TGR common alarm signal and indicated with LED lamp on the TGR front panel.
- g) Signalling from the TGR panel to the control systems in accordance with the tables in Annex 2 and in the section on supervision systems shall be installed.
- h) Junction boxes from which heat tracing is fed shall be equipped with an indicator light to indicate the presence of voltage.
- i) Heat tracing circuits with a heating tape length of more than 30 metres shall be fitted with a voltage presence indicator at the end of each circuit.
- j) Each heat tracing circuit shall be protected inside terminal distribution boxes by means of maximum 16A MCB's equipped additionally with 30 mA current leakage differential protection.
- k) The possibility of MCB's on and off operations without opening the terminal distribution board shall be provided.
- l) Maximum voltage drop on the supply cable (from power transformer to the most distant connection box of the heating cable) shall not exceed 5%.

4.16.1.9. The following control for heat tracing systems shall be designed:

- a) By means of thermostats installed close to the distribution boards for winterising.
- b) By means of thermostats installed directly on equipment or instruments to be heated for process, all season, heating.

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4.16.2. Thyristor power controllers

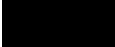
- 4.16.2.1. The installation of power circuits and control and measurement circuits shall comply with rules ensuring electromagnetic compatibility. Required distances should be respected, power circuits should be separated by placing them in a separate compartment, etc.
- 4.16.2.2. Power circuits should be equipped with disconnectors to allow safe servicing.
- 4.16.2.3. Do not connect intrinsically safe circuits, barriers, etc. to thyristor cabinets of power regulators.
- 4.16.2.4. The required temperature inside the cabinets shall be kept below 30°C (e.g. by using ventilation).
- 4.16.2.5. The noise level at a distance of 1 m from the cabinet should be less than 60 dB(A).
- 4.16.2.6. Each power controller shall have a display dedicated to it. A single display for multiple power regulators is not allowed.
- 4.16.2.7. For control circuits with a voltage other than 110 V DC, if any, redundancy shall be provided for that circuit.
- 4.16.2.8. For heating systems controlled by thyristor power controllers, a 20% power reserve shall be provided for both the heater and the power controller.
- 4.16.2.9. The thyristor power controller cabinet shall be equipped with a heater circuit earth-fault monitoring system.
- 4.16.2.10. Each thyristor power controller shall be installed in a separate cabinet.
- 4.16.2.11. Control circuits, cabinet internal lighting circuits and fan supply circuits shall be supplied via an isolating transformer.
- 4.16.2.12. The auxiliary circuits for the thyristor power controller cabinets shall be supplied from the 110 V DC TPS Panel. DC Distribution Board (TPS) 110 V.
- 4.16.2.13. The thyristor power controller cabinet shall be installed in air-conditioned rooms in which the temperature of maximal 25°C is provided.
- 4.16.2.14. Control of the thyristor power controller system:
 - a) Remote control from DCS (START, STOP, PERMIT, SET POINT CONTROL for 4-20 mA, Modbus RTU).
 - b) Control system adapted for automatic restart after instantaneous power failure (START/STOP signals cannot be used).
 - c) All other temperature control systems shall be provided under the automation discipline.
- 4.16.2.15. Indication of the system operation status
 - a) Local (thyristor power controller cabinet/facade) diodes signalling of operation states: RUN, ELECTRICAL READY, PERMIT, ALARM (durable designation in Polish language: PRACA, GOTOWOŚĆ ELEKTRYCZNA, ZEZWOLENIE, ALARM) and the diodes signalling the availability of the auxiliary voltage. Display for (among other data) readings of measured available parameters, alarms and events history (diode signal panel and the display are to be located on the door of frequency converter, available to End-Users).
 - b) Remote indication:
 - DCS system - according to Annex 2,
 - NRB UR system - RS 485 system with MODBUS RTU or IEC 60870-5-103 protocol, according to table 3,
 - System NRB-RE – according to table 2.

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4.16.2.16. Colour of signal lights on the facade of the thyristor power controller cabinet:

INDICATION LAMP				
PERMISSION	ELECTRICAL READY	ALARM	MOTOR RUNNING	AVAILABLE AUX. VOLTAGE
BLUE	WHITE	RED	GREEN	ORANGE
				

4.16.2.17. Colour of buttons on the facade of the thyristor power controller cabinet:

BUTTON	
RESET (IF APPLICABLE)	EPG (IF APPLICABLE)
BLACK	RED
	

4.16.2.18. The thyristor power controller shall be equipped with the event and alarm register with time stamp.

4.16.2.19. Protection degree - minimum IP 20.

4.16.2.20. Access for servicing - only from the front.

4.16.2.21. The thyristor power controller shall have the provision for co-operation with personal computer as well as applicable visualisation, diagnostic and parametrisation software.

4.16.2.22. Cooling and ventilation system:

- Cabinet of thyristor power controller shall be equipped with an appropriate ventilating system according to standard PN-EN 60146-1-1, protecting from overheating of semi-conductor elements of converter, for different values of speed and load which may occur.
- The thyristor power controller shall be equipped with a forced ventilation system. Enclosures shall be adapted to ensure installation of ventilation ducts on the top.
- Evacuation of heat made by thyristor power controller shall be led out to outside through the ventilation system or other technological equivalent, recommended by a producer of frequency converter or his authorised representative.
- The forced ventilation system shall be equipped with all necessary elements, i.e. filters, fans, start-up system with overload module and auxiliary relays, enabling to transmit warning and failure signals. Filters exchange must be possible without switching off the device.

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4.16.2.23. Marking

- a) Each device and equipment shall be marked in accordance with numbers specified in drawings attached to factory documentation of frequency converter.
- b) Plates with data shall be made of material resistant to corrosion and protected from loosening.
- c) All inscriptions shall be made in Polish.

4.16.2.24. Additional requirements

- a) Technical documentation in English and Polish languages. Electronic version (CD or flash drive) and a hard copy of documentation should be delivered. The documentation should include:
 - documentation from manufacture, as well signalling and control diagrams,
 - protocols of factory examinations confirming the essential technical parameters,
 - guarantee certificate for min. 24-month guarantee period from the date of putting the equipment in operation containing detailed guarantee conditions and address of the Guarantor's company,
 - the list of indispensable parts for 5-years operation.

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4.17. LIGHTNING PROTECTION AND EARTHING SYSTEM

4.17.1. Lightning protection and earthing system requirements

4.17.1.1. During the design phase, electrically conductive elements should be used as much as possible for the lightning protection installation as its natural parts, such as:

- a) Supporting structures.
- b) Structural elements of apparatus, tanks, etc.
- c) Structural elements of buildings.

4.17.1.2. The use of metal structural elements in lightning protection shall be taken into account in the structural design documentation.

4.17.1.3. Lightning protection installation of buildings:

- a) Have to meet the objectives of the PN-EN IEC 62305 series of standards.
- b) As far as possible, horizontal and vertical lightning conductors and down-conductor system must be arranged so that all parts of the building to be protected are within the protective area of the lightning conductors.
- c) Down-conductors shall be arranged so that there are several paths for discharging the charge from the point of lightning strike to the ground and that their length is as short as possible.
- d) Where the above conditions cannot be fulfilled, all non-conductive building elements located above the roof surface (chimneys, fire walls, etc.) should be equipped with air terminals and connected to the air terminal grid mounted on the roof surface. All metal parts of the building located on the roof surface (chimneys, exhaust fans, barriers, etc.) must be connected to the nearest air terminal or discharge duct.
- e) The external lightning protection system should always be supplemented by suitable internal lightning protection devices, such as equipotential bonding or suitably selected and located surge arresters.
- f) Connections of down-conductors with earth electrodes or grounding conductors should be made through a test joint.

4.17.1.4. The lightning protection system for explosion hazardous areas shall meet the requirements of PN-EN IEC 62305-3 Annex D.

4.17.1.5. Pipes for combustible media with a wall thickness of less than 5 mm shall be protected against atmospheric discharges.

4.17.1.6. Tanks of flammable liquids or gases should be earthed in at least two places.

4.17.1.7. The earthing installation is used, among others, to ensure:

- protection against lightning discharges,
- protection against electric shock for all electrical devices,
- protection against static electricity.

4.17.1.8. Each facility or process unit shall be provided with earthing ring/grid.

4.17.1.9. In the case of a foundation earthing system connected to an earthing ring, the earthing ring shall be constructed of materials that do not cause accelerated electrochemical corrosion, such as copper-bonded steel, stainless steel or copper.

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4.17.1.10. Earthing ring electrodes and earthing conductors shall be made of minimum 30 x 4-mm hot deep galvanised steel tape. The earthing connections above ground shall be made of min. 25 x 4 mm hot deep galvanised steel tape. Other elements and connections of installation should be made of galvanised steel strips of 20x3 mm and/or galvanised steel wire of 10 mm diameter.

4.17.1.11. Connections of the above-ground part of the lightning protection and grounding installation with the ring earth electrode should be made through screwed test joints enabling periodic measurements of the grounding and lightning protection systems. Test joints are a screwed connection of two grounding tapes, using at least two screws with nuts and spring washers.

4.17.1.12. The earthing system depth shall be as follows:

hot deep galvanised steel tape	not less than 0,6 m under the ground
rods or pipes	not less than 2,5 m under the ground (calculating from the bottom end of the rod or pipe)

4.17.1.13. Resistance of the earth electrode system at the plant shall not exceed 5 Ω .

4.17.1.14. Earthing resistance for DCS systems should not exceed 1 Ω unless otherwise required by the DCS manufacturer.

4.17.1.15. Earthing conductors shall be connected to the equipment, not to the foundations or plate's bolts. As for motors, the earthing conductors shall be bolted to the motor mounting leg or reinforcing rib.

4.17.1.16. All connections of the lightning protection and earthing system in explosion hazardous areas shall be welded – the welds shall be protected against corrosion and mechanical damage.

4.17.1.17. Each above-ground to ground or concrete transition point of the earthing and lightning protection system shall be provided with corrosion protection in accordance with PN-EN IEC 62305-3.

4.17.1.18. In explosion hazardous areas, for all bolted connections of supporting structures and structural elements of apparatus, tanks and buildings used as natural discharge elements in lightning protection, additional welded connections should be made between the bolted elements using a steel tape with minimum dimensions of 30 x 4 mm.

4.17.1.19. It is permissible to use uncovered test joints (bolted) in Zone 2 area only. The Zone 1 area test joints shall be installed in sand buried chambers. All connections in lightning and grounding system shall be protected against corrosion and mechanical damage.

4.17.1.20. Pipelines earthing:

- a) Flanged pipelines connections shall meet the following mechanical requirements: "To ensure electrical continuity and the dissipation of electrostatic charges, spring washers or serrated washers, or other equivalent anti-loosening measures, shall be installed on two opposite bolts of each flanged connection. This requirement does not apply where the operating pressure exceeds 6 bar or where a metallic gasket is used."
- b) Pipelines should be earthed:
 - at the beginning and end of the pipeline,
 - every 30 m along the pipeline route,
 - at pipeline entrances to facilities.
- c) Earthing must consist of electrical connection of the pipe to the earthing network through a galvanized flat tape welded to the earthing lugs, with the required reserves due to the thermal compensation of the pipeline. The tape should be placed in such a way as to maintain compensation in all directions by bending it appropriately.
- d) All welded joints should be galvanized to avoid corrosion.

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- e) The earthing tape should be marked, along the entire length of the tape with yellow-green colour.
- f) The direct earthing of the start/end of the pipeline may be replaced by:
- a fixed or flanged (with a gasket of conductive material) connection to another directly earthed pipeline,
 - a fixed or flanged (with a gasket of conductive material) connection to earthed equipment or earthed process apparatus,
 - another direct earthing located not more than 15m (measured along the pipeline route) from the flange or weld that forms the boundary of the pipeline.

4.17.1.21. Shields of control, signal and measurement cables should be earthed on one side, preferably from the side of control cabinets, unless the manufacturer of the respective control cabinet specifies otherwise.

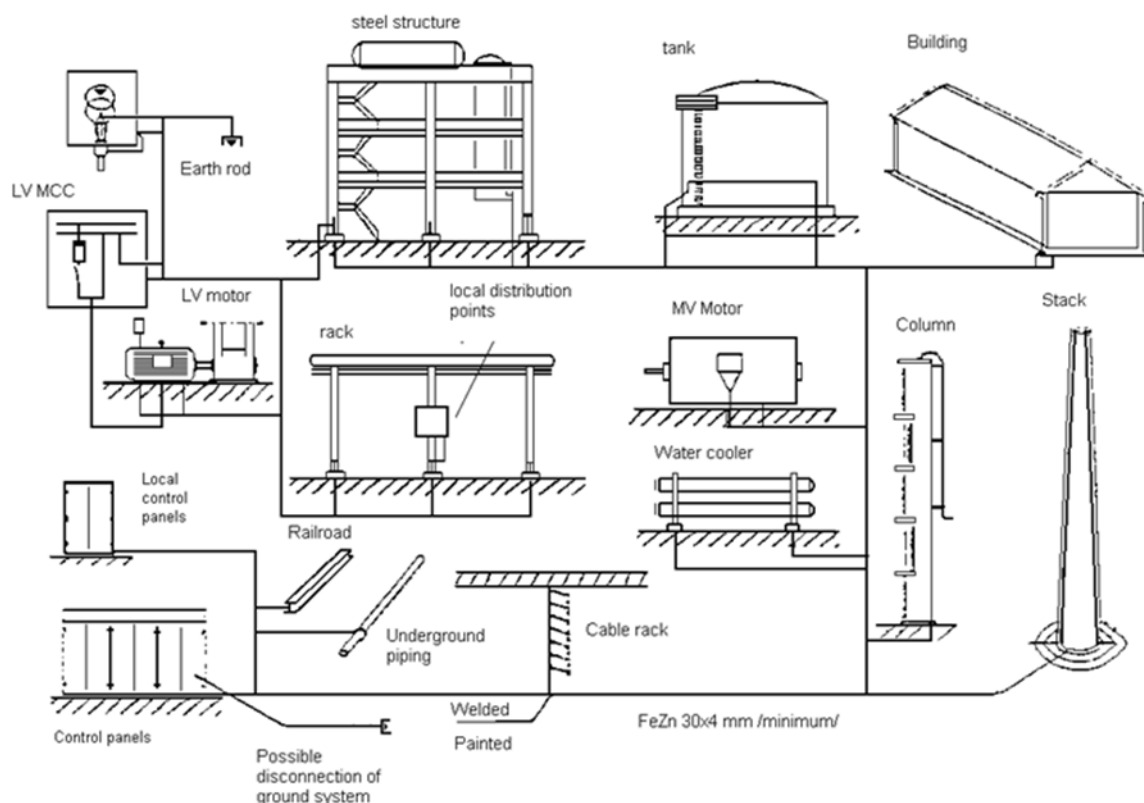
4.17.1.22. Earthing of inverter cables screens should be done on both sides, remembering about effective connection of all devices with the equipotential bonding system. Observe the recommendations contained in the operating manuals of the inverters used.

4.17.1.23. Shielded cables consisting of several sections must be provided with galvanic continuity, but without grounding at their connection points.

4.17.1.24. The connection of the screen with the ground shall have the largest possible area, which can be achieved by e.g. using special clamps and / or cable glands.

4.17.1.25. All metal elements on the plot such as structures, columns, tanks, pipe racks, cranes, pipelines, electrical equipment enclosures shall be earthed.

General installation rules for earthing system are shown below.



Dwg. 15. Earthing system

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4.18. AUXILIARY ELECTRICAL SYSTEMS

4.18.1. LV socket outlets

4.18.1.1. TN-S electrical system shall be designed for socket outlets to be used during plant maintenance or reparation.

4.18.1.2. The following socket outlets equipped with local switches shall be applied:

- a) 1-phase, 3-pole, rated current 16 A.
- b) 3-phase, 5-pole, rated current 32 A and 63 A.

Complete sets of socket and plugs in ex-proof execution should be delivered. Sockets should be equipped with internal switches. Complete sets of sockets and plugs should be delivered.

4.18.1.3. The following cables shall be used for socket outlets feeding:

- a) 3-wire cables for 1-phase socket outlets (L, N, PE).
- b) 5-wire cables for 3-phase socket outlets (L1, L2, L3, N, PE).

4.18.1.4. Allocation and the number of socket outlets depend of maintenance needs and shall be agreed upon with Client. Socket outlets should be allocated in such a way that will be possible to supply the maintenance equipment, lighting fixtures etc. in any place of the plant as follows:

- a) From 3-phase socket outlets via extension cable not longer than 40m.
- b) From 1-phase socket outlets via extension cable not longer than 30m.

4.18.1.5. Socket outlets circuits switching on and off should be done by means of circuit breaker installed in LV switchgear. During normal operation of the production unit, repair sockets outlets remain free of voltages.

4.18.1.6. Each set of sockets shall be supplied individually from the TER auxiliary board via a dedicated protective device and a dedicated cable feeder.

4.18.2. Power supply systems for high-pressure units used for cleaning and maintenance of technical installations

4.18.2.1. Close to heat exchangers on the plant there shall be provided TN-S electrical supply system for high-pressure units (i.e. WOMA units) with the rated power of 120 kW.

4.18.2.2. High-pressure units supply system shall be terminated by a terminal box in Ex-proof execution equipped with a circuit breaker.

4.18.2.3. Terminal boxes for high-pressure units shall be allocated in respect of maximally allowable distance between heat exchanger and terminal box not more than 40 m.

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4.18.3. Electrical installation for mobile gas analyser

4.18.3.1. For gas analyser houses located close to the stack on site of process units TN-S, 5-wire electrical power supply system shall be provided.

4.18.3.2. Power supply installation for gas analyser shall be terminated by means of closed junction box which includes:

- a) 5 pole, socket outlet, rated current 32 A,
- b) Circuit-breaker, rated current 32 A.

Maximum allowable distance from sample point to above-mentioned junction box should not exceed 40 m.

Additionally 1-phase, 3-pole, 16 A socket outlet supplied by separate circuit shall be installed in the distance not more than 2 m from a sample point.

4.18.3.3. Additional technical requirements will be handed over from Client during engineering phase.

4.18.4. Telecommunications system

4.18.4.1. The telecommunication system has to be integrated with existing system.

4.18.4.2. The telecommunication system must take care of the following:

- Connection with the industrial announcing system informing about chemical alarm.
- Fire-fighting pushbuttons alarm annunciation.
- Cooperation with fire detectors.

4.18.4.3. Process units shall be equipped with paging intercom loud speakers system in Ex-proof execution.

4.18.4.4. The quantity and arrangement of paging devices and the location of devices should be agreed by the Contractor with the Client during the design phase.

4.18.4.5. Intercom cable installation shall be laid along pipe racks or supporting structures in cable trays or cable ladders or cable trench or directly buried in the ground.

4.18.4.6. Required covers shall protect cable trays or ladders, against atmospheric influence, such as rainfall sunbeams, expose on mechanical electrical or chemical damages.

4.18.4.7. Self-extinguishing or fireproof-jacketed cables and conductors resistant to chemical exposures (hydrocarbons) shall be used, where necessary.

4.18.4.8. If necessary, intrinsic safe cellular phones ("Ex i" execution) shall be used additionally.

4.18.4.9. The details are to be worked out at the time of design for building permit and detailed engineering.

4.18.4.10. The telecommunication systems shall meet the requirements of Client, IT or Telecommunication discipline.

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5. TECHNICAL DOCUMENTATION

5.1. CONTRACTOR'S OBLIGATIONS

5.1.1. Contractor action guidelines for ongoing investment projects

5.1.1.1. The coordination of all activities related to the subject matter of the project shall be the responsibility of the Contractor. The above includes the main scope of the contract, as well as scopes resulting from agreements with other Participants of the investment project.

5.1.1.2. Contractor is obliged to provide the ORLEN S.A. Project Manager with:

- necessary documentation for all machinery, equipment and installations that are within the scope of the contract, as listed below,
- a complete set of documentation revised during construction for the preparation of as-built documentation.

5.1.1.3. Design solutions not included in the approved technical documentation and issued through additional KNA (design author's supervision card) entries shall, in each case, be reviewed and agreed with the Electrical Department.

5.2. DOCUMENTATION CONTENT REQUIREMENTS

5.2.1. Contents of technical documentation to be accepted, reviewed, commented on

- a) Should be issued in Polish version, optionally in addition in English.
- b) Shall be signed by at least one person with unlimited building licence for designing in the electrical speciality.
- c) It should be divided into volumes as indicated below. A different arrangement of volumes than the one presented below requires agreement with the Client.
- d) Each subsequent revision of the technical documentation shall include a table with the list of reviewer's comments for the previous revision and the designer's responses, together with an indication of which comments have been implemented and in which parts of the documentation. Corrections and supplements introduced in a given revision shall be marked in a different colour.

5.2.2. General requirements for the content of the technical design

- a) Title page.
- b) An index of the contents of the documentation or the contents of the volumes with the project documentation in terms of process, plot plan or technical requirements.
- c) List of acronyms and symbols used.
- d) List of standards and regulations used.
- e) Design assumptions, including:
 - all written agreements made with the Client during design and implementation, shall remain in association with this study,
 - consideration and reference to the tag number of the current classification of potentially hazardous areas.
- f) Technical description.
- g) Plot plans showing the layout and identification numbers of all equipment, underground and aboveground conduits and cable conduits or cable routes, grounding system, etc.

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- h) Technical and operating documents, instructions for operation, installation, operation, maintenance and repair.
- i) Test reports from manufacturers of installed equipment.
- j) The identification system for equipment, devices and cables in the design documentation shall be applied in agreement with the Electrical Department, while maintaining consistency with the marking used for existing facilities and in compliance with the relevant provisions of WTBE.

5.2.3. Detailed requirements of the content of the documentation

5.2.3.1. Contents of documentation of LV switchgear:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protections and other devices.
- h) Parameterization of protections and automatic change over (ACO) system.
- i) Power balance.
- j) Schematic diagram of switchgears.
- k) Master diagrams of individual bays of switchgears.
- l) Diagrams of connections with NRB-RE, NRB-UR systems.
- m) Diagrams of connections with DCS/ESD systems.
- n) Assembly diagrams.
- o) Elevation views of individual bays of switchgears.
- p) Interconnection diagram and view of control columns.
- q) Equipment layout.
- r) Cable route plan.
- s) Grounding plan.
- t) Quality documentation.

5.2.3.2. Contents of documentation of MV switchgear:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.

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- g) Technical calculations, selection of cables, protections and other devices.
- h) Parameterization of protections and automatic change over (ACO) system.
- i) Power balance.
- j) Schematic diagram of switchgears.
- k) Master diagrams of individual bays of switchgears:
 - Main circuits,
 - Circuit breaker diagram,
 - Circular circuits,
 - Current and voltage circuits,
 - CW1 protection circuits,
 - CW2 protection circuits,
 - Protection input circuits,
 - Signalling circuits,
 - LRW and ZS circuits,
 - External signalling circuits,
 - Circuit breaker charging circuits,
 - Diagrams of connections with NRB-RE, NRB-UR systems,
 - Diagrams of connections with DCS/ESD systems,
 - Diagrams of connections IEC 61850 GOOSE,
 - Block diagram of bay protection assemblies with interconnections,
 - Mounting diagrams,
 - Terminal plan.
- l) Elevation views of individual bays of switchgears.
- m) Interconnection diagram and view of control columns.
- n) Equipment layout.
- o) Cable route plan.
- p) Grounding plan.
- q) Quality documentation.

5.2.3.3. Electric motor list:

- a) In accordance with Appendix 5 of the WTBE.

5.2.3.4. The content of the documentation of auxiliary panels (TPZ, TGR, TOP, TER) - a separate study for each panel:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.

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- f) Cable list.
- g) Technical calculations, selection of cables, protections and other devices.
- h) Parameterization of protections and automatic change over (ACO) system.
- i) Power balance.
- j) Schematic diagram of the auxiliary panel.
- k) Main schematic with the automatic change over (ACO) system of the auxiliary panel.
- l) Diagrams of connections with NRB-RE, NRB-UR systems.
- m) Diagrams of connections with DCS/ESD systems.
- n) Assembly diagrams.
- o) Elevation view of auxiliary panel.
- p) Location of auxiliary panel.
- q) Cable route plan.
- r) Quality documentation.

5.2.3.5. The content of documentation of auxiliary panels of guaranteed voltage (TPS, TOA) - a separate study for each panel:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protections and other devices.
- h) Equipment parameterization.
- i) Power balance.
- j) Auxiliary panel schematic diagram.
- k) Main diagram of the auxiliary panel.
- l) Diagrams of connections with NRB-RE, NRB-UR systems.
- m) Diagrams of connections with DCS/ESD systems.
- n) Assembly diagrams.
- o) Elevation views.
- p) Equipment layout.
- q) Arrangement of battery banks on racks.
- r) Distances between devices in the battery room, marking of safe distances.
- s) Plan of cable routes.
- t) Parametrization charts for buffer power supplies.

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u) Quality documentation.

5.2.3.6. Contents of NRB-RE supervision system documentation:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protection and other devices.
- h) Signal list.
- i) Technical documentation of the cabinet.
- j) Cabinet location plan.
- k) Cable route plan.
- l) Quality documentation.

5.2.3.7. Contents of NRB-UR, NRB-DCS supervisory system documentation:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Technical calculations, selection of cables, protection and other devices.
- g) Cable list.
- h) List of RS-485 communication bus and DI signals.
- i) List of NRB-DCS signals.
- j) Technical documentation of the cabinet.
- k) Cabinet location plan.
- l) Cable route plan.
- m) Quality documentation.

5.2.3.8. Contents of the documentation of the uninterruptible voltage system for DCS and LSK (AC UPS), a separate study for each system:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.

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- f) Cable list.
- g) Technical calculations, selection of cables, protection and other devices.
- h) Schematic of the guaranteed voltage system.
- i) Diagrams of connections with NRB-RE, NRB-UR systems.
- j) Diagrams of connections with DCS/ESD systems.
- k) Equipment layout.
- l) Cable route plan.
- m) Elevation view of UPS system cabinets.
- n) Assembly diagrams of battery disconnectors.
- o) Arrangement of battery banks on racks.
- p) Parametrization charts.
- q) Quality documentation.

5.2.3.9. Contents of documentation of frequency converters and soft starters, separate study for each system:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protection and other devices.
- h) Settings and parameters for the devices used.
- i) Schematics of supply bays.
- j) Control schemes.
- k) Diagrams of connections with NRB-RE, NRB-UR systems.
- l) Diagrams of connections with DCS/ESD systems.
- m) Equipment layout.
- n) Assembly diagrams and equipment layout in the cabinet.
- o) Cable route plan.
- p) Elevation view of cabinets.
- q) Quality documentation.

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5.2.3.10. Contents of documentation of thyristor power controllers:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protection and other devices.
- h) Settings and parameters for the devices used.
- i) Schematics of supply bays.
- j) Control schemes.
- k) Diagrams of connections with NRB-RE, NRB-UR systems.
- l) Diagrams of connections with DCS/ESD systems.
- m) Equipment layout.
- n) Assembly diagrams and equipment layout in the cabinet.
- o) Cable route plan.
- p) Elevation view of cabinets.
- q) Quality documentation.

5.2.3.11. Contents of grounding and lightning protection installation documentation:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) technical calculation of expected earthing resistance.
- g) Technical calculations of the separation distances of the lightning protection system.
- h) Drawings confirming correct selection of LPS class.
- i) Plan of grounding installation.
- j) Plan of lightning protection installation.
- k) Plan of location of control and measurement connectors.
- l) Assembly drawings.
- m) Grounding diagrams.
- n) Quality documentation.

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5.2.3.12. Contents of transformers documentation:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protection and other devices.
- h) Switchgear plan - arrangement of equipment.
- i) Transformer chambers - arrangement of equipment.
- j) Simplified scheme of switchgear power supply.
- k) Cable route plan.
- l) Busbars arrangement.
- m) Quality documentation:

5.2.3.13. Contents of electric heating documentation:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Heating calculations - full selection of equipment.
- g) Structural diagram of heating supply.
- h) Schematic diagram of field electrical heating switchgears.
- i) Main diagram of object electric heating switchgears.
- j) Diagrams of connections with NRB-RE, NRB-UR systems.
- k) Diagrams of connections with DCS/ESD systems.
- l) General heating plan.
- m) Detailed heating plans.
- n) Isometric drawings of heating for piping and connections.
- o) Construction details of heating installation.
- p) Manufacturer documentation.
- q) Quality documentation.

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5.2.3.14. Contents of documentation of internal electrical installations: lighting, internal heating, sockets:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protection and other devices.
- h) Cable route plan.
- i) Lighting:
 - Lighting intensity calculations,
 - Schematic of power supply and lighting control,
 - Arrangement of devices,
 - Lighting installation plan,
 - Construction details of lighting installation,
- j) Internal heating:
 - Schematic of power supply,
 - Arrangement of devices,
- k) Sockets:
 - Schematic of power supply,
 - Arrangement of devices,
- l) Quality documentation.

5.2.3.15. Content of the documentation of external electrical installations: lighting, sockets:

- a) Title page.
- b) Table of contents.
- c) List of standards and regulations.
- d) Technical description.
- e) List of materials.
- f) Cable list.
- g) Technical calculations, selection of cables, protection and other devices.
- h) Cable route plan.
- i) Lighting.
 - Lighting intensity calculations,
 - Schematic of power supply and lighting control,
 - Arrangement of devices,
 - Lighting installation plan,

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- Construction details of lighting installation.

j) Sockets:

- Schematic of power supply,
- Arrangement of devices.

k) Quality documentation.

5.2.3.16. Contents of documentation of road lighting installation:

- Title page.
- Table of contents.
- List of standards and regulations.
- Technical description.
- List of materials.
- Cable list.
- Technical calculations, selection of cables, protection and other devices.
- Cable route plan.
- Lighting intensity calculations.
- Diagram of power supply and lighting control.
- Schematic of lighting installation – layout.
- Road lighting installation plan.
- Diagrams of connections with NRB-RE systems.
- Quality documentation.

5.2.3.17. Contents of Ex specifications documentation, certificates, declarations:

- Title page.
- Table of contents.
- Specification of explosion-proof electrical equipment made on the basis of data from the nameplates of installed equipment.
- EU/EC type examination certificates, EU declarations of conformity, etc.
- Operation manuals and technical and operating documentation of equipment included in the specification.

5.2.3.18. Contents of the Operation and Maintenance Manual:

- MV switchgear:
 - Description of the switchgear construction,
 - Operation of protection relays, automatic transfer systems and measuring devices,
 - Description of basic operating activities and switching operations,
 - Maintenance activities.

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- b) LV switchgear and auxiliary boards:
 - Description of the LV switchgear and auxiliary boards construction,
 - Operation of protection relays, automatic transfer systems and measuring devices,
 - Description of basic operating activities and switching operations,
 - Maintenance activities.
- c) Guaranteed voltage systems:
 - Operation of UPS units, buffer power supplies, static transfer switches (STS) and battery bank,
 - Description of basic operating activities and switching operations,
 - Maintenance activities.
- d) Electrical drive systems:
 - Operation of electrical drive systems, including MV and LV frequency converters and soft starters,
 - Operation of MV electric motors,
 - Operation of LV electric motors,
 - Description of basic operating activities and switching operations,
 - Maintenance activities.
- e) Thyristor power controllers:
 - Operation of thyristor power controllers,
 - Description of basic operating activities and switching operations,
 - Maintenance activities.
- f) NRB computer supervisory system:
 - Operation of the NRB-UR controller and application,
 - Operation of the NRB-RE controller and application,
 - Operation of the NRB-DCS controller and application,
 - Maintenance activities.
- g) Electrical Ex-proof equipment.
- h) Other electrical equipment and systems:
 - Operation of electric heating systems,
 - Operation of lighting installations,
 - Operation of repair socket installations,
 - Operation of transformers.
 - Operation of capacitor banks,
 - Operation of earthing and lightning protection systems,
 - Operation of cathodic protection systems,
 - Operation of electric heating elements in furnaces and heaters,
 - Description of basic operating activities and switching operations.

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5.2.3.19. Other manuals and equipment data sheets:

- a) Title page.
- b) Table of contents.
- c) Operation manuals issued by the manufacturer or their authorized representatives in Polish, English.

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6. STANDARDS AND REGULATIONS

For the application of regulations other than those specified below, the written consent of the Client is required. The latest editions of the relevant standards or regulations must be taken into account. In case of doubt, the interpretation of the statements contained in the standards or regulations must be agreed with the Client.

Table 4. List of applicable standards and regulations

Item	Standard No.	Title
1.	PN-EN ISO 1680	Acoustics — Test code for the measurement of airborne noise emitted by rotating electrical machines.
2.	PN-EN 12464	Light and lighting. Lighting of work places.
3.	PN-EN 12665	Light and Lighting. Basic terms and criteria and specifying requirements concerning lighting.
4.	PN-EN 13201	Road Lighting.
5.	PN-EN 13501-6+A1	Fire classification of construction products and building elements - Part 6: Classification based on tests of reaction to fire of power, control and telecommunication cables.
6.	PN-EN 1838	Application of Lighting – Emergency Lighting.
7.	PN-ISO 20816-1	Mechanical vibration. Measurement and evaluation of machine vibration. General guidelines.
8.	PN-EN 50393	Test methods and requirements for accessories for use on distribution cables of rated voltage 0.6/1.0 (1.2) kV.
9.	CLC/TR 50404	Electrostatics. Code of practice for the avoidance of hazards due to static electricity
10.	PN-EN 50522	Earthing of power installations exceeding 1 kV AC.
11.	PN-EN 50575	Power, control and communication cables – Cables for general applications in construction works subject to reaction to fire requirements.
12.	PN-EN 60034 PN-EN IEC 60034	Rotating electrical machines.
13.	PN-IEC 60050-461	International Electrotechnical Vocabulary (IEV). Electric cables.
14.	PN-EN IEC 60076-11	Power transformers. Dry type power transformers.
15.	PN-EN IEC 60079-0	Explosive atmospheres. General requirements.
16.	PN-EN 60079-1	Explosive atmospheres. Equipment protection by flameproof enclosure 'd'.
17.	PN-EN 60079-2	Explosive atmospheres. Equipment protection by pressurised enclosure 'p'.
18.	PN-EN 60079-5	Explosive atmospheres. Equipment protection by powder filling 'q'.
19.	PN-EN 60079-6	Explosive atmospheres. Equipment protection by oil immersion 'o'.

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20.	PN-EN 60079-7	Explosive atmospheres. Equipment protection by increased safety 'e'.
21.	PN-EN IEC 60079-10-1	Explosive atmospheres. Classification of areas.
22.	PN-EN IEC 60079-11	Explosive atmospheres. Equipment protection by intrinsic safety 'i'.
23.	PN-EN 60079-13	Explosive atmospheres. Equipment protection by pressurized room "p" and artificially ventilated room "v".
24.	PN-EN IEC 60079-14	Explosive atmospheres. Electrical installation design, selection and installation of equipment, including initial inspection.
25.	PN-EN 60079-18	Explosive atmospheres. Equipment protection by encapsulation 'm'.
26.	PN-EN IEC 60079-25	Explosive atmospheres. Intrinsic safe electrical systems.
27.	PN-EN 60079-28	Explosive atmospheres. Protection of equipment and transmission systems using optical radiation.
28.	PN-EN 60079-30	Explosive atmospheres. Electrical resistance trace heating.
29.	PN-EN IEC 60079-31	Explosive atmospheres. Equipment dust ignition protection by enclosure 't'.
30.	PN-EN 60079-32-2	Explosive atmospheres. Electrostatic hazards. Tests.
31.	PN-IEC 60092-353	Electrical installations in ships. Power cables for rated voltages 1 kV and 3 kV.
32.	PN-EN 60146	Semiconductor converters.
33.	PN-EN 60204-1	Safety of machinery. Electrical equipment of machines. General requirements.
34.	PN-IEC 60332-1-3	Test on electric and optical fibre cables under fire conditions. Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles.
35.	PN-IEC 60332-3-24	Tests on electric and optical fibre cables under fire conditions. Test for vertical flame spread of vertically-mounted bunched cables – Category C.
36.	PN-IEC 60364 PN-HD 60364	Electrical installations of buildings. Low voltage electrical installations.
37.	PN-HD 60364-4-41	Low-voltage electrical installations. Protection for safety. Protection against electric shock.
38.	PN-HD 60364-4-42	Low voltage electrical installations. Protection for safety. Protection against thermal effects.
39.	PN-HD 60364-4-43	Low-voltage electrical installations. Protection for safety. Protection against overcurrent.
40.	PN-HD 60364-4-442	Low-voltage electrical installations. Protection for safety. Protection of low voltage installations against temporary over-voltages due to

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		earth faults in the high voltage system and due to faults in the low voltage systems.
41.	PN-HD 60364-4-443	Low-voltage electrical installations. Protection for safety. Protection against voltages disturbances and electromagnetic disturbances. Protection against overvoltages of atmospheric origin or due to switching.
42.	PN-HD 60364-4-444	Low-voltage electrical installations. Protection for safety. Protection against voltage disturbances and electromagnetic disturbances.
43.	PN-HD 60364-5-52	Low-voltage electrical installations. Selection and erection of electrical equipment – Wiring systems.
44.	PN-HD 60364-5-54	Low-voltage electrical installations. Selection and erection of electrical equipment. Earthing arrangements and protective conductors.
45.	PN-HD 60364-5-56	Low voltage electrical installation. Selection and erection of electrical equipment. Safety services.
46.	PN-HD 60364-7-706	Low-voltage electrical installations. Requirements for special installations or locations. Conducting locations with restricted movement.
47.	PN-EN IEC 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals, conductor terminals and conductors.
48.	IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV.
49.	PN-EN 60529	Degrees of protection provided by enclosures (IP code).
50.	PN-EN IEC 60664	Insulation coordination for equipment within low-voltage systems.
51.	PN-EN 60909	Short-circuit currents in three-phase a.c. systems.
52.	IEC 60986	Short-circuit temperature limits of electric cables with rated voltages from 6 kV ($U_m = 7,2 \text{ kV}$) up to 30 kV ($U_m = 36 \text{ kV}$).
53.	PN-EN 61000-6-2	Electromagnetic compatibility (EMC). Generic standards - Immunity standard for industrial environments.
54.	PN-EN 61000-6-4	Electromagnetic compatibility (EMC). Generic standards - Emission standard for industrial environments.
55.	PN-EN 61000-6-5	Electromagnetic compatibility (EMC). Generic standards - Immunity for equipment used in power station and substation environment.
56.	PN-EN 61000-6-7	Electromagnetic compatibility (EMC). Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations.
57.	PN-EN 61340	Electrostatics.
58.	PN-EN IEC 61439	Low-voltage switchgear and control assemblies.

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59.	PN-EN 61508	Functional safety of electrical/electronic /programmable electronic safety-related systems.
60.	PN-EN IEC 61936	Power installations exceeding 1 kV AC and 1,5 kV DC.
61.	PN-HD 620 S3	Power cables with extruded insulation for rated voltages from 3.6/6 (7.2) kV and not exceeding 20.8/36 (42) kV.
62.	PN-EN IEC 62271-200	High voltage switchgear and controlgear A.C. metal enclosed switchgear and controlgear for rated voltages above 1 kV up to and including 52 kV.
63.	PN-EN IEC 62305	Protection against lightning.
64.	PN-EN IEC 62485	Safety requirements for secondary batteries and battery installations.
65.	N SEP-E-004	Elektroenergetyczne i sygnalizacyjne linie kablowe. Projektowanie i budowa.
66.	KSP ORLEN S.A.	Overall Prevention System of ORLEN S.A.
67.	Dz.U. 1994 nr 89 poz. 414	Construction Law.
68.	Dz.U. 2004 nr 92 poz. 881	Act on Construction Products.
69.	Dz.U. 2007 nr 82 poz. 556	Act on Electromagnetic Compatibility.
70.	Dz.U. 2010 nr 138 poz. 931	Regulation of the Minister of Economy on minimum requirements for the safety and health protection concerned workplaces exposed potentially at risk from explosive atmospheres.
71.	Dz.U. 2016 poz. 542	Act on conformity systems and market supervision.
72.	Dz.U. 2016 poz. 806	Regulation of the Minister of Development on the requirements for electrical equipment.
73.	Dz.U. 2016 poz. 817	Regulation of the Minister of Development on requirements for equipment and protective systems intended for use in potentially explosive atmospheres.
74.	Dz.U. 2018 poz. 1233	Regulation of the Minister of Investment and Development amending the Regulation on the method of declaring the performance of construction products and the method of marking them with the construction mark.
75.	Dz.U. 2022 poz. 1225	Regulation of the Minister of Infrastructure on technical conditions to be met by buildings and their surroundings.
76.	Dz.U. 2023 poz. 822	Regulation of the Minister of Internal Affairs concerning fire protection for buildings and other building projects as well as sites.
77.	Dz.U. 2023 poz. 1707	Regulation of the Minister of Economy on technical conditions to be met by liquid fuel base and stations, long-distance pipelines used to transport crude oil and petroleum products.

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78.	Dz.U.2024 poz. 1540	Regulation of the Minister of Infrastructure amending the Regulation on aviation obstacles, obstacle limitation surfaces and devices of a hazardous nature.
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7. LIST OF PRODUCERS/TYPES OF ELECTRICAL BRANCH DEVICES

The list of manufacturers accepted by the Client, is included in Appendix No. 1 of this study.

It is recommended to include in the offers information as to the performance of inspections, repairs, maintenance and overhaul, by representative offices of companies located in Poland or Polish manufacturers.

If there is a manufacturer's company or its authorized representative office on the territory of Poland - designs, deliveries, commissioning of equipment should be carried out through them. Otherwise, the Contractor should provide a written statement of the Polish representative office about the resignation from this scope.

In requests for quotations to sub-suppliers, the Contractor should clearly indicate ORLEN S.A. as the final recipient. The Contractor shall not forbid sub-suppliers to contact representatives of ORLEN S.A. in technical matters in its purchasing procedures.

The selection of a manufacturer or type of equipment other than that indicated in Appendix No. 1 should be agreed with ORLEN S.A. - Electrical Department, based on: certificates, attestations, references presented by the given manufacturer, supplier.

The rules for ordering equipment from sub-suppliers should be based on the procedures used in the European Union.

7.1. CRITERIA FOR EVALUATING EQUIPMENT SUPPLIED BY MANUFACTURERS

- a) Warranty period - the warranty should cover the period as for the entire installation or longer.
- b) Time required to repair faulty equipment - the time required to repair a fault in the equipment (from notification of failure to repair of the equipment) should be the shortest.
- c) Warranty services - Polish companies should perform warranty services, if any, acting, as an authorized representative of the manufacturer.
- d) Scope of warranty services - the warrantee should provide a schedule of services performed during the warranty period with an indication of free services.
- e) Activities after the end of the warranty period - the guarantor should offer post-warranty services performed by Polish companies, acting as an authorized representative of the manufacturer.
- f) Availability of spare parts - the guarantor should ensure availability of spare parts for the longest possible period of time, however 10 years from the end of production is the minimum.

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9. APPENDICES

9.1. APPENDIX 1 - LIST OF ACCEPTED PRODUCERS/TYPES OF ELECTRICAL BRANCH DEVICES.

No.	Devices group	Producer	Devices type/series/comments
1.	Power generators	Caterpillar Cummins Power Generation Pramac	-
2.	Cable accessories - couplers, cable heads	3M Cellpack Nexans Power Accessories Tyco Electronics	-
3.	Batteries	Energys Hoppecke batteries TAB Batteries/PBI POLDHAM Yuasa	PowerSafe SBS XL Ogi, GRoE, OSP, OPzS Ogi, GRoE, OSP, OPzS SWL
4.	Capacitor banks	Elma Olmex Schneider Electric Taurus-Technic Twelve Electric	-
5.	Cable glands/cable entries (standard construction, i.e. non Ex)	ABB Bartec CMP EATON Elektro-Plast Nasielsk Elektro-Plast Opatówek ERGOM ERKO HENSEL INDUSTRIAS STAHL Schneider Electric SIMET	-

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No.	Devices group	Producer	Devices type/series/comments
6.	Sockets and plugs (standard construction, i.e. non Ex)	BALS ELEKTROMET Dzierżoniów ELEKTRO-PLAST Nasielsk ELEKTRO-PLAST Opatówek ETI-POLAM Legrand MENNEKES Schneider electric SPAMEL	-
7.	Power and signal cables	DRUT-PLAST CABLES Eltrim Kable Fabryka Kabli ELPAR Helukabel Lapp Kabel Nexans Prysmian Technokabel Telefonika Kable Zakłady Kablowe Bitner	-
8.	Electric cables and wires for telecommunications	DRUT-PLAST CABLES Eltrim Kable Helukabel Lapp Kabel Nexans Prysmian Technokabel Telefonika Kable Zakłady Kablowe Bitner	-
9.	Cable trays and cable ladders	BAKS EL-PUK OBO Bettermann UNEX	- - - Indoor applications. Not in explosive hazardous areas
10.	Indicator lamps (standard construction, i.e. non Ex)	Golland LOVATO PROMET	-

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No.	Devices group	Producer	Devices type/series/comments
11.	Grid parameter meters	LUMEL Schneider Electric	ND45 PM8000
12.	Low-voltage busbar bridges	GE GRID SOLUTIONS S.A. Schneider Electric SIEMENS ZARMEN GROUP ZPUE	-
13.	Electric valve actuators	AUMA ROTORK	-
14.	Cathodic protection	AREM CATHODIC PROTECTION CO LTD CORRPOL CORRSTOP	-
15.	Lightning arresters, surge arresters LV, MV	ABB Dehn&Sohne EATON Legrand OBO Bettermann Phoenix Contact SIEMENS	-
16.	Cable ties	3M ABB AKS ZIELONKA ELEKTRO-PLAST Nasielsk ELEKTRO-PLAST Opatówek ERKO Legrand	-
17.	Explosion-proof lighting fixtures	ATM LIGHTING CORTEM EATON/CEAG ELEKTROMETAL SA R. Stahl Schaltgerate	

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No.	Devices group	Producer	Devices type/series/comments
18.	Lighting fixtures of normal execution	ATM LIGHTING ELEKTROMETAL SA INTELIGHT KANLUX LEDVANCE GmbH LUG LUXON OSRAM PHILIPS	-
19.	Explosion-proof accessories, (control columns, intermediate boxes, sockets, plugs, etc.).	EATON/CEAG HARDO R. Stahl Schaltgerate	-
20.	Emergency evacuation lighting: control and supervision panels	Hybryd AWEX	-
21.	Obstacle lighting	BlueSoft STC CORTEM, SPA (SAFETY PROTECTION) EATON CROUSE HINDS (COOPER INDUSTRIES) Golland INDUSTRIAS STAHL	-

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No.	Devices group	Producer	Devices type/series/comments
22.	Auxiliary and signaling relays	Allen Bradley ALSTOM EATON / ETI EAW / Merazet F&F FANOX Finder GE Hitin JUMO MEDCOM Moeller Phoenix Contact RELPOL Schneider Electric SIEMENS WAGO	-
23.	Low voltage frequency converters	ABB Danfoss/ VACON Rockwell Automation SIEMENS	ACS880-01/31/37 FC102, FC202, FC302, NXS PowerFlex 755TL Sinamics G150, S120, G180
24.	Medium voltage frequency converters	Rockwell Automation INNOMOTICS	PowerFlex 7000 Perfect harmony
25.	Power distribution boxes and wall-mounted indoor switchboards	BALS ELEKTRO-PLAST Nasielsk ELEKTRO-PLAST Opatówek ENSTO HENSEL SIMET SPAMEL	-
26.	LV main distribution switchgears	ABB EATON HABER Energia Schneider Electric / REVICO SIEMENS Zarmen/Elektrobudowa ZPUE	MNS xEnergy Elite XL, XXL Okken Sivacon NGWR ZR-W

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No.	Devices group	Producer	Devices type/series/comments
27.	MV switchgears	ABB Elektrometal-Energetyka REVICO Schneider Electric Zarmen/Elektrobudowa ZPUE	UGZS1 e ² ALPHA RS-12 PIX PREM 14SM, D-12P(L) RELF
28.	Heat shrinkable tubes and electrical insulating tapes	3M CELLPACK POLSKA ERGOM ELEKTRO-PLAST Opatówek ERKO Tyco Electronics	-
29.	Asynchronous electric motors	ABB ATB SCHORCH CANTONI (EMIT, CELMA) DFME DAMEL ELIN Motoren GE INNOMOTICS VEM Gruppe WEG	-
30.	Synchronous electric motors	ABB DFME DAMEL GE INNOMOTICS VEM Gruppe	-
31.	Programmable logic controllers in speed control systems	Allen-Bradley GE Automation&Control Siemens	RX3i S7-300

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No.	Devices group	Producer	Devices type/series/comments
32.	Air and vacuum contactors	ABB Apator EATON Electric ERGOM ETI-POLAM F&F GE GE Power controls Legrand ORAM RELPOL Schneider Electric SIEMENS	-
33.	Explosion-proof heating systems	Bartec Chemelex Hew-Kabel H.Eilentropp Heat Trace Ltd. Thermon Europe BV	-
34.	SCADA supervision systems	Apator Mikronika	-
35.	ACO Automatic Change Over/ SPSCO Scheduled Power Supply Change Over	ENERGOTEST Mikronika LOVATO	ATL610 (LV distribution boards)
36.	Fiber optics	Nexans Prysmian Telefonika Kable Zakłady Kablowe Bitner	-
37.	LV auxiliary panels	ABB EATON HABER Energia Schneider Electric / REVICO SIEMENS Zarmen/Elektrobudowa ZPUE	- xEnergy Elite - PRISMA, SAREL - - RN-W

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No.	Devices group	Producer	Devices type/series/comments
38.	MV/LV transformers	ELHAND TRANSFORMATORY Fabryka transformatorów w Żychlinie GBE S.p.A HITACHI LEF Poland Mefta Green Transfo Energy Poland SGB-SMIT Transformers Polska Michał Latosiński Trafta	-
39.	Thyristor power controllers	ABB Advanced – Energy	DCT880 Thyro-Px
40.	Soft-start systems for LV motors (soft-starts)	ABB CES EATON Fairford SIEMENS	-
41.	MV soft-start systems (soft-starts) for asynchronous and synchronous motors	ABB CES/ SOLCON IGEL INNOMOTICS	LCI SOLCON IGEL PERFECT HARMONY
42.	Cabinet fans	ABB EBMPAPST NMB PAPST SUNON Venture Industries	-

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No.	Devices group	Producer	Devices type/series/comments
43.	Fuses	ABB Bussmann EATON ENSTO ETI-POLAM F&F FERRAZ Legrand Schneider Electric Schrack Technik SIEMENS WESTCODE	-
44.	Power circuit breakers and compact circuit breakers LV	ABB EATON HYUNDAI GE Power Controls Schneider Electric SIEMENS	-
45.	LV overcurrent and residual current circuit breakers, LV fuse and isolating disconnectors, LV fuse and isolating switch disconnectors	ABB EATON ELEKTRO-PLAST Nasielsk ETI Polam GE Industrial Solutions Legrand Schneider Electric Schrack Technik SIEMENS SOCOMEK TELERGON	-
46.	MV vacuum circuit breakers	ABB Schneider Electric	VD4 HVX
47.	LV protections (electronic, digital)	ABB Elektrometal Energetyka SIEMENS ZAZ-En	UMC100.3 e ² Tango 150 Simocode iZAZ200

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No.	Devices group	Producer	Devices type/series/comments
48.	MV protections (electronic, digital)	Elektrometal Energetyka GE Schneider Electric ZAZ-En	e ² Tango 800/1000 Multilin, Agile PowerLogic P5, Easergy P1 iZAZ400
49.	Terminals, connectors and cable lugs	Conta Clip ELEKTRO-PLAST Nasielsk ELEKTRO-PLAST Opatówek ENSTO ERGOM ERKO ETI-POLAM HENSEL Legrand Phoenix Contact SIEMENS SIMET WAGO Weidmuller WIELAND ELECTRIC	-
50.	DC buffer power supplies (rectifiers)	Medcom Gutor (manufactured in Switzerland)	-
51.	DC power supplies (rectifiers) - in speed control systems	Phoenix Contact WAGO Weidmuller	-
52.	UPS power supplies for IT loads, DCS systems of non-continuous processes	Medcom Gutor (manufactured in Switzerland)	Overload capacity of 500% for 5 seconds
53.	UPS power supplies for DCS/ESD systems	Medcom Gutor (manufactured in Switzerland)	Overload capacity of 500% for 5 seconds
54.	Light sources and ballasts	INTELIGHT KANLUX OSRAM PHILIPS PILA	-

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9.2. APPENDIX 2 - LIST OF SIGNALS TRANSMITTED HARD WIRED BETWEEN ELECTRICAL BRANCH AND DCS SYSTEM (ESD, PLC, ETC.)

No.	Description	Control, Signalling, Measurements	From	Source of signal	To	Contact Voltage	Voltage Source
1	2	3	5	6	7	8	9
1.	MV Switchgears	1. Circuit-breaker status signalling for incoming feeders and bus-tie panel (one-bit system)	MV incoming feeders and bus-tie panel	Circuit-breaker	IRC Panel	110VDC	SWGR/MCC
		2. Common protection devices trip signalling	MV Switchgear	Feeder protection device			
		3. ACO/SPSCO signal of successful automatic changeover	MV coupling feeder	ACO relay			
		4. Bus-bar voltage measurement for both sections	MV measurement feeder	Protection/Voltage converter			
2.	LV Switchgears	1. Circuit-breaker status signalling for incoming feeders and bus-tie panel (one-bit system)	LV incoming feeders and bus-tie panel	Circuit-breaker	IRC Panel	110VDC	SWGR/MCC
		2. Protection device trip for incoming feeders and bus-tie panels signalling	LV incoming feeders and bus-tie panel	Circuit-breaker			
		3. ACO/SPSCO signal of successful automatic changeover	LV coupling feeder	ACO relay			
3.	MV/LV Transformer feeder	1. Winding temperature overrun signalling - first activation threshold	MV feeder/protection device	Transformer temperature sensor	IRC Panel	110VDC	SWGR/MCC
		2. Winding temperature overrun signalling - second activation threshold	MV feeder/protection device	Transformer temperature sensor		(4-20mA)	ACTIVE from SWGR
		3. Load current measurement	MV transformer feeder	Current converter IL2 5A/4-20mA			
4.	MV Motors (DOL)	1. Motor operating status signalling: a) permit/stop	IRC Panel	DCS / ESD relay	MV motor feeder	110VDC	SWGR/MCC
		b) start	IRC Panel (Auto mode)	DCS / ESD relay			
		c) stop	IRC Panel (Auto mode)	DCS / ESD relay			
		d) run	MV motor feeder	MV motor feeder	IRC Panel		
		e) electrical ready (permit signal from DCS/ESD not included)	MV motor feeder	MV motor feeder			
		f) auto/manual	Remote Control Unit	Remote Control Unit via MV motor feeder			
		2. Load Current measurement	MV feeder	Current converter IL3 5A/4-20mA		(4-20mA)	ACTIVE from SWGR
		3. Bearings temperature measurement PT100	Temperature sensor via MMS or directly to DCS	Motor bearing temperature sensor	According to Instrumentation discipline	According to Instrumentation discipline	According to Instrumentation discipline
		4. Measurement of vibration parameters (when required)	Motor vibrations sensor via MMS	Motor vibrations sensor			
5.	LV Motors (DOL)	1. Motor operating status signalling: a) permit/stop	IRC Panel	DCS / ESD relay	LV motor feeder	230VAC	SWGR/MCC
		b) start	IRC Panel (Auto mode)	DCS / ESD relay			
		c) stop	IRC Panel (Auto mode)	DCS / ESD relay			
		d) run	LV motor feeder	LV motor feeder	IRC Panel		

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No.	Description	Control, Signalling, Measurements	From	Source of signal	To	Contact Voltage	Voltage Source
		e) electrical ready (permit signal from DCS/ESD not included)	LV motor feeder	LV motor feeder			
		f) auto/manual	Remote Control Unit via LV feeder	LCU			
		2. Current measurement (if required by Instrumentation discipline)	LV motor feeder	Current converter IL2 1A/4-20mA	IRC Panel	(4-20mA)	ACTIVE from SWGR
		3. Bearings temperature measurement PT100 (only for >110kW)	Temperature sensor via MMS or directly to DCS	Motor bearing temperature sensor	According to Instrumentation discipline	According to Instrumentation discipline	According to Instrumentation discipline
		4. Measurement of vibration parameters (when required)	Motor vibrations sensor via MMS	Motor vibrations sensor			
6.	Frequency Converters	1. The same list of signals as respectively for MV and LV motors - electrical ready splitted according to below	Frequency converter cabinet			110VDC - MV VSD 230V AC - LV VSD	SWGR/MCC
		2. Common Alarm signal	Frequency converter unit	Relays in LV/MV switchgear	IRC Panel		
		3. Signal 4-20mA - set point for motor speed	IRC Panel (Auto mode)	DCS	Frequency converter cabinet	(4-20mA)	ACTIVE from DCS
		4. Signal 4-20mA - actual motor speed	Frequency converter cabinet	Frequency converter	IRC Panel	(4-20mA)	ACTIVE from SWGR
		5. Bypass operation / frequency converter operation (if bypass implemented)	Frequency converter cabinet	Frequency converter cabinet	IRC Panel	110VDC - MV VSD 230V AC - LV VSD	SWGR/MCC
7.	Soft-Start Systems	1. The same list of signals as respectively for MV and LV motors	Soft starter cabinet			110VDC - MV SS 230V AC - LV SS	SWGR/MCC
		2. Common Alarm signal	Soft-Start Unit	Soft-Start Unit	IRC Panel		
8.	UPS Power Supply	UPS units status signalling: a) warning (plus alarm signal from the auxiliary buffer power supply units for batteries)	Each UPS Unit	Each UPS Unit	IRC Panel	230VAC	TP UPS bus A or B
		b) failure	Each UPS and buffer supply Unit	Each UPS and auxiliary buffer supply Unit			
9.	Buffer power supply units (110V DC for TPS and 220V for TOA) and Static-Switch	Alarm signal from buffer power supply units and Static-Switch	Acc. To column 2	Acc. To column 2	IRC Panel	110VDC for TPS, 220VDC for TOA	by TPS/TOA
10.	Thyristor Power Controllers for electric heaters	1. Motor operating status signalling: a) permit/stop	IRC Panel	DCS / ESD	Power Controller unit	230VAC	Power Controller Cabinet
		b) start	IRC Panel	DCS / ESD			
		c) stop	IRC Panel	DCS / ESD			
		d) run	Power Controller unit	Power Controller unit	IRC Panel		
		e) electrical ready	Power Controller unit	Power Controller unit			
		3. Signal 4-20mA - set point for power	IRC Panel	DCS	Power Controller unit	(4-20mA)	ACTIVE from DCS

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No.	Description	Control, Signalling, Measurements	From	Source of signal	To	Contact Voltage	Voltage Source
		4. Signal 4-20mA - actual power	Power Controller unit	Power Controller unit	IRC Panel	(4-20mA)	ACTIVE from PCU
11.	TOA DC Panel	Alarm signal (one group signal) consisting: a) voltage failure	TOA panel	Undervoltage relay	IRC Panel	220VDC	TOA
		b) protection device trip - one collective signal		Outgoing protection devices auxilliary contacts			
12.	TPS DC Panel	Alarm signal (one group signal) consisting: a) voltage failure	TPS panel	Undervoltage relay	IRC Panel	110VDC	TPS
		b) protection device trip - one collective signal		Outgoing protection devices auxilliary contacts			
		c) ground fault		Insulation monitoring device			
13.	Battery disconnecter (fireman's switch)	Trip signal	From each battery (TPS, TOA, UPS) disconnecter (fireman's switch)	Battery disconnecter (fireman's switch) - auxilliary contacts	IRC Panel	220VDC/110VDC	DC batteries, from between Fuse Disconnecter and fireman switch
14.	Outside cabinet containing a fireman's switch substitute	Door opened signal	Outside cabinet containing a fireman's switch substitute.	Outside cabinet containing a substitute fireman's switch - auxilliary contacts	IRC Panel	230VAC	TPZ
15.	TGR (heat tracing) Panel	Common alarm signal including alarm signals from HTP panels	TGR Panel	Heat tracing distribution boards on plant	IRC Panel	230VAC	TGR
16.	Emergency Diesel Generator	1. Run	EDG	EDG	IRC Panel	110VDC	TPS
		2. Electrical ready					
		3. Outgoing circuit-breaker/contactors status					

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9.3. APPENDIX 3 - TEMPLATE FOR THE TABLE “SPECIFICATION OF EXPLOSION-PROOF ELECTRICAL EQUIPMENT”.

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Specyfikacja wykonana z natury dla elektrycznych urządzeń w wykonaniu przeciwwybuchowym zainstalowanych na
w ramach zadania inwestycyjnego nr/remontu** pn.
na podstawie projekt technicznego nr, pn.....

Data sporządzenia.....

Lp.	Dane z tabliczki znamionowej urządzenia				Dane klasyfikacyjne i miejsce zainstalowania urządzenia					Dopuszczenie
	Nazwa urządzenia, nr technologiczny, typ, dla silników podać moc i czy współpracuje z przełącznikiem częstotliwości	Producent	Nazwa jednostki certyfikującej. Nr. atestu	Cecha przeciwwybucho- wości urządzenia i oznaczenie ATEX	Strefa zagro- żenia wybuch- em	Grupa wybuchowości i klasa temperaturow- a	Miejsce zainstalowania np.zbiornik, pompownia itp.	Ilość sztuk	Nr certyfikatu według „Wykazu załączonych certyfikatów „*	Podpis i pieczętka osoby dopuszczającej
1	2	3	4	5	6	7	8	9	10	11
1										

Wykonano na podstawie klasyfikacji stref zagrożenia wybuchem, karta klasyfikacyjna nr

Sprawdził za zgodność ze stanem faktycznym

Wykonawca Specyfikacji

Inspektor Nadzoru Inwestorskiego

Realizator Zadania

Podpis, pieczętka

Podpis, pieczętka

Podpis, pieczętka

UWAGA: nagłówek specyfikacji, nagłówek tabeli specyfikacji oraz podpisy na każdej numerowanej stronie specyfikacji

* numer kolejny z wykazu załączonych certyfikatów

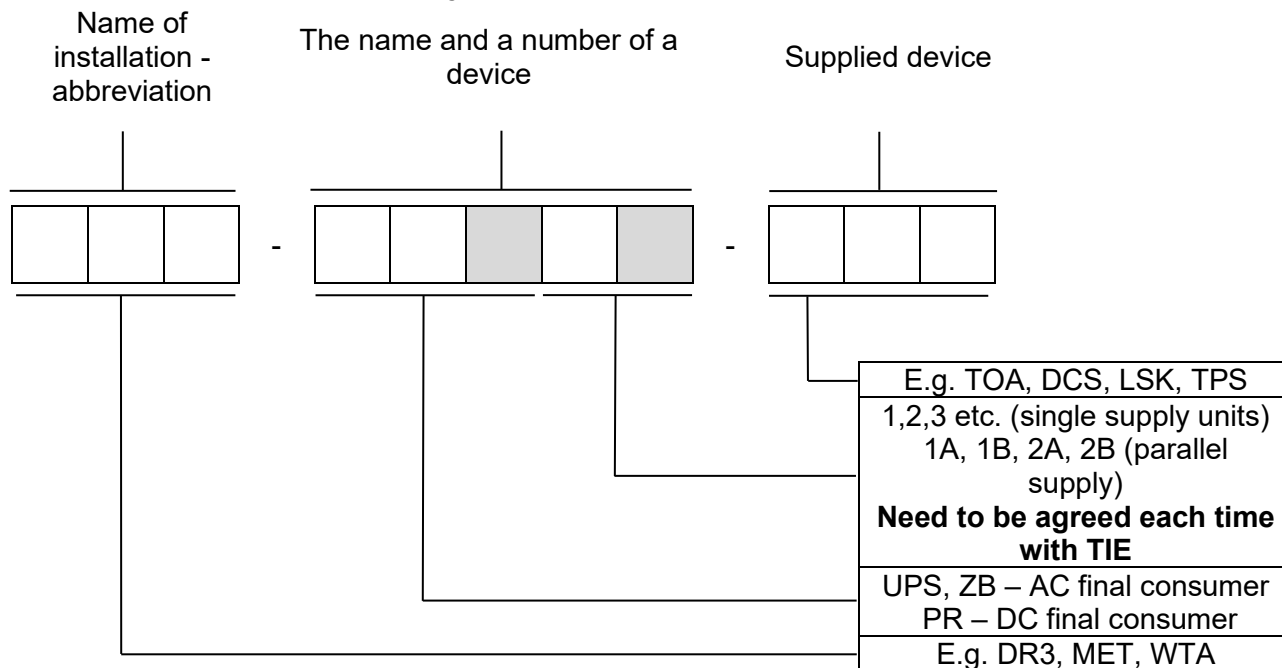
** niepotrzebne usunąć

strona 1 z 1

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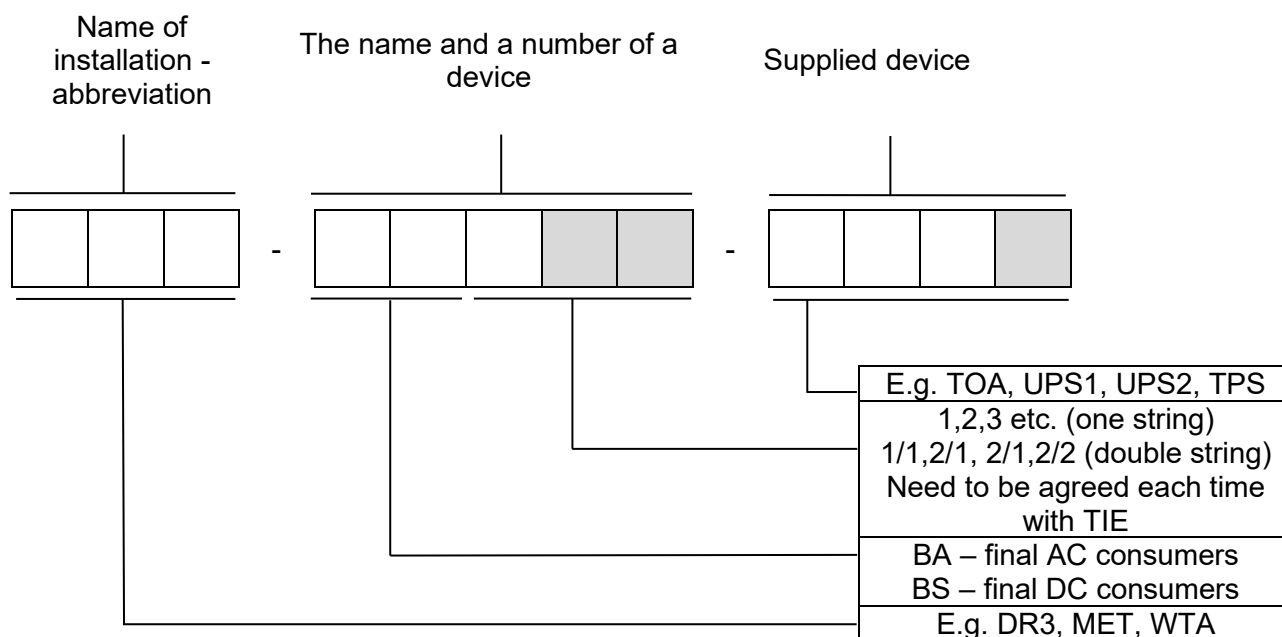
9.4. APPENDIX 4 - TEMPLATE FOR NAMING THE ELEMENTS OF THE GUARANTEED VOLTAGE SYSTEM AT THE PRODUCTION FACILITIES OF ORLEN S.A. IN PŁOCK

1. UPS, buffer power supply units, rectifiers :



Example: DR2-UPS1A-DCS

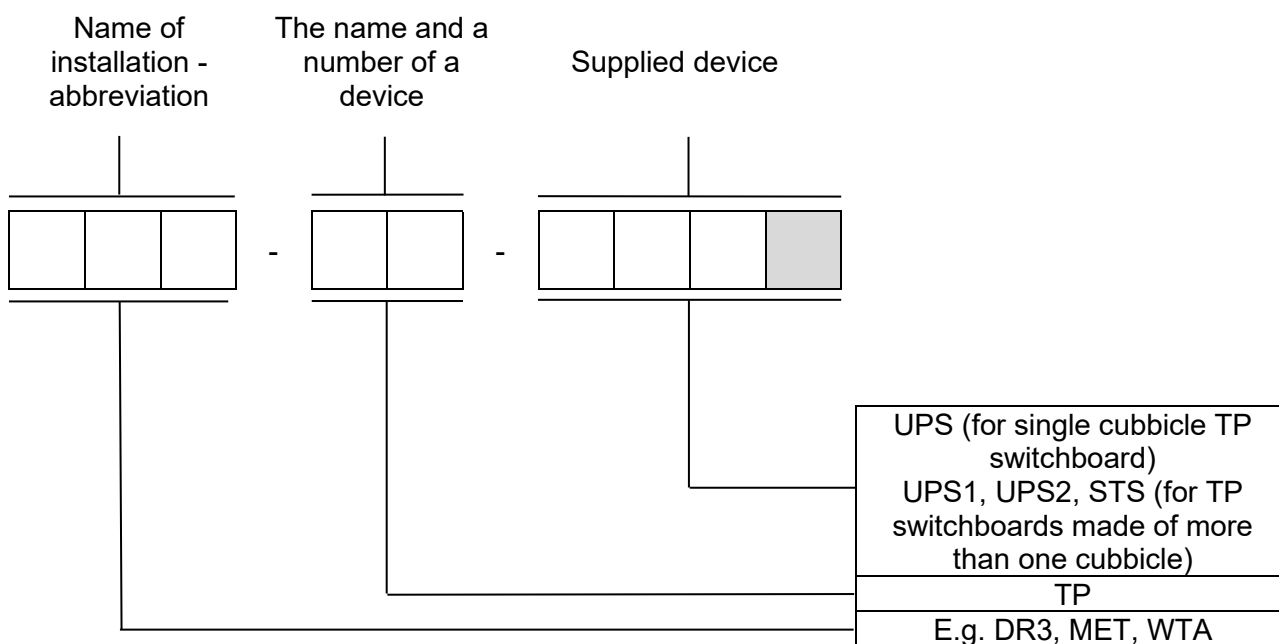
2. Accumulator batteries:



Example: KOM-BS1-TPS

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3. TP switchboards



Example: RF5-TP-UPS

4. Elements of the battery disconnection and protection system:

Element	Nomenclature	Example
Battery fuse disconnecter	NI-F-NB	DR3-F-BA1
Battery disconnecter (fireman's switch)	NI-R-NB	MET-R-BA3
Battery disconnecter's cabinet (fireman's switch)	NI-SZWP-UZ-NB	RF6-SZWP-TOA-BA1
Outside cabinet containing a substitute fireman's switch	SZWP (if one) SZWP-1, SZWP-2 etc. (if more than one)	
Substitute Fireman's switch in SZWP cabinet	NI-WP-UZ-NB	WTA-WP-DCS-BA2
Power supply selection switch cabinet for buffer power supplies	NI-PZ-NPR	VBU-PZ-PR1A

WHERE:

- NI – Name of installation;
- NB – Battery name;
- UZ – A device supplied by a guaranteed voltage circuits (np. DCS, TOA, LSK, TPS);
- NPR - Name of the rectifier of the guaranteed voltage system;.

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5. Electrical drive systems – frequency converter cabinets, power controller cabinets, soft starter cabinets.

Name of installation - abbreviation	The name and a number of a device	Supplied device
	-	
Technological name of the supplied equipment		
PC1, SM1, SS1		
Np. DR3, MET, WTA		

Example of nomenclature:

- Frequency converters, e.g. DR3-PC1-NGA 301
- Power controllers, e.g. MET-SM1-EBA 901
- Soft starter systems, e.g. WTA-SS1-ME 102

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9.5. APPENDIX 5 - LIST OF ELECTRIC MOTORS

L.p./ Item	Lokalizacja /Site	Instalacja technologiczna / Production plant	Numer technologiczny / Drive name	Typ silnika/ Motor type	Forma wykonania silnika / Motor construction type	Napięcie znam. / Nominal voltage [V]	Wznios wału / Frame size [mm]	Liczba biegunów / Number of poles	Prędkość znamionowa/ Nominal Speed	Moc znamionowa / Nominal Power [kW]	Oznaczenie Ex / Ex marking	Status silnika / Status of the motor	Prąd znamionowy / Nominal Current [A]	Krotność prądu rozruchowego / Startup current ratio	Producent / Manufacturer	Urządzenie napędzane / Load type	Miejsca zasilania / Electrical Fed from	Waga / Weight [kg]	Łożysko NDE / Bearing type NDE	Łożysko DE / Bearing type DE	Nr seryjny / Serial No.	Nr inwentarzowy / Inventory tag number	Uwagi/ Remarks

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9.6. APPENDIX 6 – TEMPLATE OF APPLICATION FOR DEVIATION FROM TECHNICAL REQUIREMENTS FOR THE ELECTRICAL BRANCH

LOCATION, date.....

APPLICATION FOR DEVIATION FROM TECHNICAL REQUIREMENTS FOR ELECTRICAL BRANCH – DESIGN AND CONSTRUCTION (WTBE).

Do: Manager of the Electrical Department (TIE)

1. APPLICANT DETAILS (full company name, contact person details):

--

2. DETAILS OF PROJECT MANAGER / INVESTMENT COORDINATOR FROM ORLEN:

--

3. NAME AND NUMBER OF INVESTMENT / MAINTENANCE PROJECT:

--

4. NAME OF THE INSTALLATION COVERED BY THE PROJECT:

--

5. WTBE CLAUSES FOR WHICH A DEVIATION IS REQUIRED:

--

6. CONTENT OF THE APPLICATION INCLUDING JUSTIFICATION:

--

7. ATTACHMENTS (Documentation, approvals with Electrical Inspector and the relevant Electrical Production Support Engineer and other Stakeholders):

--

Signature of Project Manager / Investment Coordinator	Signature of Applicant

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9.7. STANDARD'S CHANGE AND UPDATE SHEET

No.	CONTENT OF THE ENTRY, MODIFICATIONS	EDITION	DATE
1	Detailed device parameters, updated diagrams, tables, list of acceptable manufacturers. Update and adding of some standard numbers. Removal of provisions relating to the scope of the Hazardous Area Classification.	2.9	22.05.2024
1	Reorganization of numbering.	3	16.06.2026
2	Update of drawings.		
3	Addition and update of selected definitions.		
4	Revision of short-circuit current levels for MV switchgear equipment selection.		
5	Removal of provisions requiring submission of Explosion Protection Document to the Electrical Department.		
6	Addition of requirements for residual current devices (RCDs).		
7	Clarification of requirements for motor vibration velocity.		
8	Addition of LV frequency converter configuration diagram.		
9	Addition of an example view of a synoptic cassette.		
10	Clarification of requirements for lighting installation.		
11	Detailed provisions regarding heat tracing installations and lightning protection and earthing systems.		
12	Addition of requirements for protection systems in LV switchgear.		
13	Addition of requirements for the use of online insulation monitoring and insulation fault location devices.		
14	Clarification of selected provisions regarding UPS systems and battery banks.		
15	Extension of requirements for power generators.		
16	Addition of requirements regarding the content and preparation of subsequent documentation revisions.		
17	Addition of provisions defining the required content of Operation and Maintenance Manual.		
18	Update of the table of standards and regulations and the list of accepted producers/types of electrical branch devices.		
19	Addition of a requirement for an additional signal from the frequency converter cabinet to the DCS system in Appendix No. 2		
20	Update of Appendix No. 4 and addition of Appendix No. 6.		