



**ELECTRICAL –
GENERAL REQUIREMENTS
FOR NEW AND MODERNISED PRODUCTION PLANTS –
TECHNICAL ANNEXES TO CONTRACTS**

Wloclawek, September 2021



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1. INTRODUCTION


This document defines the technical standardisation and covers the general design and construction requirements for the technical scope of the electrical industry.

The subject matter of this document includes issues related to design, construction, modernisation, reconstruction, etc. of production plants and technological facilities on the premises of ANWIL SA.

The document is an internal document of ANWIL SA and the observance of its provisions is the responsibility of all employees of the Company and the third parties that provide services for the Company.

The implementation of the technical standardisation and the design guidelines contained herein should contribute, among others, to:

- increase the availability of production plants and technological objects,
- extend the cycles between overhauls,
- reduce the failure rate,
- optimise investment costs and maintenance costs.

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2. GENERAL TECHNICAL REQUIREMENTS

2.1. SCOPE

All the issues within the scope of the electrical industry that are not included in this document and are related to the subject matter of the contract are subject to Polish regulations and standards or internal regulations of PKN ORLEN S.A. In case there is a need to extend the scope, the CONTRACTOR should apply to the Technical Analysis Department for additional necessary information.

All deviations from the technical requirements contained in this documents should be agreed upon and approved in writing by the BUYER's Technical Analysis Department.

Electricity can be supplied at the following phase voltages:

- Medium voltage (MV): $U_N=10\text{kV}$, $U_N=6\text{kV}$,
- Low voltage (LV): $U_N=690\text{V}$, $U_N=400\text{V}$.

The above-mentioned options should be selected according to the results of the technical and economic analysis.

If it is necessary to use other supply voltage values, the CLIENT shall be informed of this fact so that specific conditions can be agreed upon.

2.2. CODES AND REGULATION

The design, construction and fitting-out of the electrical installations shall meet the requirements of the Polish law, standards and regulations and this document, including:

- **PN** (National Polish Standards).
- **CENELEC** (European Committee for Electrotechnical Standardisation).
- **IEC** (International Electrotechnical Commission).

The latest, most up-to-date edition of the standards or regulations shall be used.

2.3. DEFINITIONS

The following definitions shall apply in this technical specification:

- **CLIENT** - ANWIL SA or a company acting on behalf of ANWIL SA.
- **CONTRACTOR** - A third party that performs the design and/or procurement and/or construction.

Whenever the word “shall” or “must” is used, its meaning is to be understood as mandatory. Whenever the word “recommended” is used, its meaning is to be understood as a recommendation.

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

3. GENERAL REQUIRMENTS

The production plant shall be adapted for self-start. if it is impossible to perform a self-start of the production plant, the offer must obligatorily provide an appropriate explanation.

The existing infrastructure of the electrical power system shall be taken into consideration. All Polish legislation, laws/acts, regulations and procedures/practices shall be observed during the performance of the contract, starting from the building permit, to detailed design & engineering, to erection/assembly, to testing & acceptance, even if they are not mentioned in this specification.

Before the submission of the offer, the CONTRACTOR is obliged to familiarise themselves with the existing electrical power system and clarify any doubts.

It is mandatory to perform the subject matter of the Contract for the electrical industry in accordance with the European Parliament Directives (as amended), in particular:

- Directive 94/9/EC on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres (ATEX).
- Directive 1999/92/EC on minimum requirements for the safety and health protection concerned workplaces exposed potentially at risk from explosive atmospheres (ATEX-USERS).
- Low Voltage Directive 2006/95/EC on the harmonisation of the laws of the Member States legislation relating to electrical equipment designed for use in specific voltage limits (LVD).
- Directive 2004/108/EC on the approximation of laws of the Member States relating to electromagnetic compatibility (EMC).

3.1. DESIGN REQUIREMENTS

In performing design work, the following rules shall be observed:

- Maintenance safety,
- Supply of high-quality electricity with high reliability of power supply,
- Energy efficiency,
- Maintenance-free operation.

Design temperatures:

- Maximum design temperature: +40°C,
- Minimum design temperature: -25°C,
- Minimum temperature in the winter period: -29°C.

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Atmospheric conditions of the designed devices, machines, apparatuses, etc., such as temperature and humidity, shall be taken into consideration in accordance with the manuals issued by manufacturers or their authorised representatives.

3.2. GENERAL SAFETY CRITERIA

No electrical devices, equipment, apparatus, etc. shall contain any PCB.

If cables, conduits or piping pass through firebreaks, the openings shall be sealed with an approved sealant with the required rating.

Where it is necessary, non-insulating shunts shall be installed to maintain electrical continuity and avoid static charge build-up, such as shunts connecting pneumatic pipe conveyors.

All moving equipment shall be provided with lockable switches.

Where frequent shutdown is required, the switches shall be located in close proximity to the equipment controls.

Where necessary, flame-retardant, non-fire propagating electrical cables, etc. shall be installed.

Storage tanks for flammable liquids or gases shall be grounded at least in two locations.

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3.2.1. NOMINAL PARAMETERS OF POWER SUPPLY SYSTEM FOR PRODUCTION FACILITIES

Table 1. Medium voltage network (MV).

1. Rated voltage:	I	$U_N=10\ 000V, \pm 5\%$
	II	$U_N=6\ 000V, \pm 5\%$
2. Rated frequency:	$f=50Hz, \pm 2\%$	
3. Short circuit current:		
▪ To select equipment and switchboards:	I	Shall be calculated according to the technical and economic assumptions.
▪ To start motors:		Shall be calculated according to the technical and economic assumptions.
▪ To select equipment and switchboards:	II	$I_k''=31.5kA$
▪ To start motors:		$I_k''=15kA$
4. MV network system	IT system	
	I	Isolated neutral point
	II	Isolated neutral point

Table 2. Low voltage network (LV).

1. Rated voltage:	I	$U_N=690V, \pm 5\%$
	II	$U_N=400V, \pm 5\%$
2. Rated frequency:	$f=50\text{ Hz}, \pm 2\%$	
3. Short circuit current:		
▪ To select switchboard equipment:	I	Shall be calculated according to the technical and economic assumptions.
▪ To start motors:		Shall be calculated according to the technical and economic assumptions.
▪ To select switchboard equipment:	II	$I_k''=80kA$
▪ To start motors:		$I_k''=28kA$
4. LV network system	TN-S, IT	

Table 3. Low voltage uninterruptible network (UPS systems) for DCS/ESD system etc.

1. Rated voltage:	$U_N=230/400\text{V}$ <ul style="list-style-type: none"> ▪ $\pm 1\%$ statically, ▪ $\pm 5\%$ dynamically.
2. Rated frequency:	$f=50\text{Hz},$ <ul style="list-style-type: none"> ▪ $\pm 0.1\%$ for battery bank operation, ▪ $\pm 6\%$ for by-pass operation
3. Network system	TN-S
Note: If it is necessary to use 230/400V three-phase voltage, please notify the Buyer of it.	


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Table 4. Guaranteed direct voltage network to supply the protection, control and signalling systems in LV/MV switchboards

1. Rated voltage:	$U_N=220\text{VDC}$, +10/-15%	Shall be calculated according to the technical and economic assumptions.
2. Network system:	IT	Shall be calculated according to the technical and economic assumptions.

Table 5. Guaranteed direct voltage network to supply the emergency lighting system

1. Rated voltage:	$U_N=230\text{VAC}$, $\pm 5\%$ $U_N=220\text{VDC}$, +10/-15%
2. Network system:	TN-S

Additionally:

- Calculations and/or measurements of the distortions caused by current and voltage harmonics shall be performed (the measurement point shall be clearly agreed upon with the CLIENT). If the maximum permissible value has been reached for the harmonics, filters shall be installed to reduce harmonics distortion.
- The following active power factors shall be preserved:
 - The power factor for the MV network power supply shall be maintained at the level of $\text{tg}\varphi=0.4$ ($\cos\varphi=0.93$).
 - The power factor for the LV network power supply shall be maintained at the level of $\text{tg}\varphi=0.2$ ($\cos\varphi=0.98$).
- The power factor shall be improved by means of capacitor banks that automatically maintain the required power factor.
- The Contractor shall fulfil the requirements for the metering systems used to measure: electricity, the allowable power factor, the allowable level of higher harmonics, etc.

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3.2.2. SCOPE OF DELIVERIES OF ELECTRICAL DEVICES

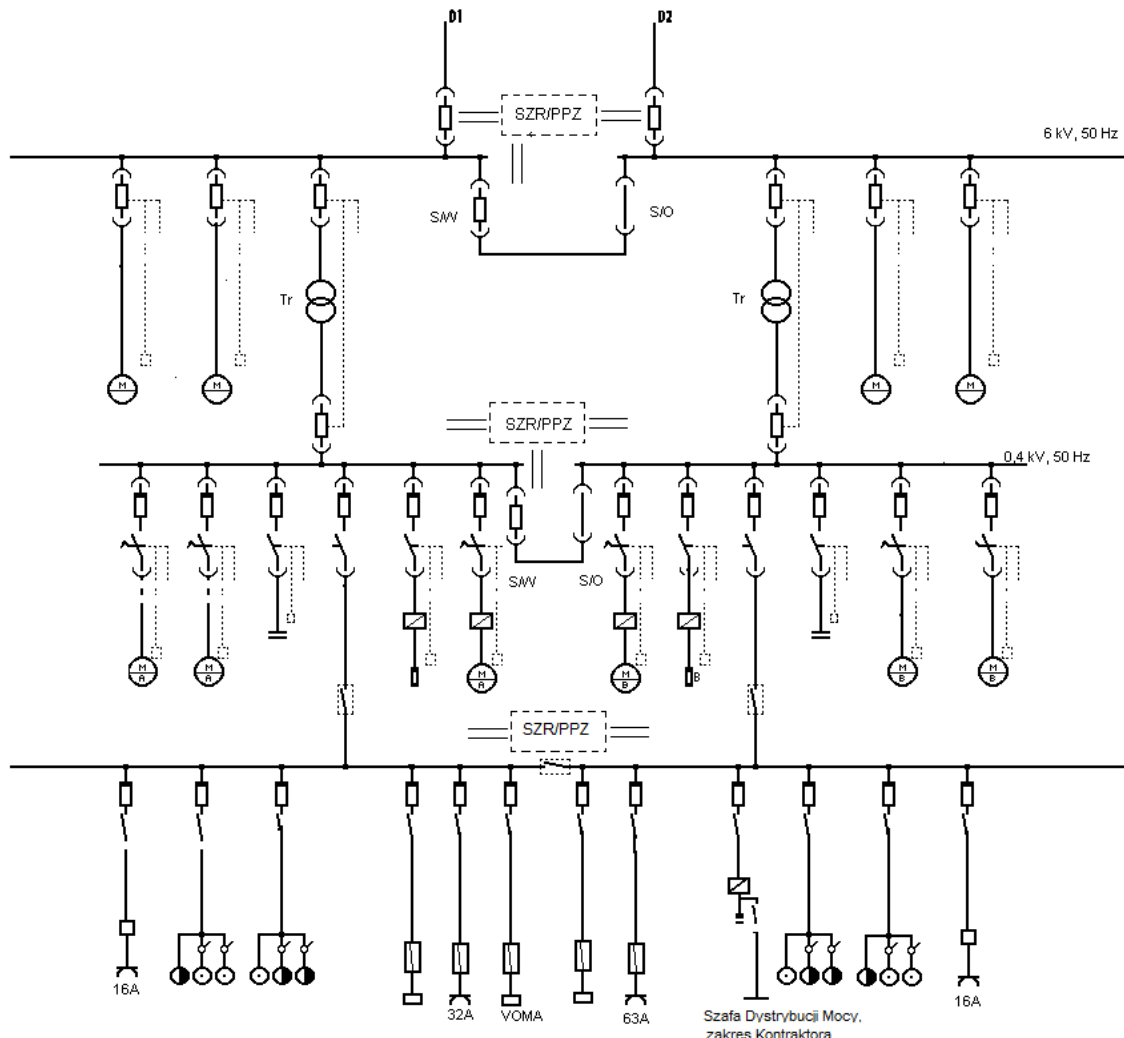


Fig. 1. One-line diagram

1. CONTRACTOR is responsible for:
 - Detailed design & engineering. Delivery of the agreed scope of documentation,
 - Delivery of the machines, equipment, etc. in the agreed scope,
 - Definition of the assumptions for testing, commissioning and start-up of the entire subject matter of the agreement. The assumptions for testing, commissioning and start-up of the entire subject matter of the agreement defined by the CONTRACTOR shall require the approval of ANWIL SA.
 - Participation in testing and start-up of the entire subject matter of the agreement, which shall be confirmed by an appropriate acceptance certificate issued by ANWIL SA.
 - The Contractor's offer must provide a list of training courses that are necessary for the proper operation and maintenance of the subject matter of the agreement. The list of the training courses requires the approval of ANWIL SA. The training courses mentioned above

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are within the scope set for the Contractor. The completion of the course shall be confirmed by appropriate certificates.

Each delivery of devices and equipment shall be properly protected against expected atmospheric exposure and conditions that may occur in transport and locations of the delivery and temporary storage.

2. The CONTRACTOR shall deliver the following technical documentation for:

- Power and control cables, etc.
- Electrical motors, relevant junction boxes and motor control stations,
- Lighting systems,
- Lightning and grounding systems,
- Het tracing systems,
- Intercom telecommunication system, including the equipment being replaced,
- Auxiliary materials and systems,
- Switchboards/control gear/ electrical power substations, electrical devices, electrical motors, transformers and frequency converters,
- UPS systems,
- Capacitor banks,
- Battery banks & buffer power supply units,
- Any other devices, equipment, materials, etc. within the Contractor's scope.

The Contractor shall deliver a list of devices, equipment and materials for the process modules (e.g. a compressor unit). A detailed list of equipment and materials shall be handed over at the design stage.

3.2.3. POTENTIALLY EXPLOSIVE AREA CLASSIFICATION

1. Prior to the commencement of the design work for the electrical industry, the Contractor shall examine the explosion hazards and indicate potentially explosive areas where the subject matter of the agreement is to be performed.
2. To secure safety and functioning of the process plant and eliminate explosion hazards, the facilities shall be individually examined, taking into account all the factors that may cause an explosive mixture or an ignition source.
3. A potentially explosive area classification documentation shall be produced in accordance with the regulation on the classification of potentially explosive areas, the rules for drawing up the Explosion Protection Document (DZPW) and the assessment of explosion risk in ANWIL SA by the CEO of ANWIL SA.

The hazardous area classification documentation shall be accepted by the ANWIL SA Commission for the Classification of Facilities Exposed to Explosion Hazard and approved in accordance with the above-mentioned regulation.

3.2.4. ELECTRICAL EXPLOSION-PROOF DEVICES

Devices and equipment shall comply with the requirements set by Polish Standards and CENELEC Standards. IEC Standards will be used if appropriate CENELEC standards are not available. All electrical devices shall be marked with a CE mark and delivered with an EC Declaration of Conformity and an EC-type Examination Certificate.

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3.2.4.1. DESIGN OF THE ELECTRICAL EXPLOSION-PROOF DEVICES

Electrical equipment designed for operation in potentially explosive areas shall meet the requirements specified in the EC type examination certificates issued by notification bodies, EC declarations of conformity issued by manufacturers or their authorised representatives and in the standards below, taking into account the detailed requirements applicable in ANWIL SA:

PN-EN 60079-0	Explosive atmospheres. General requirements.
PN-EN 60079-1	Explosive atmospheres. Equipment protection by flameproof enclosures 'd'.
PN-EN 60079-2	Explosive atmospheres. Equipment protection by pressurised enclosure 'p'.
PN-EN 60079-5	Explosive atmospheres. Equipment protection by powder filling 'q'.
PN-EN 60079-6	Explosive atmospheres. Equipment protection by oil immersion 'o'.
PN-EN 60079-7	Explosive atmospheres. Equipment protection by increased safety 'e'.
PN-EN 60079-11	Explosive atmospheres. Equipment protection by intrinsic safety 'i'.
PN-EN 60079-17	Explosive atmospheres. Electrical installations inspections and maintenance.
PN-EN 60079-18	Explosive atmospheres. Equipment protection by encapsulation 'm'.
PN-EN 60079-25	Explosive atmospheres. Intrinsically safe electrical systems 'i'.
PN-EN 60079-30	Explosive atmospheres. Electrical resistance trace heating.
PN-EN 60079-31	Explosive atmospheres. Equipment dust ignition protection by enclosure 't'.


ANWIL SA does not allow the use of explosion-proof equipment category 3.

3.2.4.2. SELECTION OF ELECTRICAL EXPLOSION-PROOF DEVICES AND SYSTEMS

The electrical equipment designed for operation in potentially explosive areas shall be selected in accordance with the requirements specified in EC-type examination issued by notification bodies, EC declarations of conformity, manuals issued by manufacturers or their authorised representatives and in the standards below, taking into account the detailed requirements applicable in ANWIL SA:

PN-EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection.
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It is not recommended to select electrical equipment designed in accordance with the following standard or their equivalents:

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PN-EN 60079-15 IEC 60079-15	Explosive atmospheres. Equipment protection by type of protection 'n'.
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3.2.4.3. INSTALLATION OF ELECTRICAL EXPLOSION-PROOF DEVICES AND SYSTEMS

Installations and supervision of installation of electrical explosion-protected equipment and systems shall be carried out by persons with necessary expertise required by manufacturers, the requirements of explosion-proof design documentation, explosion-proof design certificates, the relevant Polish standards and regulations.

The expertise of the persons taking part in the installation and supervision of the installation of electrical explosion-proof devices and systems shall be confirmed by relevant certificates.

3.2.4.4. PERMIT FOR THE OPERATION OF ELECTRICAL EXPLOSION-PROOF DEVICES

To obtain admission to operate electrical devices, follow the instructions given below:

1. Responsibilities of the CONTRACTOR:

The contractor is obliged, after the assembly is completed, within a minimum of two weeks from the date of planned final acceptance of the investment, submit to the Project Implementation Manager / Employee of the SUR Office Ex documentation:

- for an application (cover letter) for verification and issuing opinions on the admission of electric Ex installed equipment to be used as part of the investment / renovation project,
- for the current classification of potentially explosive zones for the area covered by the investment / renovation project,
- protocols from measurements of the effectiveness of defeat protection,
- protocols for insulation resistance measurements,
- for protocols from lightning protection measurements,
- for specification of electric Ex devices made in nature according to the pattern in force in ANWIL S.A.,
- for the list of certificates according to the template in force in ANWIL S.A. for devices included in the specification made from facility,
- the set of required EC certificates and EU declaration of conformity for electrical Ex devices,
- for devices in Ex p pressure casing according to PN-EN 60079-2: 2015-02 standard, a protocol is required for functional tests of correct operation of interlocking devices Ex p device during the purposeful trial of unsealing of this casing. Participation of a specialist in the Technical Analysis Department during functional tests of the blow-out system is,
- possibly other necessary documentation (eg technical documentation) in Polish.

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The condition for obtaining approval for commissioning and operation of the Ex equipment is a positive opinion of the Technical Analysis Department and approval by the Automation and Electricity Office issued in writing within 2 weeks after verification of the Ex Documentation provided with the actual condition of the equipment installed on the facility.

NOTE:

Delivery of complete certificates with necessary additions or supplements in the English or German language version, which state explosion-proof performance of supplied electrical devices, equipment, etc. is a condition for their installation on the facility.

2. Responsibilities of ANWIL SA INVESTOR:


Project Implementation Manager / SUR Office Worker:

- verifies the completeness of the Ex Equipment Documentation,
- provides Device Documentation Ex to the Technical Analysis Department,
- provides the Contractor with any comments and conclusions arising from reviewing the Ex Device Documentation,
- participates in technical acceptance.

Technical Analysis Department of ANWIL SA:

- The Technical Analysis Department verifies the correctness of the information contained in Ex Equipment Appliances - are they consistent with the actual state of the site and give an appropriate,
- In the case of a positive opinion of the Technical Analysis Department and approval by the Automation and Electricity Office, the Ex Equipment Documentation forwarded to the Project Implementation Manager / SUR Office Worker, constitutes a formal admission of the Ex electrical equipment for commissioning and operation,
- **In the case of a negative opinion and lack of permission from the Automation Office and Electricity, commissioning, functional tests are not allowed and operation of electrical Ex devices.** Technical Analysis Department forwards a negative opinion to the Project Implementation Manager / SUR Office Worker. After removing the remarks / faults, the Technical Analysis Department again issues an opinion on the admission of electrical Ex devices for commissioning and operation, and then goes to the Automation and Electricity Department for approval.
- Participates in technical acceptance.

3.2.4.5. ELECTRICAL INSTALLATIONS IN POTENTIALLY EXPLOSIVE AREAS

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1. Electrical installations designed for operation in potentially explosive areas shall be produced in accordance with the requirements specified in explosion-proof design certificates or test certificates, taking into account the detailed requirements applicable in ANWIL SA and the standards below:

PN-EN 60079-14	Explosive atmospheres – Part 14: Electrical installations design, selection and erection.
PN-IEC 60364 PN-HD 60364	Electrical installations of buildings. Low voltage electrical installations.
PN-EN 61936-1	Power installations exceeding 1 kV a.c. Part 1 – Common rules
PN-EN 50522	Earthing of power installations exceeding 1 kV a.c.

2. The electrical installations designed as a TN-S system that power loads in potentially explosive areas shall be provided with apparatus to perform the operation of disconnecting phase conductors together with a neutral conductor.

3.2.5. FIRE PROTECTION

Electrical installations shall meet, in particular, the requirements specified below:

Dz.U. 2017 pos. 736	Fire Protection Law
Dz.U. 2010 no. 109 pos. 719	Regulation of the Minister of Internal Affairs and Administration on fire protection for buildings and other building projects and sites.
Dz.U. 2015 pos. 1422	Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location
PN-HD 60364-4-42	Low voltage electrical installations. Part 4-32: Protection for safety. Protection against thermal effects.
PN-HD 60364-5-56	Low-voltage electrical installations -- Part 5-56: Selection and erection of electrical equipment - Safety services

Cables and conductors with self-extinguishing or fireproof sheaths that are resistant to chemical exposures (hydrocarbons) shall be used.

Separate fire protection systems with manual fire alarm buttons shall be installed on the plant. The systems shall be connected to the appropriate fire alarm centre, whose location will be indicated by the CLIENT.

Fire-fighting monitoring system shall be used.

The currently applicable regulations of the European Union shall be applied after receiving an acceptance from the CLIENT in case economic reasons suggest solutions other than those indicated.

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3.2.6. ELECTRICAL SHOCK PROTECTION

The electric shock protection for the MV installation includes an automatic shutdown and an earthing system.

In the low voltage installations, the electric shock protection from indirect touch should be accomplished by an automatic shutdown of power supply along with the application of additional main and local equipotential bonding.

The electrical installations shall meet, in particular, the following requirements:

PN-HD 60364-4-41	Low voltage electrical installations. Part 4-41: Protection for safety. Protection against electric shock.
PN-HD 60364-4-43	Low voltage electrical installations. Part 4-43: Protection for safety - Protection against overcurrent.
PN-HD 60364-5-54	Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements and protective conductors
PN-HD 60364-7-706	Low voltage electrical installations. Part 7-706: Requirements for special installations or locations - Conducting locations with restricted movement

In final circuits that power:

- socket outlets,
- heat tracing circuits,

additional protection shall be used by means of residual current-operated circuit-breakers with a rated differential activation current of no more than 30mA.

3.2.7. OVERVOLTAGE PROTECTION

In the MV installations, one shall take into account, in particular, the possibility of their temporary operation in a system without grounding through resistance.

The electrical installations shall meet, in particular, the following requirements:

PN-HD 60364-4-442	Low voltage electrical installations. Part 4-442 Protection for safety - Protection of low-voltage installations against temporary overvoltages due to earth faults in the high-voltage system and due to faults in the low voltage system
PN-HD 60364-4-443	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances. Protection against transient overvoltages of atmospheric origin or due to switching
PN-HD 60364-4-444	Low-voltage electrical installations - Part 4-444: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances

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The electrical installation overvoltage protection should be coordinated with the protection of other installations that require protection, e.g. guaranteed voltage, telephone, technical and aerial installations, etc.

The overvoltage protection by means of surge arresters should cover individual sections of the bus bars in the medium and low voltage switchboards. Loads are not usually equipped with additional surge arresting devices unless the seller explicitly specifies so.

Surge arresters should be switched on through fuses. The fuses should switch off the damaged surge arresters without disturbing the continuous power supply of the electrical loads.


A surge arrester monitoring system should be used. The devices for monitoring of surge arresters should work with the NRB system.

3.2.8. ELECTROSTATIC PROTECTION

Electrostatic protection shall meet, in particular, the following requirements:

PN-EN 61340	Electrostatics.
CLC/TR 50404	Electrostatics. Code of practice for the avoidance of hazards due to static electricity.
PN-EN 50272	Safety requirements for secondary batteries and battery installations.

Flexible ground connections with electronic control devices shall be used on the loading and unloading stations used for lorries, trailers, rail cars, etc.

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4. DETAILED REQUIREMENTS

4.1. CABLE LINES

1. Cables and conductors shall meet the requirements specified in the regulations below:

PN-EN 61936	Power installations exceeding 1 kV a.c.
PN-EN 50522	Earthing of power installations exceeding 1 kV a.c.
PN-EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection.
PN-IEC 60332	Tests on electric and optical fibre cables under fire conditions.
IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1kV (Um=1.2kV) up to 30kV (Um=36kV).
PN-IEC 60092-353	Electrical installations in ships. Power cables for rated voltages 1 kV and 3 kV.
DIN VDE 0278-623 DIN VDE 0278-623/A1	Power cable accessories with rated voltages U up to 3 kV.
IEC 60986	Short-circuit temperature limits of electric cables with rated voltages from 6kV (Um=7.2kV) up to 30kV (Um=36kV).
N SEP-E-004	Power and signalling cable lines. Design and construction.
IEC 60287-3-1	Electric cables – Calculation of the current rating – Part 3-1: Sections on operating conditions – Reference operating conditions and selection of cable type.
PN-EN 60332	Tests on electric and optical fibre cables under fire conditions.

2. All power, control and signalling cables placed on the production plant and in the electrical power substation building shall have an outer flame-retardant sheath and shall be resistant to the environmental conditions present at the location.
3. The cables to be laid for the devices installed outside potentially explosive areas shall not run through those areas.
4. The power supply cables for electric motors that drive redundant process machines shall be powered from different switchboard sections.
5. The cables in potentially explosive areas shall be laid:
 - Underground in concrete cable ducts fully filled with sand,
 - Above ground on a cable racks, cable trays or ladders.
6. Cable trays or cable ladders shall be protected against external factors, such as atmospheric precipitation, sunlight and unintentional mechanical or thermal damage, by using appropriate protective covers.
7. Cable tray or ladder components shall be:

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- Designed with at least 30% spare space,
 - Made of hot deep galvanised steel sheets (as per DIN 50976; zinc coating thickness should be at least 50 µm).
 - In the entire Fertilisers area, the cable trays and ladders shall be made of stainless materials, such as aluminium or stainless steel,
 - Equipped with full cover protection against sunlight,
 - The side walls and the bottom of the cable trays must be perforated and the perforations shall cover at least 30% of the area
 - Mounted in a way that ensures the durability of the applied corrosion protection.
 - Automation and telecommunication cables shall be run separately from power cables,
 - Emergency lighting circuit wiring shall be installed separately from the primary lighting wiring,
 - AC wiring must run separately from DC wiring,
 - Properly protected against corrosion during the insertion of the wiring and cables into their cable trays and/or ladders.
8. While inserting cables and conductors into cable trays and/or ladders, such a method shall be applied that ensures that the effectiveness of the applied corrosion protection is maintained.
 9. All the connections between cable trays and ladders shall have electrical continuity. All the trays, ladders and support structures for cable routes shall be connected to the earthing network.
 10. The power cables for electric motors to be laid in potentially explosive areas shall have a current carrying capacity of no less than 125% of the rated motor current at a maximum voltage drop of 5%.
 11. Guaranteed voltage system cables, such as for emergency installations, shall be laid in separate, marked routes protected against expected mechanical, thermal and chemical risks.
 12. Power cables running from the frequency converter to the motor shall be fully shielded and meet the requirements of the electromagnetic compatibility (EMC) of the converter-motor system. In case sinus filters are used in the output, it is not necessary to use shielded cables provided such a solution is permitted by the manufacturer of the frequency converter.
 13. Sleeve pipes for the installation shall be made of galvanised steel. Zinc coating shall be put both inside and outside the pipe using the hot dipping method. For the entire Fertilisers area, sleeve pipes shall be made of stainless materials, such as aluminium or stainless steel.
 14. All the cables passing through walls shall be run in permanently sealed cable ducts. The cable ducts on the plant used to route cables from underground to an intermediate junction box shall be sealed with a sealant with the properties that are appropriate to the expected mechanical, chemical and thermal risks.
 15. The cables passing through roads and squares that are at risk of mechanical damage shall be protected with cable ducts approved by the Client.

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16. The cables running underground or above ground to a particular:
- LV motor shall be terminated in separate terminal boxes. The connections between the intermediate terminal boxes and the motor terminal boxes shall use appropriate flexible cables,
 - MV motor should be terminated in the main junction box of the motor.
17. The currently applicable regulations of the European Union shall be applied after obtaining the Client's acceptance if economic reasons suggest solutions other than those specified.

4.1.1. SELECTION OF ELECTRICAL CABLES, ELECTRICAL CONDUCTORS AND ACCESSORIES

1. Cables and conductors shall meet the requirements specified in the regulations below:

IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1kV to 30kV.
PN-IEC 60092-353	Electrical installations in ships. Power cables for rated voltages 1 kV and 3 kV.
DIN VDE 0278-623 DIN VDE 0278-623/A1	Power cable accessories for power cables with rated voltages U up to 30kV.
IEC 60986	Short-circuit temperature limits of electric cables with rated Voltages from 6kV (Um=7.2kV) up to 30 kV (Um=36kV).
N SEP-E-004	Power and signalling cable lines. Design and construction.
IEC 60287-3-1	Electric cables – Calculation of the current rating – Part 3-1: Sections on operating conditions – Reference operating conditions and selection of cable type.
PN-HD 60364-5-52	Low-voltage electrical installations -- Part 5-52: Selection and erection of electrical equipment - Wiring systems
PN-EN 60909-0	Short-circuit currents in three-phase a.c. systems - Part 0: Calculation of currents
PN-EN 60865-1	Short-circuit currents - Calculation of effects - Part 1: Definitions and calculation methods


2. Cable routes shall be designed for the following environmental conditions:
- Atmosphere: Aggressive, chemical industrial dust
 - Min. ambient temp.: -29°C,
 - Max. Ambient temp.: +40°C,
 - Min. relative humidity: 70%,
 - Max. relative humidity: 90%,
 - Altitude above the sea level: 57m
 - Average wind speed: 22m/s (Zone 1 as per PN-EN 1991-1-4),
3. Cables shall be designed for the following environmental conditions:
- Air temperature: +25°C,

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- Ground temperature: +20°C,
 - Soil resistivity: 1.0m*K/W,
 - Placement depth <1kV: 0.7m,
 - Placement depth >1kV: 0.8m,
4. The electrical installations supplying power to MV loads on production plants shall use single-core or three-core power cables with:
- Copper cores,
 - Cross linked polyethylene insulation,
 - Radial distribution of electric field,
 - A joint return copper core,
 - A longitudinal and radial anti-moisture seal,
 - An outer sheath made of polyethylene or PVC that is flame-retardant and resistant to UV radiation,
 - An outer sheath that is resistant to corrosion caused by chemical exposure (e.g. hydrocarbons) present in the cable environment.
5. The electrical installations supplying power to LV loads for production plants shall use three, four or five core power cables with:
- Copper cores,
 - Cross linked polyethylene insulation,
 - Identical cross-section of phase and protective cores,
 - An outer sheath made of polyethylene or PVC that is flame-retardant and resistant to UV radiation,
 - An outer sheath that is resistant to corrosion caused by chemical exposure (e.g. hydrocarbons) present in the cable environment.
6. When using 230 VAC voltage or 220 VDC voltage (e.g. connections with local control stations), the electrical control, signalling and measurement installations in production plants shall use multi-core signalling cables with:
- Copper cores,
 - Cross linked polyethylene insulation,
 - Identical cross-sections of signal and protective cores,
 - A joint shield made of copper wires,
 - An outer sheath made of polyethylene or PVC that is flame-retardant and resistant to UV radiation,
 - An outer sheath that is resistant to corrosion caused by chemical exposure (e.g. hydrocarbons) present in the cable environment.
7. The control, signalling and measurement installations using 24 VDC voltage (e.g. connections with the DCS, NRB) installed in production plants shall use multi-pair telecommunication cables with:
- Copper cores,
 - Cross linked polyethylene insulation,
 - Individual cable core pairs stranded and protected with individual shields,
 - A joint shield made of copper wires,
 - An outer sheath made of polyethylene or PVC that is flame retardant and resistant to UV radiation,

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- An outer sheath that is resistant to corrosion caused by chemical exposure (e.g. hydrocarbons) present in the cable environment.
8. The electrical installations that supply power to LV and MV loads through frequency converters on production plants shall use single-core or multi-core power cables with:
- Class 5 copper cores,
 - Cross linked polyethylene insulation,
 - A joint shield made of copper wires that meets the requirements of EMC,
 - An outer sheath made of polyethylene or PVC that is flame retardant and resistant to UV radiation,
 - An outer sheath that is resistant to corrosion caused by chemical exposure (e.g. hydrocarbons) present in the cable environment.
 - A symmetrical cable design (3+3PE).
9. For cables with a single conductor cross section equal to 185mm² or more, such cable routes shall be single-core (e.g.: 5 x YnKXS 1x185mm², 0.6/1kV).
10. The selection of cables should consider the rated current of the powered loads that takes into account the installation conditions, short circuit criteria (initial, symmetrical short-circuit current - I_k", short circuit current duration) and following maximum voltage drops:
- 5% at a rated load, 15% at electrical motor start-up,
 - 5% for power cable supply units,
 - 3% for electrical lighting cable supply units,
 - 2% for branch circuits.
11. Power supply system (cables, cable trays and supports) for emergence installations (which are used in firefighting activities) running through fire hazard areas shall ensure at least 60-minute fire resistance.
12. Cables laid, entirely or in part, in potentially explosive areas shall have the following minimum core cross section areas:
- Power cables: 2.5mm²,
 - Control/signalling cables: 1.5mm²,
 - Telecommunication cables 1.0mm².
- The usage of cables with cores of a smaller cross-section than those indicated above requires a written consent of the Client.
13. Cables shall have improved insulation endurance, i.e.:
- Medium voltage power cables with U_n=10kV: U₀/U(U_m)=12/20(24)kV,
 - Medium voltage power cables with U_n=6kV: U₀/U(U_m)=6/10(12)kV,
 - Low voltage and control cables with U_n=400/230V: U₀/U=0.6/1kV,
 - Cables in DC circuits with U_n=220V: U₀/U=0.6/1kV,
 - Industrial rubber cables with U_n=400/230V: U₀/U=450/750V,
 - Single-core for grounding connections: U₀/U=450/750V,

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14. Signalling and telecommunication cables shall have an allowance of core pairs of at least 10%. It is recommended that the maximum number of cores in any one cable does not exceed 24 pieces.
15. Cable accessories for medium voltage lines shall be designed in the cold-shrink technology.
16. The number of cores in the control cables for an MV-remote control station or LV-remote control station shall be standardised.

4.1.2. CABLE LINE MARKING

At both ends and every 10 meters along the cable route, all cables shall be marked using firmly secured corrosion-resistant plates that contain the following information:

- Technological mark of the cable corresponding to the mark on the cable list in the technical documentation.
- Type of cable, number and size of cores.
- The year the cable was laid,
- Technological mark of the powered device, fixed at the beginning of the cable in the switchboard.
- Switchboard symbol and number of the supply bay, fixed at the end of the cable, next to the powered device.

4.2. ELECTRIC DRIVE SYSTEMS

Electric drive systems for machines shall meet the requirements specified in the following regulation:

PN-ISO 10816	Mechanical vibration.
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The vibrations of the drive systems for machines being accepted for operation shall not go beyond Zone A, as defined in the above-mentioned standard.


4.2.1. ELECTRIC MOTORS

1. Electric motors shall meet the requirements specified in the following regulation:

PN-EN 60034	Rotating electrical machines.
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2. The electric motors intended for operation in potentially explosive areas shall additionally meet the requirements indicated in the following standards:

PN-EN 60079-0	Explosive atmospheres. General requirements.
PN-EN 60079-1	Explosive atmospheres. Equipment protection by flameproof enclosures 'd'.

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PN-EN 60079-2	Explosive atmospheres. Equipment protection by pressurised enclosure 'p'.
PN-EN 60079-7	Explosive atmospheres. Equipment protection by increased safety 'e'.
PN-EN 60079-11	Explosive atmospheres. Equipment protection by intrinsic safety 'i'.
PN-EN 60079-25	Explosive atmospheres. Intrinsically safe electrical systems 'i'.
PN-EN 60079-31	Explosive atmospheres. Equipment dust ignition protection by enclosure 't'.

3. The following electric motors shall be used:

- Energy-efficient motors with a minimum efficiency class of IE3 (as per PN-EN 60034-10-1),
- Squirrel-cage directly started three-phase induction motors with an insulated winding of at least F temperature insulation class. The insulation for medium voltage motors shall be designed in VPI technology (Vacuum Protected Insulation).
- Operating with a maximum 80% load on the motor shaft in relation to the minimum required load due to the process conditions,
- Motors shall provide at least IP54 level of protection and be cooled with an internal fan. If this solution is not available for larger motors for economical or technical reasons, a closed water-air circuit cooled with integral coolers shall be used.
- Adjusted to external environmental conditions and direct sunlight without any additional protective measures,
- In potentially explosive areas, explosion-proof and fire-proof motors with increased safety shall be used. Otherwise, it is recommended to use ventilated motors. The motors should be equipped with appropriate temperature sensors, vibrations sensors, etc.
- The maximum noise level shall be 85 dB (to be confirmed) according to PN-EN ISO 1680 Acoustics. The method of measurement of the noise emitted by rotating electrical machines, measured at a 1-meter distance.
- The main terminal box shall be located on top of the motor case and enable rotations in 90-degree steps or in a place agreed with the Client. The terminal box should be made of thick cast iron, cast steel or steel sheets that are at least 3 mm thick.
- With separate auxiliary terminal boxes to measure the temperature of bearings, windings and vibrations (as necessary). Each terminal box should be made of cast iron, cast steel or steel sheets at least 3 mm thick.
- Equipped with roller bearings, except for 2-pole motors with a rated power equal to or higher than 500 kW which shall be equipped with slide bearings.

4. 6kV and 10kV rated voltage motors shall be equipped with:

- Temperature sensors for measuring the temperature of bearings, windings and anti-condensation heaters.
- Terminals of sensors for the measurement of the temperature of windings, bearings or vibration parameters shall be installed in separate terminal boxes.
- Double resistance sensors of type Pt 100 shall be used (one spare sensor).
- One double sensor to measure the temperature of the front bearing mounting and one double sensor to measure the temperature of the back bearing mounting. Bearing temperature sensors shall work with the process control system (DCS).

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- The terminal clamps of the bearing temperature sensors shall be routed into a separate terminal box. The explosion-proof design of the temperature sensors and sensor terminal box shall meet the Client's requirements for the automation industry.
 - One double sensor to measure the phase of each winding shall be used (sensors to measure stator winding temperature shall stand a voltage test with the voltage of $2 \times (2 \times U_n + 1 \text{ kV})$). The terminal clamps of the winding temperature sensors shall be routed into a separate terminal box. The winding temperature sensors shall work with the motor protection system.
 - The motor winding temperature measurement system consisting of temperature sensors, connecting circuits and auxiliary terminal boxes shall be designed in accordance with requirements for "increased safety" or "fireproof" design.
 - The terminals for anti-condensation heaters shall be routed into a separate terminal box.
 - Vibration sensors shall meet the Client's requirements for the mechanical industry. Vibration sensor terminals shall be routed into a separate terminal box.
5. Low voltage motors with a rated power higher than 110 kW shall be equipped with:
- One double (one spare) sensor to measure the temperature of the front bearing mounting and one double sensor (one spare) to measure the temperature of the back bearing mounting. The bearing temperature sensor terminals shall be routed into a separate terminal box. The bearing temperature sensors shall work with the process control system (DCS).
 - The explosion-proof design of the temperature sensors and the temperature sensor terminal box shall meet the ANWIL SA requirements for the instrumentation industry.
 - The vibration sensor terminals shall be routed into a separate terminal box.
 - The vibration sensors shall be designed in accordance with the Client's requirements set out for the mechanical industry.
6. Electric motors shall be adapted to operation in 5-year cycles between overhauls.


The manufacturer shall define the required checks for the motor throughout a 5-year operation period between overhauls by indicating the necessary periodical diagnostic checks that can be performed during normal operation of that motor in the location where it is installed.

The operating and maintenance manual shall indicate the following:

- The conditions to permit an electrical motor to be operated continuously as part of 5-year cycles; a period of continuous operation between two subsequent overhauls approximately 40,000 h or longer.
- The conditions for the approval of the motor for operation in 5-year cycles between overhauls by indicating necessary periodical diagnostic tests that can be performed when the motor operates under load in the location of where the motor is installed.
- Manufacturer's drawings with dimensions for: arrangement of holes for fixing bolts, shaft height, overall dimensions, gauges etc.

4.2.2. SELECTION OF ELECTRIC MOTORS

1. The following should be taken into account when selecting electric motors:
 - Self-start of the process plant.

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- Electric motors with a rated power:
 - a) Higher than 160 kW should be powered from the 6kV, 50 Hz medium voltage network. In case the 10 kV, 50 Hz network is used, electric motors with a rated output of 400 kW.
 - b) Higher than 0.25 kW up to 160 kW should be powered from the low voltage network (0.4 kV; 50 Hz). In case the 690V, 50 Hz network is used, the electric motors with a rated output higher than 0.25 kW to 400 kW.
 - c) Below or equal 0.25 kW shall be powered from the low voltage network (0.23 kV; 50 Hz).

- 2. Designed short circuit current for starting the motors:
 - MV switchboards:
 - a) 6 kV bus bars – initial symmetrical short circuit current, I_k equal to or higher than 15 kA (as per PN-EN 60909).
 - b) 10 kV bus bars – initial symmetrical short circuit current, I_k shall be calculated according to the technical and economic assumptions; according to PN-EN 60909.
 - LV switchboards:
 - a) 0.4 kV bus bars – initial symmetrical short circuit current, I_k equal to or higher than 28 kA; according to PN-EN 60909.
 - b) 0.69 kV bus bars – initial symmetrical short circuit current, I_k shall be calculated according to the technical and economic assumptions; according to PN-EN 60909.

- 3. Motor self-start:
 - If a voltage dip occurs, it shall be possible to self-start the motor:
 - a) In a system with MV switchboards with two power supply units, for maximum durations of the Automatic Transfer Switch System (SZR):
 - For medium voltage motors: SZR setting = 1.0 sec, SZR limit time – max. 3.0 sec.
 - For low voltage motors: SZR setting = 1.5 sec., SZR limit time – max. 3.5 sec.
 - b) In a system with MV switchboards with three power supply units, for the maximum durations of Automatic Transfer Switch System (SZR):
 - For medium voltage motors: SZR setting = 1.2 sec., SZR limit time – max. 3.0 sec.
 - For low voltage motors: SZR setting = 1.7 sec., SZR limit time – max. 3.5 sec.

Automatic Transfer Switch System (SZR) starts at:

 - a) 40% nominal rated voltage for the MV switchboard,
 - b) 50% nominal rated voltage for the LV switchboard.
 - In the case of a failure of the SZR system, the electric motors driving process machines should be switched off by the electrical protection systems (Automatic Engine Shutdown (SWS)) after 6 sec.

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- Electrical motor control circuits shall be equipped with systems that support their operation during short-time voltage outages due to the operation of the network automation. Such a system shall cooperate with the DCS system.
- 4. The assurance of correct operation with other electrical devices that are powered from the same network under normal and emergency operating conditions.
 - Motors shall have root-mean-square values for free vibration velocities that are not higher than the values for the vibration level referred to as “reduced” in accordance with the standard:

PN-EN 60034-14	Rotating electrical machines. Mechanical vibration of certain machines with shaft height 56 mm and higher - Measurement, evaluation and limit of the vibration severity.
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- The motor manufacturer shall indicate the measured motor vibration root-mean-square value in the shop testing certificate.
- The motor soft start systems or frequency converters shall be used if it is necessary to limit the drive start-up current values.
- The Client reserves the right for final technical acceptance of the motors which are important for the process at the location of the manufacture of the motor or a unit consisting of a driven machine and a motor.

4.2.3. ELECTRIC MOTOR CONNECTIONS

1. Medium voltage motors shall be fed from the medium voltage switchboard using cables that run directly into the motor main terminal box.
 - Motor terminal boxes shall be compatible with the selected cable and cable accessories and located so as to ensure an easy access to the terminals.
 - The way the cable enters the terminal box shall take into consideration the impact of mechanical vibrations on the reliability of the electric motor connection.
2. Low voltage motors shall be fed from the low-voltage switchboard using cables and motors intermediate terminal boxes located next to the motors.
3. The connection between the intermediate boxes and the electric motor shall be made of a rubber insulated flexible cable (class 5, e.g. heavy rubber isolated conductors).
4. Motor terminal boxes, junction boxes close to engines shall be coordinated with the selected cable and cable accessories and located so as to provide easy access to terminals.
5. The motor station shall be located in such a place as to ensure that assembly and disassembly operations are easy to perform.

4.2.4. ELECTRICAL MOTOR OPERATION IN CONJUNCTION WITH SOFT START SYSTEM

1. The drive system consisting of a motor, power cables, control cables and a soft start system shall meet the requirements of the standards below:

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PN-IEC 60364	Electrical installations of buildings.
PN-HD 60364	Low voltage electrical installations.
PN-EN 60079-0	Explosive atmospheres. General requirements.
PN-EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection.
PN-EN 61000-6-2	Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments.
PN-EN 61000-6-4	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environment

2. The Client shall be informed that a soft start needs to be used.
3. While selecting soft start systems, the following aspects shall be considered in particular:
 - Certificates, attestation certificates or permissions issued by appropriate testing station which define the conditions for the operation of the soft start system with an explosion-proof motor operated in a potentially explosive area,
 - Motor self-start after a supply voltage dip,
 - Informing DCS (NRB) about operation and failures.
4. The soft start system shall be installed in the low voltage switchboard or inside boxes with a protection degree of at least IP20.
5. The soft start system shall be mounted inside the boxes when it is mounted on a wall of the LV switching station.
6. Appropriate ventilation and air conditioning shall be designed to provide a temperature that meets the requirement set by the manufacturer.
7. The soft start systems shall be connected through the equipment that makes it possible to disconnect the inputs and outputs of the soft start system.

4.2.5. LV ELECTRIC MOTOR OPERATION WITH FREQUENCY CONVERTER

1. The system consisting of a motor, power cables, control cables and a frequency converter shall meet the requirements of the standards below:

PN-IEC 60364	Electrical installations of buildings.
PN-HD 60364	Low voltage electrical installations.
PN-EN 60079-0	Explosive atmospheres. General requirements.
PN-EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection.
PN-EN 60146	Semiconductor converters.
PN-EN 60034	Rotating electrical machines.

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PN-EN 61000-6-2	Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments.
PN-EN 61000-6-4	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environment

2. The Client shall be notified if a frequency converter needs to be used. The Contractor is obligated to submit a justification for the use of frequency converters.
3. While selecting frequency converters, the following aspects shall be considered in particular:
 - Certificates, attestation certificates or permissions issued by appropriate testing station which define the conditions for the operation of the soft start system with an explosion-proof motor operated in a potentially explosive area,
 - Motor self-start after a supply voltage dip,
 - Informing the DCS (NRB) about operation and failures.
4. Motors intended for operation with a frequency converter should be adapted by the motor manufacturer to frequency-based rotation speed adjustment. The parameters confirming the adaptation must be placed both on the motor rating plates and in the operating & maintenance manuals.
5. In the case of a load that is located in a potentially explosive area or is powered by a frequency converter, sinus filters shall be applied at the frequency converter output.
6. Frequency converters shall be installed in the low voltage switchboard or inside boxes with at least a IP20 class protection.
 - Installation inside boxes can be used if the frequency converter is mounted on the wall of the LV switching station.
 - An appropriate ventilation and air conditioning system shall be designed to provide the temperature that meets the requirements set by the manufacturer.
 - The frequency converter shall be connected through the equipment that enables the disconnection of the input and output of the converter.
7. Cables operating with the frequency converter, i.e. power cables between the frequency converter and the motor, signalling cables and control cables, shall be shielded.
8. The method of mounting the frequency converter drive should be agreed with CLIENT.

4.2.6. REQUIREMENTS FOR LV FREQUENCY CONVERTERS


1. Each frequency converter has separate systems for the power supply, signalling and control.
2. 15 kW and higher output frequency converters are to be installed in a separate enclosure with forced air circulation.
3. The enclosures of the frequency converters with a power output above 250 kW are to be adapted to be installed from the top of the ventilation ducts.

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4. Each frequency converter system must have a manual service by-pass with a motor operation state signalling – from the converter or from the by-pass. The by-pass system should have a set of protections and a control system as for directly controlled process motor.
5. The frequency converter should have an input system that ensures the THD of the input current that is less than 10% for the converters above 75 kW and less than 50% for the converters below 75 kW. This parameter must be met for the full control range for any given application.
6. Controlling a drive system equipped with a frequency converter:
 - Remote control from the DCS/ESD (START, STOP, PERMIT, SET POINT for 4-20 mA ROTATION SPEED),
 - Local control from a local control station (LCS) located near the motor (STOP-0-START and REMOTE-LOCAL switches).
 - Control system adapted to automatic re-start after a temporary voltage failure (START-STOP signals cannot be used),
 - The motor system must have a winding temperature protection based on PTC or Pt 100 sensors in the motor winding,
 - In the case of ESD control, the converter shall have an independent STO input (Safe Torque Off),
 - Shall have separate communication for all signals on the Modbus RTU or Profibus protocols.
7. Indication of the system operation state:
 - Local (frequency converter enclosure) diodes that signal operation states: RUN, READY, PERMIT, FAILURE (permanent designation in Polish: PRACA, GOTOWOŚĆ, ZEZWOLENIE, AWARIA) and a display for (among others) reading the available measured parameters, alarms and history events (the signal diodes and the display shall be located on the frequency converter door that is accessible to operators).
 - Locally (Local Control Station) diodes that signal operation states: RUN, READY, FAILURE (permanent designation in Polish: PRACA, GOTOWOŚĆ, AWARIA)
 - Remote signalling covering the signals below transmitted to:
 - DCS/ESD system: RUN, READY, FAILURE, REMOTE-LOCAL (Polish translation: PRACA, GOTOWOŚĆ, AWARIA, ZDALNE-LOKALNE) and 4-20 mA ROTATION SPEED READING 4-20mA (in Polish: ODCZYT PRĘDKOŚCI OBROTOWEJ 4-20mA) signal – the motor speed.
 - NRB UR system – RS 485 system with a MODBUS RTU protocol.
8. The frequency converters with a rated power lower than 250 kW are recommended to be installed in air-conditioned rooms. The frequency converters with a rated power higher or equal to 250 kW shall be installed in air-conditioned rooms.
9. Frequency converter must be equipped with an event and alarm log with a real time stamps,
10. AC-AC efficiency at a full load: >90%,

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11. Input voltage tolerance: +/-15%,
12. Noise level at the distance of 1m: <60 dB,
13. Max. output voltage distortions: du/dt : <500V/ μ s,
14. Maximum overvoltage amplitude of the output voltage $U_{peak}<750$ was measured phase-to-phase and phase-to-neutral conductor or phase-to-protective neutral conductor,
15. Protection degree – minimum IP20,
16. Access for servicing – only from the front,
17. Shall be equipped with systems for the operation with a personal computer as well as applicable visualisation, diagnostics and parametrisation software should be provided.
18. The calculation of output cable tolerance shall be based on the maximum value of total root mean square (TRMS) of the output current.
19. The tolerance for the maximum short-circuit power in a supplying substation.
20. Protection functions. The following protection functions are required:
 - Temperature protection for motor windings,
 - Temperature protection for motor bearings,
 - Three-phase overcurrent protection,
 - Earth-fault protection for the motor,
 - Overload protection for the motor – thermal model,
 - Loss of load protection,
 - Non-full-phase protection,
 - Motor load-unbalance protection,
 - Protection against a prolonged motor start-up or stuck motor shaft,
 - Protection for a permissible number of motor start-ups,
 - Short-circuit protection for the inverter,
 - Overload protection for the inverter,
 - Thermal protection for the inverter,
 - Control voltage failure protection.
21. Motor circuit breaker.
22. Cooling and ventilation system:
 - The enclosure of the frequency converter shall be equipped with an appropriate ventilation system according to PN-EN 60146-1-1, protecting against overheating of the converter semi-conductor elements, for various possible speed and load values.
 - The frequency converter shall be equipped with a forced ventilation system. The enclosures shall be adapted to the installation from the top of the ventilation ducts.
 - The heat generated by the drives shall be evacuation through the ventilation system or another technological equivalent recommended by the manufacturers of the frequency converter or their authorised representative.

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- The forced ventilation system shall be equipped with all necessary elements, i.e. filters, fans, start-up system with an overload module and auxiliary relays enabling the transmission of warning and failure signals. Filter replacement shall be possible without having to shut down the device.

23. Capacitor discharge system:

- Built-in discharge resistors ensuring the reduction in the voltage on the capacitors up to 50V within the period of 5 minutes or less after switching off the power supply.

24. Marking:

- Each device and equipment shall be marked in accordance with the numbering specified in the drawings attached to the frequency converter manufacturing documentation.
- Plates containing data shall be made of a material resistant to corrosion and secured against loosening.
- All markings shall be in Polish.
- The frequency converter shall have a plate with data that contains at least the following information:
 - Input parameters: rated voltage, rated frequency, the number of phases, rated current.
 - Output parameters: rated voltage, rated current, rated load, rated frequency, the number of phases, power factor range.


25. Additionally, the technical and maintenance documentation or the plate with data shall specify the following data:

- Minimum speed,
- Maximum output load at minimum and maximum speeds,
- Frequency at minimum and maximum speeds,
- Voltage at minimum and maximum speeds.

26. Technical parameters of the drive system

- The drive system with a frequency converter shall have the certificates for the entire drive assembly (the motor and the frequency converter) in order to guarantee high-quality output voltage and safe operation.
- The drive system with a frequency converter shall fulfil the requirements of EU for electromagnetic compatibility (EMC).
 - Resistance to external electromagnetic interference.
 - Shall not send self-generated interference (conducted and radiated) to the power supply network and shall not emit it to the environment.
 - Signalling and control cables must be laid in cable trays away from power cables (the minimum distances between cables required by manufacturers of frequency converters must be maintained).
 - Control and power cables shall be shielded. The shielding must be properly earthed.

27. Additional requirements:

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- Technical documentation in English and Polish. An electronic version (CD or flash drive) and a hard copy of documentation shall be delivered. The documentation shall include:
 - Manufacturer's documentation, as well as signalling and control diagrams.
 - Factory examination certificates confirming the essential technical parameters.
 - A guarantee for at least 24 months from the date of putting the equipment in operation; the guarantee shall contain detailed warranty conditions and address of the guarantor's company.
 - A list of parts that are necessary for operation for 5 years.

28. Seller/manufacture shall assure the performance of acceptance tests for frequency converters confirming the fulfilment of the aforementioned requirements.


- In the factory (FAT) and on the installation site (SAT) for the converters with a 250 kW and higher output.
- On the site for the converters below 250 kW.

4.2.7. REQUIREMENTS FOR MEDIUM VOLTAGE CONVERTERS

1. Medium voltage frequency converter systems must be designed to use an isolation transformer at a converter power supply according to the following requirements.
2. While selecting the frequency converter, it is necessary to consider, in particular:
 - EC type examination certificates, attestation certificates or permits issued by relevant testing bodies, manuals, EC conformity declarations, manuals attached by manufacturers to the devices – determining the conditions for the operation of the frequency converters in conjunction with cable lines, electric motors, including those operating in potentially explosive areas and the equipment of the supply power station.
3. The frequency converter should meet the requirements for Electro Magnetic Compatibility (EMC) specified in directives and standards of the European Union.
4. The drive system equipped with a frequency converter should meet the requirements of directives 2006/95/EC and 2004/108/EC.
5. The frequency converter shall be installed in an air-conditioned room and together with a forced ventilation system, in an enclosure made by the manufacturer or their authorised representatives. It is necessary to consider, in particular, the connection of input circuits and output circuits of the converter through the apparatuses that enable the disconnection operation, e.g. through the application of an isolating switch or a cut-off switch.
6. 6kV/6kV (10kV/10kV) direct frequency converter.
 - The converter shall be equipped with an input and output isolating switch or a cut-off switch to ensure safe measurement of cables and devices.
 - The frequency converter shall have independent supplies for high current circuits and control and signalling circuits.
 - Spare parts shall be available for a period of at least 10 years.

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- The frequency converter system shall be designed, manufactured and installed in accordance with this specification unless the bid submitted by the Bidder specifies an option with a more optimal converter system.
 - The converter shall have high pulse resistance against switching and atmospheric overvoltage. The BIL (Basic Impulse Level) value shall be above 25kV.
7. The control of the drive system equipped with a frequency converter:
- Remote control from the DCS/ESD (START, STOP, PERMIT, SET POINT for 4-20 mA ROTATION SPEED),
 - Local control from the local control station (LCS) located close to the motor (STOP-0-START and REMOTE-LOCAL switches).
 - The control system adapted to automatic re-starting after a temporary voltage failure (START-STOP signals cannot be used),
 - The motor system must be equipped with a winding temperature protection based on PTC or Pt100 sensors in the motor winding,
 - In the case of the ESD control, the converter shall have an independent STO input (Safe Torque Off),
 - Shall have separate communication for all signals on the Modbus RTU or Profibus protocols.
8. Indication of the system operation state:
- Local (frequency converter enclosure) diode that signal operation states: RUN, READY, PERMIT, FAILURE (permanent designation in Polish: PRACA, GOTOWOŚĆ, ZEZWOLENIE, AWARIA) and the display for (among other data) reading the measured available parameters, alarms and history events (the signal diodes and the display shall be located on the frequency converter door accessible to operators).
 - Locally (Local Control Station) diode that signal operation states: RUN, READY, FAILURE (permanent designation in Polish: PRACA, GOTOWOŚĆ, AWARIA)
 - Remote signalling covering the signals below transmitted to:
 - DCS/ESD system: RUN, READY, FAILURE, REMOTE-LOCAL (Polish translation: PRACA, GOTOWOŚĆ, AWARIA, ZDALNE-LOKALNE) and 4-20 mA ROTATION SPEED READING 4-20mA (in Polish: ODCZYT PRĘDKOŚCI OBROTOWEJ 4-20mA) signal – the motor speed.
 - NRB UR system – via RS 485 system, MODBUS RTU protocol.
- Informing the DCS and SCADA systems (NRB – at least 3 binary signals, details to be arranged at the detailed engineering design stage) of drive system operation and faults.
- The control and signalling system shall ensure that the motors self-start after a supply voltage failure
- The converter shall make it possible to read data after the power supplied is completely shut down. The interference logs should be available at least for 100 hours from the complete shutdown of the supply voltage.
9. Cooling requirements:

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The enclosure of the frequency converter shall be equipped with an appropriate ventilation system that complies with the standard: PN-EN 60146-1-1 and protects the semi-conductor elements of the converter from overheating, at various possible speed and load values. The frequency converter system shall have an air forced cooling system. The converter cabinets shall support the incorporation of the ventilation ducts from the top.

The heat generated by converters shall be evacuated through the ventilation system of the converter systems or other equivalent technical solutions recommended by the manufacturers or their authorised representatives.

The forced ventilation system should be equipped with all necessary elements, i.e. a filter, fan, starter with an overload protection and auxiliary relays, making it possible to route the failure and alarm signals. The replacement of a filter should be possible without a need to shut down the devices.

10. The requirements for the electrical parameters of frequency converters:

- Input frequency - 50 Hz
- AC-AC efficiency with a rated load: >90%.
- Input frequency tolerance: 49-51 Hz.
- Output frequency accuracy (without a feedback signal): +/- 0.5%,
- THDi factor of the current supplied from the supply switchboard shall be satisfied within the full range of adjustment of the motor rotational speed and shall be lower than 5%.
- The rate of rise in output voltage du/dt : < 300V/ μ s.
- The maximum amplitude of the overvoltage of the output voltage U_{peak} measured phase-to-phase and phase-to-earth needs to be smaller than the voltage strength of the motor insulation in a particular drive system.
- The short circuit resistance on the output cable without damaging the power and signalling and control circuits.
- The design shall consider the maximum short circuit power of the 6kV (10 kV) switchboard from which the converter is to be powered.
- Resistance to the reduction in voltage up to 15% within 6 sec. and to complete loss of voltage in a period of up to 300 ms. during a disturbance in the supply network.
- The converter shall have a feature to reduce the rotational speed during a temporary overload and automatically return to the set rotational speed after the disappearance of the temporary overload (without disconnecting the drive).
- The converter shall not send self-generated interference (conducted and radiated) to the power supply network and shall not emit it to the environment.
- The method to control semi-conductor power connectors – scalar and vector control.

11. Requirements for construction:

- High current connection bus bars shall be made of copper and insulated.
- Signalling and control cables placed in cable trays shall be isolated from power cables, (the required minimum distances between cables required by manufacturers of converters must be maintained). Control and power cables should be shielded and the cable shielding shall be properly earthed.

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- Built-in discharge resistors shall ensure a voltage reduction on the condensers up to 50V no longer than within 5 minutes after shutting down the power supply.
- Built-in anti-condensing heaters.
- All the metal parts that are not used in the conduction of the current shall be connected galvanically with each other and connected to a common earthing bus of the frequency converter. The earthing bus of the frequency converter shall be connected to the earthing system of the building.
- Service access only from the front.

12. Other requirements:


- Noise level at the distance of 1m: < 80 dB,
- Flying start: yes,
- Control panel: yes,
- Soft start: yes,
- Permissible ambient temperature: from 5 to 45°C,
- Storage temperature: from -20 to +60°C,
- Allowable ambient humidity without condensation: 5-95%,
- Allowable altitude: <1000m,
- Slip compensation,
- Converter service life: at least 15 years,
- Must be delivered together with diagnostics software for the offered frequency converter which makes it possible to carry out diagnostics and parameterisation of the frequency converter in online and offline modes.
- It is necessary to deliver manufacturer's documentation in English and Polish. The documentation needs to be provided in printed and electronic versions (CD or memory stick).
- The frequency converter for the supply of a motor incorporated in an explosion hazard area shall be equipped with protection systems in accordance with requirements of the Ex certificates for the motor.
- As part of the delivery, detailed engineering design and as-built designs should include settings, logic and parameterisation of the frequency converter.
- All the descriptions of the signalling system and control connectors for the frequency converters should be described in Polish.

13. Safety functions. The following safety functions are required:

- Temperature protection for the motor,
- Short circuit protection for the motor,
- Overload protection for the motor,
- Short circuit protection for the converter,
- Overload protection for the converter,
- Temperature protection for the converter,
- Protection against a loss of control voltage,
- Protection against unbalance.

14. Markings:

- All devices and apparatuses shall be described in accordance with the names of the apparatuses given in the converter manufacturing documentation.

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- Description plates shall be made of a material resistant to corrosion and secured against loosening.
- All descriptions shall be in Polish.
- The converter shall have a rating plate that contains at least the following data:
 - Input parameters: voltage, frequency, the number of phases and current.
 - Output parameters:
 - Rated voltage,
 - Rated current,
 - Rated power,
 - Rated frequency,
 - Frequency range,
 - Number of phases,
 - Power factor range.

In addition, the technical and maintenance documentation or the rating plate shall specify the minimum speed of the drive system.

15. Requirements for the isolation transformer:

- The transformer shall meet the requirements specified in the following regulations and the CLIENT's detailed requirements:

PN-EN 60726	Dry-type transformers.
PN-EN 60726-11	Transformers. Dry-type transformers.
IEEE Std C57.110-2008	IEEE Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents

- The power transformer should have the following parameters:
It is necessary to meet the requirements of the manufacturer of the frequency converters and the requirements of the BUYER specified for the inverter system, indicating at least the following arrangement of guaranteed parameters:

Group of connections:	Provided by the Bidder
Rated voltage:	6kV/6kV (10kV/10kV)
Voltage adjustment:	Through switching taps in the upper voltage winding, in the voltage-free state, within the range of $\pm 2 \times 2.5\%$
Short circuit voltage:	Provided by the Bidder
Insulation:	Resinous, class F
Type:	Dry

- The power transformer shall be placed in an enclosure at least with the IP20 level of protection.
- The transformer shall be equipped with necessary kinds of factory protections and protections incorporated in the 6 kV (10kV) switch bay.

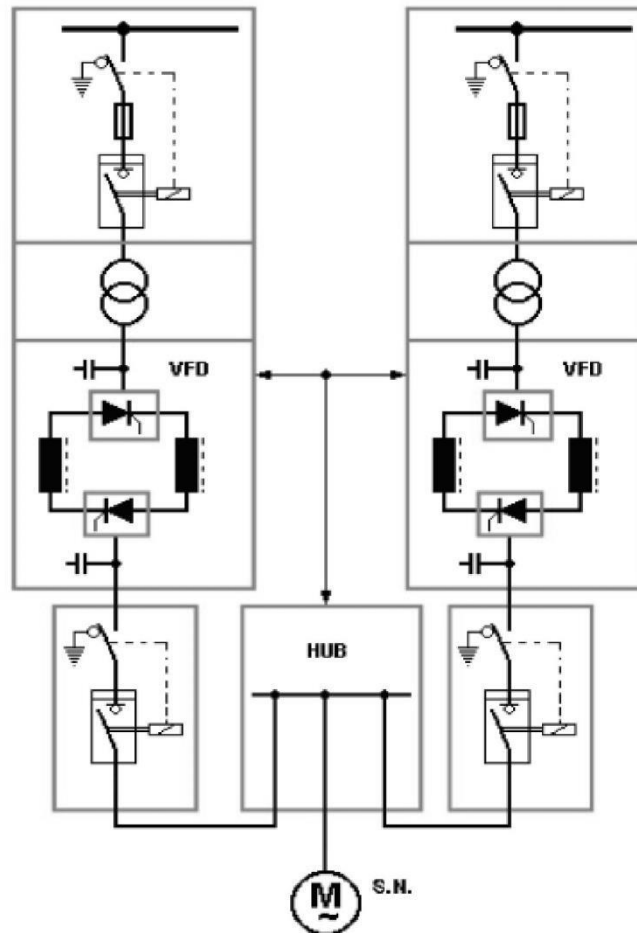
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- The neutral point of the winding on the secondary side of the transformer shall be connected in accordance with the requirements of the manufacturer of the converter and in compliance with the system of protections agreed upon with the Ordering Party.
- The power transformer shall be connected:
 - from the primary side: through a cable line or a bus bar bridge or insulated bus-ducts,
 - from the secondary side: through a cable line or a bus bar or insulated bus-ducts.
- The transformer shall be adapted to the drive system with frequency converters and the requirements of the process and the power system.
- The transformer shall be placed in a separate cabinet incorporated in a room of the 6 kV (10 kV) switching station (joint incorporation with a converter).
- The power transformer shall be equipped with a thermal protection provided and monitored by the frequency converter.

4.2.8. MV AND LV FREQUENCY CONVERTERS CRITICAL TO PRODUCTION PLANTS

1. Frequency converters critical to production plants are considered to be those frequency converters for which the shutdown of the drive will cause the production plant to stop.
2. The configuration of the drive system for critical devices needs to be consulted with the Technical Analysis Department on a case-by-case basis.
3. The control circuits of frequency converters must be fed from an external guaranteed voltage system.
4. The configuration systems with two frequency converters shall meet the following requirements:
 - Each converter needs to be fed from a separate section of the switchboard.
 - The system should have procedures ensuring the safety of operation and repair activities when the system is in the operation mode. These procedures need to make it possible to safely switch off and on any unit during the operation of the system.
 - The drive system shall work without interruptions in emergency states, such as a loss of power supply from the power transformer or any error of one of the frequency converters.
5. In addition to the above-mentioned requirements, the frequency converters of the critical drives shall meet the requirements of a redundant configuration, as specified below:

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6. The drive system should support emergency states mentioned below:
 - A loss of power supply from the power transformer,
 - Any error of one of frequency converters.
7. In the normal operation mode, frequency converters divide the load into two parts, 50% each. In the case of a failure in a unit, the other unit takes over 100% of the load, without any disturbance to the driven motor.
8. Each frequency converter must be powered from a separate section of the switchboard.
9. The Contractor shall provide procedures that ensure the safety of operation and repair activities when the system is in the operation mode. These procedures must make it possible to safely switch off and on any single unit during the operation of the system.

4.2.9. SPECIAL MEDIUM VOLTAGE SUPPLY SYSTEMS

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1. The intent to install the special medium voltage supply systems, such as medium voltage power electronic devices (UPS units, soft start systems, frequency converters, power controllers, etc.) shall be consulted with the CLIENT's Technical Analysis Department.
2. Before the installation and after the first power-up of the MV electronic power device, tests shall be conducted to check whether the correct device has been selected, in particular the level of harmonics in the place of installation shall be checked.
3. The electronic power device testing programme should be consulted with the CLIENT's Technical Analysis Department.
4. The documentation of the electronic device, the testing documentation (i.e. the qualifications of the persons carrying out the tests, the details of the measurement instruments, the development of measurement results, data recording, etc.) and the testing results shall be submitted to the Client's Technical Analysis Department to obtain a permit for operation.

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4.3. CONTROL, PROTECTION, SIGNALLING AND MEASUREMENT SYSTEMS

1. The protection, control, signalling and measurement systems shall meet the requirements of the standards listed below:

PN-EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection.
PN-IEC 60364 PN-HD 60364	Electrical installations of buildings. Low voltage electrical installations.
PN-EN 61000-6-2	Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments.
PN-EN 61000-6-4	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environment.
PN-EN 61508	Functional safety of electrical/electronic /programmable electronic safety-related systems.
PN-EN 60950	Information technology equipment – Safety.

2. The ratio between the motor start-up current and the rated current shall not exceed the following values:
 - For MV motors.
 - With a rated voltage of 6 kV, 10 kV:
 - a) Motors with a rated power lower than 1000kW: 5.8,
 - b) Motors with a rated power higher than or equal to 1000kW: 4.0.
 - With a rated voltage 10kV: shall be chosen based on the technical and economic assumptions.
 - For LV motors.
 - Motors with a rated power higher than or equal 160 kW and a rated voltage of 400V: 6.0-8.0,
 - Motors with a rated power lower than or equal 400 kW and a rated voltage of 690V: shall be chosen based on the technical and economic assumptions.
3. If it is impossible to meet this requirement, the following shall be agreed upon: the improvement of the parameters of the used motor, a soft start system or a frequency converter system.
4. The following auxiliary voltage values are allowable:
 - Protection for MV and LV motors, LV motor control: Un=220VDC,
 - Power supply for LV motor control systems: Un=230VAC, 220VDC, 24VDC
 - Power supply for control systems with the DCS system: Un=24VDC.
5. The cable power line that powers the motor must be equipped with an instantaneous overcurrent protection against short circuits as well as a motor protection.
6. The protection system for medium voltage motors shall be designed using comprehensive digital protective devices that provide the following functionalities:

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- Instantaneous overcurrent protection against internal short circuits,
- Earth fault protection,
- Time-delay overcurrent protection against overloads,
- Protection against excessive rise in bearing and/or winding temperature,
- Phase failure or phase unbalance protection,
- In addition, motor protection for motors with a rated power equal to or higher than 2000 kW shall be supplemented with a differential protection,
- Protection against motor falling out of synchronisation (for synchronous motors only).


The Contractor shall provide accurate motor heating and cooling time constants from the motor manufacturer in order to correctly set the medium voltage motor protection based on the thermal model.

7. The protection system for low voltage motors shall be designed using electronic relay protection with the following functionalities:
- Time delay overcurrent protection against overloads,
 - Protection against excessive rise in the bearing and/or winding temperatures,
 - Phase failure or phase unbalance protection.

The protection shall be equipped with an external signalling module located on the switch bay panel.

8. General technical requirements for the local control stations located close to motors:
- Cable glands and plugs made of plastic must be flame retardant.
 - The enclosure used outdoors must be resistant to environmental conditions present in the production plant and resistant to UV radiation.
 - Metal elements, such as screws, springs, washers and terminals, must be made of stainless steel.
 - Internal connection cables must have a cross-section of 2.5mm².
 - The protection degree for the enclosure must be at least IP65.

9. The motor load controlled locally and from DCS/ESD shall be equipped with a local control station with the following parameters:
- REMOTE-LOCAL switch
 - Position REMOTE (stable position, +135°, closed with a key),
 - Position LOCAL (stable position, +45°),
 - STOP-0-START switch:
 - Position STOP (stable position, +135°),
 - Position 0 (stable position, +90°, closed with a key),
 - Position START (unstable position, +45°),
 - "PERMISSION to start" indicator:
 - Type: LED,
 - Colour: green,
 - "RUN" motor indicator:
 - Type: LED,
 - Colour: red,
 - An ammeter required only for motors with a power equal to or greater than 10 kW.

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10. The motor load controlled only locally shall be equipped with a local control station with the following parameters:

- STOP-0-START switch:
 - Position STOP (stable position, +135°),
 - Position 0 (stable position, +90°, closed with a key),
 - Position START (unstable position, +45°),
- “PERMISSION to start” indicator:
 - Type: LED,
 - Colour: green,
- “RUN” motor indicator:
 - Type: LED,
 - Colour: red,

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

- Local switching on and off the motor from the local control unit,
- Local emergency switching off the motor or a group of motors (if necessary) with a local emergency button,
- Permanent (lockable) “0” position for maintenance, repair and overhaul purpose,
- In LV switchboard panels of motors controlled by DCS shall be equipped with optical signalling of signals: permission, stop, running, available.

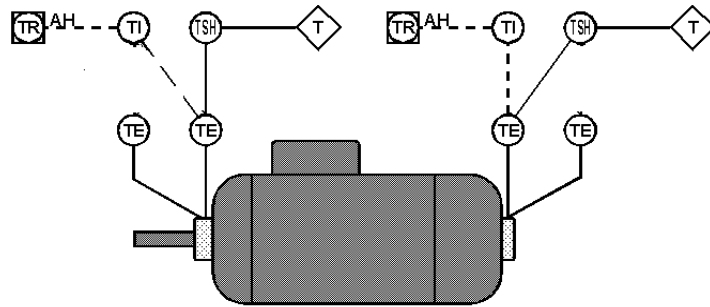
12. The control and signalling systems should be protected with overcurrent circuit breakers.

13. The recommended temperature protections settings for electric motors with 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	SHUTDOWN
BEARINGS	80°C	95°C
WINDINGS	115°C	125°C

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a) Silniki niskiego napięcia o mocy większej od 110 kW



b) Silniki średniego napięcia

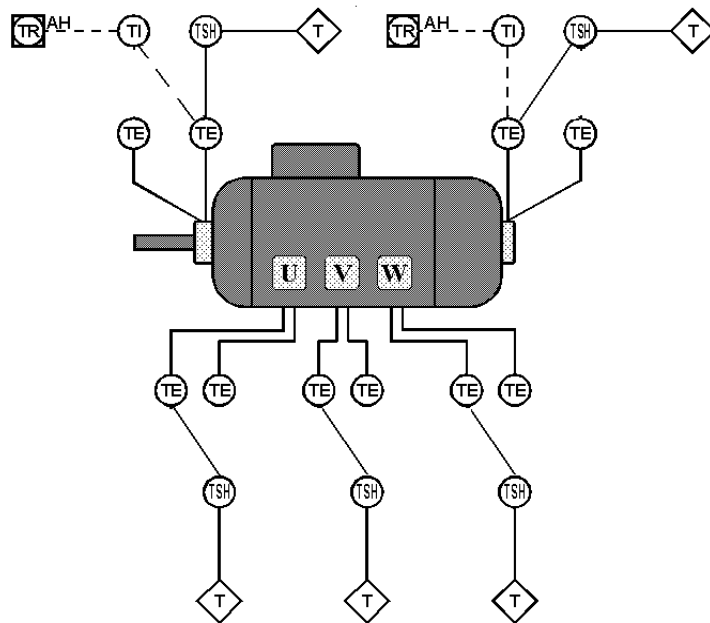



Fig. 1. Temperature measurement method for electric motor bearings or windings:

a) Low voltage motors with a rated power higher than 110 kW, b) Medium voltage motors.

Where:

- TE – temperature sensor,
- TSH – temperature setpoint exceedance signalling (I°),
- T – shutdown after a temperature setpoint is exceeded (II°),
- TI – temperature indication; TR – temperature logging in the DCS system,
- AH – DCS temperature setpoint exceedance alarm,
- U, V, W – motor stator windings.

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The MV motor winding temperature measurement system shall be protected against an MV winding short circuit with a special short circuit protection which provides a ground connection – on the motor. The solution for the protection system shall be agreed with the CLIENT.

4.4. CONTROL SYSTEMS

- Control systems should meet the requirements specified in Polish regulations and standards and take into account the Client's requirements, including the provisions specified in:


PN-EN 61508	Functional security of electrical / electronic / programmable systems connected with security.
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- Control systems may be designed through the application of:
 - contact systems,
 - programmable controllers.
- Control systems should be characterised by high operating reliability, modular design, scalability of the implemented technical solutions.
- The intent and scope related to the installation of control systems should be approved by the Client's Technical Analysis Department

4.5. LIGHTING SYSTEMS

- The lighting system shall meet the Client's detailed requirements, including those specified in the standards below:

PN-EN 12464	Light and lighting. Lighting of work places.
PN-EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection.
PN-IEC 60364 PN-HD 60364	Electrical installations of buildings. Low voltage electrical installations.
PN-EN 12665	Light and Lighting. Basic terms and criteria and specifying requirements concerning lighting
PN-EN 1838	Application of Lighting – Emergency Lighting
PN-EN 50171	Central power supply systems
PN-EN 50172	Emergency escape lighting systems
PN-EN 60598	Luminaires
PN-EN 13201	Road Lighting
PN-84/E-02035	Electrical equipment. Electric lighting energy facilities
PN-EN 60670-22	Fire boxes.

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DIN 1402-12	Trace cables and cables.
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2. Luminaires shall be designed with at least IP55 protection.

4.5.1. PRIMARY LIGHTING

1. Primary lighting means the lighting system designed for a specific type of room, space, device or activity in normal working conditions.
2. The lighting system for process plants, pumping stations and the main, internal and access roads, service yards, rooms intended for the personnel, control rooms, storage and handling tanks, etc. shall maximally utilise luminaires with fluorescent light sources and electronic starters or luminaires with electro-luminescent diodes.
3. The lighting system shall be designed as 1-phase TN-S system installation. The circuits shall be protected using circuit breakers with a 16A rated current.
4. The entire production plant lighting system should be separately switched on and off from the control room. Indoor lighting for the process area objects, such as pump stations or other poorly-lit spaces, should be switched on locally.
5. Twilight switches (if necessary) shall be used to automatically switch on the lighting for outdoor roads and yards.
6. The maximum voltage drop from the power transformer bars to the luminaire shall not exceed 5%. From the transformer to the luminaire (at maximum 1% from the transformer to lighting switchboard in the substation and at maximum 4% further to the luminaire).
7. The load of the lighting circuits located in potentially explosive areas shall not exceed 80% of the rated load.
8. The load of the lighting circuits located outside potentially explosive areas shall not exceed 90% of the rated load.
9. Luminaires shall be split into groups for lighting specific portions of the process plant, e.g. the process equipment, the pumping station, etc. A luminaire group shall be powered from the same voltage phase and switched on or off with one switch.
10. Luminaires shall be fixed in a way that enables easy servicing. Local lighting luminaires above communication roads, stairs, platforms, etc. shall make it possible to replace the lighting source without a ladder.
11. Fluorescent lighting sources with an extended lifetime (approx. 30000 hours) shall be used in explosion-proof luminaires.
12. It should be taken into account that the Client can increase the number of luminaires according to specific local conditions (no more than 10% of the total number of luminaires).

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4.5.2. EMERGENCY LIGHTING

- The emergency lighting system includes:
 - Emergency lighting which shall ensure safe completion of an activity in potentially hazardous situations in the event of a failure of the primary lighting.
 - Emergency exit lighting which shall ensure effective identification and utilisation of escape routes in the event of a failure of the primary lighting.
- Ratio between illuminance of emergency lighting to illuminance of primary lighting according to table below.:

Name of the location being lit	Percentage ratio of emergency illuminance to primary illuminance
Control rooms	50%
Substation rooms	30%
Other places	10%

The entire area should be treated as industry plant wherein emergency lighting have to meet the conditions for high risk zone according to PE-EN-1838 which is 10% of primary lighting illuminance to but not less than 15 [Lux].

- An emergency lighting system with an instant restart functionality shall be provided to indicate exits and illuminate exit routes and shall cover: the control rooms, substations, battery rooms and marshalling or rack rooms, process structures, illuminate exits and exit routes in unloading areas for flammable materials, pallet unloading, fire pumps, etc.
- The emergency lighting system should be based on central battery system. The backup lighting time in the wheelhouse should be at least 60 minutes. System should provide 20% power and space reserve. Extending the back-up time of emergency lighting can be based on the analysis of activities necessary for the safe shutdown of the technological installation. This time should be agreed between the contractor and the buyer.
- The system of cable routes (electric cable carrier trays and mounting elements) and cables should be designed in accordance with a fire resistance of at least E60.
- LED should be used as source of light in luminaires, adapted to supply from alternating voltage and constant voltage.
- Provide a solution that allow use system to during normal operation from emergency lighting as primary lighting. Battery central system should comply assumptions:
 - In normal state, the luminaires are supplied with alternating voltage of $U_n = 230\text{VAC}$.
 - In an emergency condition, the luminaires are supplied with DC voltage $U_n = 220\text{VDC}$ supplied from the central battery cooperating with the system.
 - The central battery system should be equipped with a lighting control system and the ability to generate reports after functional tests according to PN-EN 50171 PN-EN 50172.
 - Central battery system should supply maximum 20 luminaires in circuit.

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- Emergency lighting system including cable routes, cables, electrical boxes and mounting elements should be selected in fire-resistant E60 or according to backup time.
- Technical room where the central battery system board is positioned should be treated as separate fire zone

The emergency lighting system should be equipped with lighting fittings using LED diodes. Emergency lighting system (cable, boxes, cable routes, mounting elements) are required to have a CNBOP certificate.

4.5.3 LED LIGHTING LUMINAIRES

LED lighting luminaires should meet the following requirements:

Technical data	Requirements	Notes / Certificates
Optics	The optical system complies with the standard (according to PN-EN 12464-2 or equivalent) about photobiological safety	
Durability of use	L80-B10 for 50000h	ENEC/VDE
SDCM	3	ENEC/VDE
Temperature color	4000K	ENEC/VDE
Indicator color rendering	Ra>80	ENEC/VDE
Temperature range working	from -30 °C to +55°C	ENEC/VDE
Light efficiency lighting fixture	Minimum 120lm from Watt	ENEC/VDE
Current ripple	<5%	ENEC/VDE
IP	Minimum IP65	
Reactive power	$\cos\phi \geq 0,9$	
Warranty on lighting fixture	Minimum 5 years	

4.6. HEATING SYSTEM

1. The electric heating system shall meet the requirements specified in the regulations below and the Client's detailed requirements:

PN-EN 60079-30	Explosive atmospheres. Electrical resistance trace heating.
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PN-EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection.
PN-IEC 60364	Electrical installations of buildings.
PN-HD 60364	Low voltage electrical installations.
PN-EN 60947	Low-voltage switchboard and controlgear
PN-EN 60439	Low-voltage switchboard and controlgear assemblies.

2. Electrical heating system (including heating switchboards, terminal boxes, junction boxes, heating systems, cables and connecting conductors) shall meet the requirements of explosion-proof designs. Self-regulating heating cables should be used where possible.
3. TN-S system shall be used for the supply of the electrical heating system.
 - Electric heating switchboards on the production area shall be fed from the auxiliary low voltage distribution panel (TGR) located in the substation by means of 3-phase 5-wire cables.
 - The distribution boxes shall be supplied from above-mentioned electric heating switchboards by means of 1-phase 3-wire cable lines. Separate bus bars shall be provided inside electric heating switchboards for the supply of winterising heating system and process heat. tracing From each electric heating switchboard section, a separate fault signal shall be routed to the low voltage switchboard. Collective heating fault signals from LV distribution board:
 - shall be sent to the NRB system,
 - could be sent to the DCS system (to be agreed with the maintenance service).
 - Junction boxes shall be fed from distribution boxes by means of 1-phase 3-wire cables.
 - 1-phase circuits shall be protected inside distribution boxes by means of 16A MCBs equipped with 30 mA overcurrent differential protection.
 - The possibility of switching on and off the MCBs without opening the distribution boxes shall be provided.
4. The following heating control systems shall be designed:
 - using thermostats installed close to the electric heating switchboards for the winter heating,
 - using thermostats installed directly on the devices or heated apparatus for process all-year heating.

4.7. LIGHTNING PROTECTION AND EARTHING SYSTEMS

1. The lightning protection and earthing system shall meet the requirements specified in the regulations below and the Client's detailed requirements.
2. The lightning protection and earthing system shall meet the requirements specified in the standards below:

PN-EN 62305	Protection against lightning.
PN-HD 60364-5-54	Low voltage electrical installations. Selection and erection of electrical

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	equipment. Earthing arrangements and protective conductors and protective bonding conductors.
PN-IEC 60364-7-707	Electrical installation of buildings. Requirements for special installations or locations. Earthing requirements for the installations of data processing equipment.
PN-86/E-05003/01	Lightning protection of structures. General requirements.
PN-EN 61340-5-1	Electrostatics - Part 5-1: Protection of electronic devices from electrostatic phenomena - General requirements.
PN-EN 61936-1	Power installations exceeding 1 kV a.c. - Part 1: Common rules.

3. The lightning protection and earthing system are used to provide:
 - Protection against atmospheric discharges,
 - Protective earthing,
 - Functional earthing,
 - Equipotential bonding,
 - Protection against static electricity.
4. Each facility or process unit must be provided with an earthing ring.
5. Earthing rings and earthing conductors shall be made of hot deep galvanised steel tape with the minimum dimensions of 30x4mm. The earthing conductors above ground shall be made of hot deep galvanised steel tape with the minimum dimensions of 25x4mm. Other elements and connections shall be made of 20x3mm galvanised steel tape of and/or galvanised steel wire with a 10-mm diameter.
6. The earthing system placement depth shall be as follows:
 - Hot deep galvanised steel tape: at least 0.6m underground
 - Rods and pipes: at least 2.5 m underground (calculated from the bottom end of the rod or pipe).
7. The resistance of earthing electrode on the production plant shall not exceed 5Ω.
8. The earthing conductors shall be connected to the apparatuses, not to the foundations or footing bolts. For motors, the earthing conductors shall be bolted to the motor mounting leg or reinforcing motor rib.
9. A separate earthing system shall be designed for the control and automation system. The system shall be isolated from other earthing systems. The distance between the earthing system of the control and automation system and other earthing systems shall be at least 10 m, and its earthing resistance shall not exceed 1Ω (DCS system supplier's requirements shall be taken into consideration).
10. All connections in the lightning protection and earthing system shall be welded – the welds shall be protected against corrosion.

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11. It is permissible to use bare monitoring (bolted) connections only in the area designated with the marking Zone 2. The Zone 1 area, monitoring connections shall be installed in sand-filled chambers. All connections in the lightning and earthing system shall be protected against corrosion and mechanical damage.
12. The pipes for combustible media with the wall thickness less than 5 mm shall be protected against atmospheric discharges.
13. The flange connections for the piping located in potentially explosive areas shall have the appropriate electrical conductivity. This can be achieved by using two bolts with the minimum diameter of 6mm, equipped with spring washers. Bolt heads should be painted red.
14. All metal elements on the production area, such as structures, columns, tanks, pipe racks, cranes, pipelines and electrical equipment enclosures, shall be earthed. The general installation diagram for the earthing system is shown below.

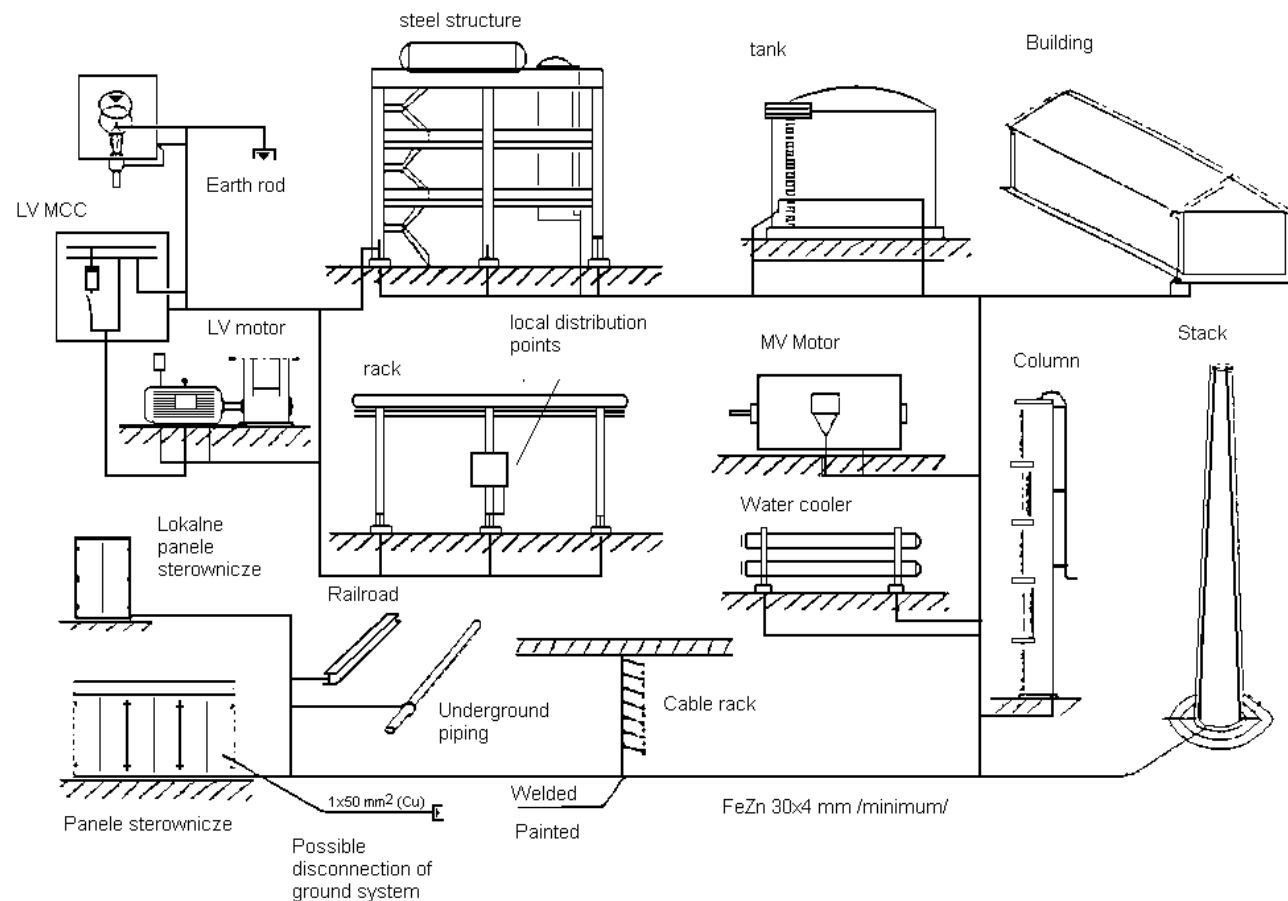


Fig. 2. Earthing system



5. AUXILIARY ELECTRICAL SYSTEMS

5.1. LV SOCKET OUTLET SYSTEMS

1. An electrical installation designed as a TN-S system shall be designed to supply power to socket outlets used during plant maintenance or repairs.
2. Socket outlets shall meet the requirements specified in the standards:

PN-EN 60529	Degrees of protection provided by enclosures (IP Code).
PN-EN 60309-1	Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements.
PN-EN 60309-2	Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories.
PN-EN 60309-4	Plugs, socket-outlets and couplers for industrial purposes – Part 4: Switched socket-outlets and connectors with or without interlock.
PN-EN 60079-0	Explosive atmospheres - Part 0: Equipment - General requirements
PN-EN 60079-1	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d".
PN-EN 60079-7	Explosive atmospheres - Part 7: Equipment protection by increased safety "e".

3. Socket outlets equipped with local circuit breakers with the following parameters shall be applied:
 - 1-phase 3-pole outlets with a 16A rated current,
 - 3-phase 5-pole outlets with a 32A and 63A rated current.

Sockets and plugs shall have an explosion-proof design and shall be delivered as complete sets of sockets and plugs.

4. Socket outlets shall be supplied using the following cables:
 - 3-wire cables for 1-phase socket outlets (L, N, PE),
 - 5-wire cables for 3-phase socket outlets (L1, L2, L3, N, PE).
5. The distribution and number of the socket outlets depend on the maintenance needs and shall be agreed with the Client. The socket outlets should be distributed in such a way that will make it possible to supply power to the maintenance equipment, luminaires etc. in any location of the plant, as follows:
 - From 3-phase socket outlets via an extension cable that is not longer than 40m,
 - From 1-phase socket outlets via an extension cable that is not longer than 30m.
6. Socket outlets circuits shall be switched on and off by means of a circuit breaker installed in the LV switchboard. During normal operation, maintenance socket outlet circuits remain deenergised.



5.2. SAFETY EXTRA LOW VOLTAGE SOCKET OUTLET SYSTEM

1. Socket outlets with a rated 24V AC voltage shall be installed in the proximity of all columns and tanks. The socket outlet system will be powered by a 230V AC voltage through explosion-proof sockets. Each socket shall have an integral switch and a 230/24V safety transformer.
2. Portable luminaires are to be powered from these socket outlets using a cable no longer than 10m.
3. The distribution and number of socket outlets depend on the maintenance and overhaul needs and shall be agreed with the Client.

5.3. VOMA UNIT SYSTEM

1. Close to tubular heat exchangers, TN-S electrical installations shall be designed to supply Voma units with the rated power of 120 kW.
2. Voma unit power supply system shall be terminated using a terminal box with an explosion-proof design equipped with a circuit breaker.
3. The terminal boxes for Voma units shall be distributed in such a way that the maximum allowable distance between the heat exchanger and the terminal box is no more than 40 m.

5.4. MOBILE GAS ANALYSER SYSTEM

1. In the process plant area, TN-S 5-wire electrical power supply system shall be designed to power the gas analyser close to the stacks.
2. The power supply system for the gas analyser shall be terminated with a closed junction box which shall contain:
 - A 5-pole socket outlet with a rated current of 32A,
 - A circuit breaker with a rated current of 40A.
3. The maximum allowable distance from the sampling point to the above-mentioned junction box should not exceed 40 m.
4. Additionally, 1-phase 3-pole 16A socket outlet supplied from a separate circuit at a distance of no more than 2 m from the sampling point shall be installed.
5. Any additional technical requirements regarding the location of the boxes and the design of the system shall be agreed with the Client at the design stage.

5.5. TELECOMMUNICATION SYSTEM

1. The telecommunication system must be integrated with the existing system.
2. The telecommunication system must ensure the following:
 - Connection with the industrial annunciation system used to inform of a chemical alarm.



- Alarm reporting using a manual fire alarm call point.
 - Operation with fire detectors.
3. The production plant shall be equipped with an intercom speaker system in an explosion-proof design.
 4. The Contractor shall agree upon the number and distribution of the paging devices with Client at the design stage.
 5. Intercom system cables shall be laid on cable gantries or supporting structures, in cable trays or cable ladders, or cable ducts or directly buried in the ground.
 6. Cable trays and ladders shall be covered to protect them against atmospheric factors, such as rainfall, sunlight, mechanical, electrical or chemical damage, by using appropriate covers.
 7. Cables and conductors with self-extinguishing or fireproof sheaths that are resistant to chemical exposures (hydrocarbons) shall be used.
 8. If necessary, intrinsic safe cellular phones shall be additionally used.
 9. The details shall be worked out at the construction permit design and detailed design stage.
 10. The telecommunication systems shall meet the Client's requirements for the IT industry.

5.6. BATTERY ROOMS

1. Battery rooms shall meet, in particular, the following requirements:

PN-EN-IEC-62485-2:2018	Safety requirements for secondary batteries and battery installations.
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2. Battery rooms shall be equipped with a ventilation system that is sufficient to remove hazardous gases, vapours, dusts, etc.
3. The battery room where gas-emitting batteries are used shall be provided with ventilation over the battery charging area sufficient to remove any flammable gases in accordance with the standard specified above.
4. A safety shower and eyewash station shall be installed in the battery room if acid is added to batteries.



6. PRODUCTION PLANT POWER SUPPLY SYSTEM

1. MV supply bays and cable lines shall meet the requirements for the required equipment, electricity measurement systems, power factor requirements, harmonic distortion specified in the Technical Requirement for Electricity Supply issued by the Electrical System Operator.
2. Providing MV bays and MV cable lines shall be designed to withstand the short circuit power, the whole load of the production plant in normal conditions. The cable lines shall be symmetrically loaded. No line shall be overloaded under any circumstances.
3. MV cable lines powering the production units shall meet the requirements specified in the regulations below.

PN-EN 61936	Power installations exceeding 1 kV a.c.
PN-EN 50522	Earthing of power installations exceeding 1 kV a.c.
IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1kV to 30kV.
DIN VDE 0278-623 DIN VDE 0278-623/A1	Power cable accessories with rated voltages u up to 30 kV.
IEC 60986	Short-circuit temperature limits of electric cables with rated voltages from 6kV (Um=7.2kV) up to 30kV (Um=36kV)

4. The cable lines supplying power to the production plants shall be designed with single core power cables with the following characteristic:
 - copper cores,
 - cross linked polyethylene insulation,
 - radial distribution of the electric field,
 - joint return copper core,
 - longitudinal moisture protection seal,
 - radial moisture protection seal,
 - outer sheath made of polyethylene or PVC that is flame retardant and resistant to corrosion due to chemical exposure (e.g. hydrocarbons) in the place of installation of the cable.
5. All the cables passing through walls shall run in permanently sealed cable ducts.
6. Cables passing through roads and squares that are at risk of mechanical damage shall be protected with cable ducts approved by the Client.
7. The currently applicable regulations of the European Union shall be applied after obtaining an approval from the CLIENT in case economic reasons suggest solutions other than those indicated.

6.1. ELECTRICAL STATIONS AND SUBSTATIONS

1. Depending on the importance of the production plant to the continuity of the technological process, the plant substation shall be fed by two independent cable supply units.



2. Each of the cable supply units shall be able to cover the full power demand of the switchboard.
3. The plant substation supply power to the branch transformer stations, which provide production units with electrical energy with a rated voltage of 400V or 690V.

6.2. PRODUCTION PLANT SUPPLY SYSTEM

1. Branch Distribution Points (OPR) supply the production plants with electric energy with a rated voltage of 6 kV. If it is necessary to supply a production plant with a voltage of 10 kV, it is necessary to additionally consider a 30/10 kV station.
2. Depending on the importance of the plant for the continuity of a technological process, power substations (OPR) are supplied with:
 - Two independent power supply units, or
 - Three power supply units.

Each power supply unit shall cover the full power demand for the entire switchboard.

3. Power Substations (OPR) supply Branch Transformer Points (OPT). Branch Transformer Points (OPT) supply the production plant with electric energy with a rated voltage of 690V and/or 400V.
4. The Branch Distribution Points (OPR) and Branch Transformer Points (OPT) are equipped with automation systems:
 - Automatic Transfer Switch System (SZR),
 - Scheduled Power Supply Switching (PPZ).The automation systems (SZR and PPZ) shall be designed based on a separate microprocessor automaton approved by the Client's Technical Analysis Department.

5. The SZR automation system for switching stations with two power supply units works in a single-stage operation and has the following switching times:
 - For a medium voltage switchboard with two supply units:
 - SZR delay from the loss of voltage 1.0 sec.
 - SZR limit time 3.0 sec.
 - SZR starting voltage 0.4 Un
 - For cooperating with the foregoing LV switchboard:
 - SZR delay from the loss of voltage 1.5 sec.
 - SZR limit time 3.5 sec.
 - SZR starting voltage 0.5 Un
6. For a medium voltage switchboard with three supply units:
 - For a medium voltage switchboard with three supply units:
 - SZR delay from the loss of voltage 1.2 sec.
 - SZR limit time 3.0 sec.
 - SZR starting voltage 0.4 Un
 - For cooperating with the above-mentioned low voltage switchboard:
 - SZR delay from the loss of voltage 1.7 sec.
 - SZR limit time 3.5 sec.
 - SZR starting voltage 0.5 Un



7. The SZR automation system for medium voltage switching station with three supply units works on a two-stage basis and has the following switching times:

1st stage	0.8 sec.
2nd stage	If stage 1 responses correctly, stage 2 is blocked.
	If stage 1 responses incorrectly, it is delayed in relation to stage 1 by circuit breakers response times.

8. Some low voltage boards are equipped with SZR automation systems operating with a time dependent on the used connectors, usually shorter than 0.2 sec.
9. The Client's power system uses various devices that require special protection against interference occurring in an extensive industrial power network. This applies, in particular, to electronic equipment, such as UPS units, buffer power supply units, frequency converters, computer systems, controllers etc.
10. The supply system for 10kV, 6kV medium voltage switching station and 690V, 400V low voltage switching station in configurations with two and three power supply units is presented below:

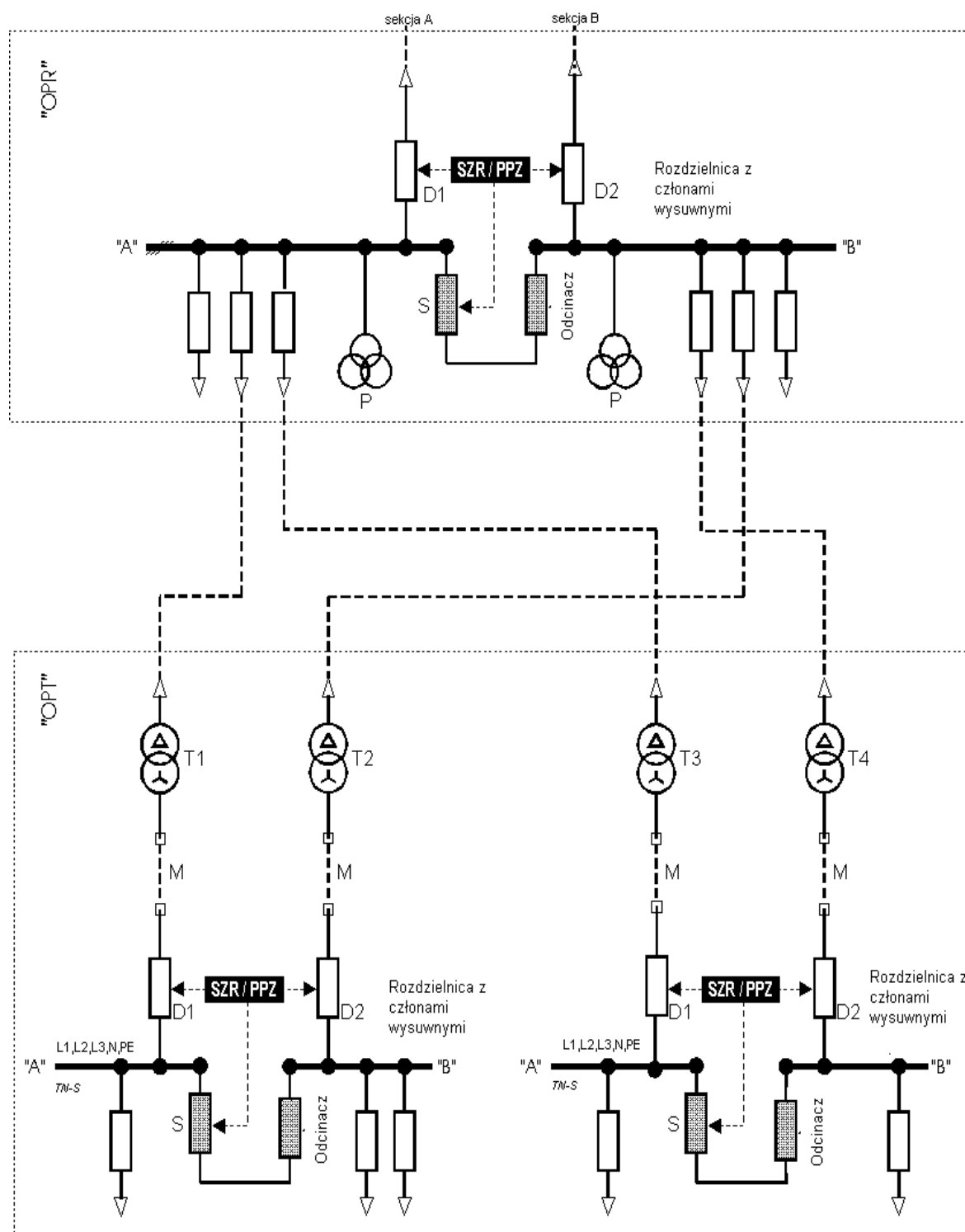


Fig. 3. Electrical energy distribution in configuration with two sources, where: D1, D2 – main inflows, S - coupling, M – bus bar bridge

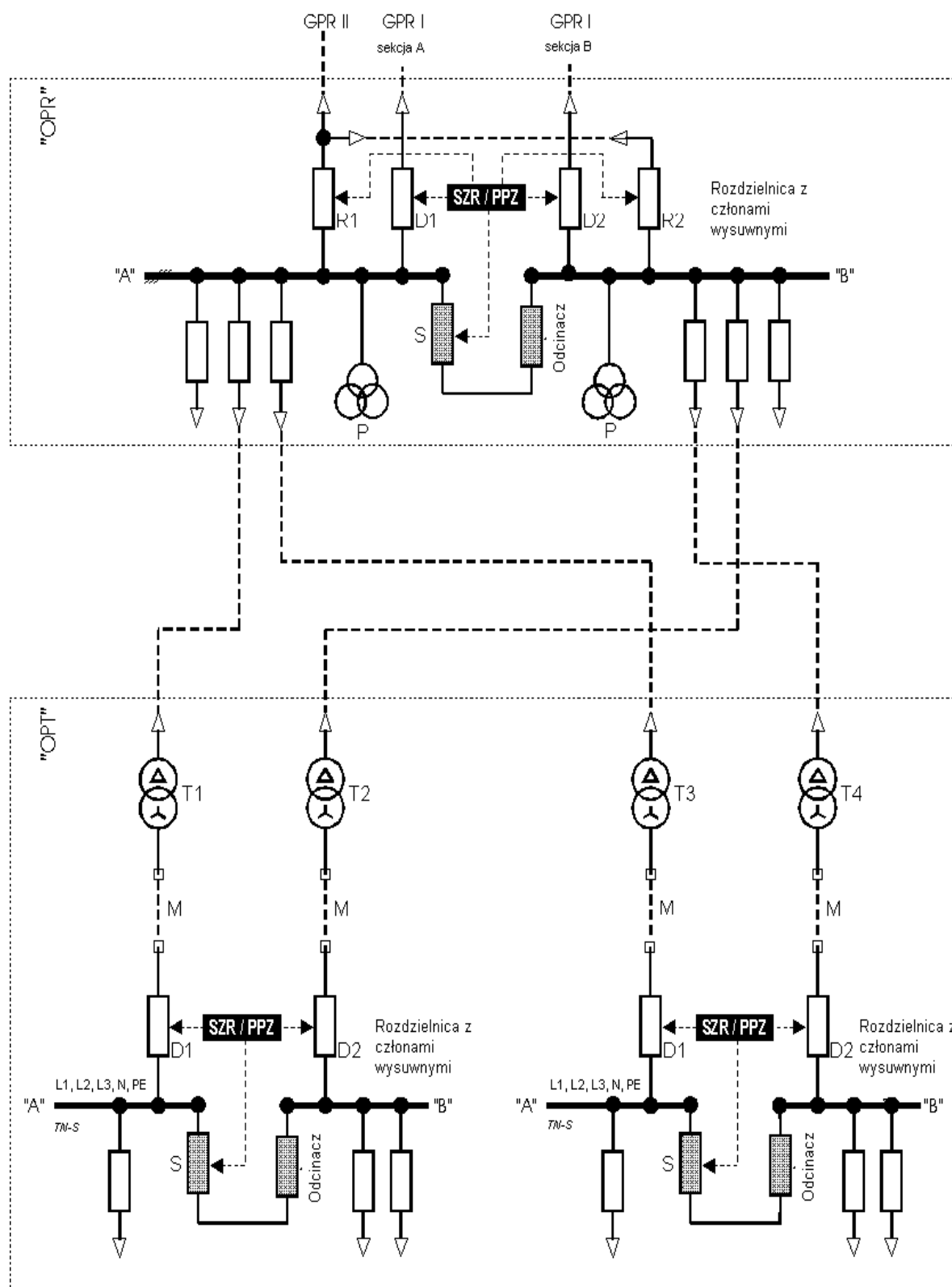


Fig. 4. Electrical energy distribution in a configuration with three power supplies, where: D1, D2 – main inflows, S - coupling, M – bus bar bridge

11. The microprocessor automaton for the SZR/PPZ automation systems shall perform the following functions:

- Automatic Transfer Switch System (SZR) – synchronous with simultaneous impulse transmission, activated by an external initiation signal.
- Automatic Transfer Switch System (SZR) – synchronous with a short interruption of the supply voltage, activated by an external electric signal which opens the circuit breaker of the supply line.
- Automatic Transfer Switch System (SZR) – synchronous with a short interruption of the supply voltage, activated when the circuit breaker of the primary supply line is mechanically switched off.
- Automatic Transfer Switch System (SZR) – slow, activated when the circuit breaker of the primary supply line is mechanically switched off.
- Automatic Transfer Switch System (SZR) – slow, activated by a loss of voltage at the bus bars with the switched-on circuit breaker of the primary supply line.
- Automatic Scheduled Power Supply Switching (PPZ) – uninterrupted synchronous.
- Additional functions:
 - Operator panel (HMI) displaying the synoptic state of the primary switchboard supply units,
 - Event log,
 - Permanent and transient interlocks,
 - Local communication port (RS 232).

12. The interlocks for the Automatic Transfer Switch System (SZR) and MV cable supply unit protection:

- A local reserve or automatic of circuit breaker reserve switching (LRW) implemented within one section, activated by switching off the basic or reserve incoming bay or switching off the coupling bay.
- Incoming bay switch-off interlock for the time needed to switch off the outgoing bay.
- Sectional protection (incoming bay protection – protection of the outgoing bay from master supply station) to speed up the operation of the automation or protections in the incoming bay.

13. Requirements for the protection system for MV switch station bays.

13.1. The microprocessor protection for the MV supply line bay shall be equipped with the following functions:

- 3-phase overcurrent directional protection [50/51],
- Earth fault directional overcurrent protection [50N/51N],
- Watt-metric earth fault protection [32N],
- Phase under/over voltage protection [27, 59]
- Voltage-controlled overcurrent protection [51V],
- Under/over frequency protection [81 U/O],
- Output latching relays [86],
- Circuit breaker state control,
- Output relay testing,
- Measurements,
- Event log,
- Interference log,
- Fault log,
- Remote communication port (RS 485),

- Local communication port (RS 232).
- 13.2. The Microprocessor protection for the MV coupling shall be equipped with the following protection functions:
- 3-phase directional overcurrent protection [50/51],
 - Earth fault directional overcurrent protection [50N/51N],
 - Watt-metric earth fault protection [32N],
 - Phase under/over voltage protection [27, 59],
 - Voltage-controlled overcurrent protection [51V],
 - Under/over frequency protection [81 U/O],
 - Output latching relays [86],
 - Circuit breaker state control,
 - Output relay testing,
 - Measurements,
 - Event log,
 - Interference log,
 - Fault log,
 - Remote communication port (RS 485),
 - Local communication port (RS 232).
- 13.3. The microprocessor protection for the MV measurement bay shall be equipped with following protection functions:
- Phase undervoltage protection [27],
 - Phase overvoltage protection [59],
 - Zero-sequence overvoltage protection [59N],
 - Negative-sequence overvoltage protection [47],
 - Positive-sequence overvoltage protection [27D],
 - Under/over frequency protection [81 U/O],
 - Frequency change indicator [81 R],
 - Undervoltage blocking,
 - Measurements,
 - Peak value measurements,
 - Event log,
 - Interference log,
 - Remote communication port (RS 485),
 - Local communication port (RS 232).
- 13.4. The microprocessor protection for the MV motor bay shall be equipped with following protection functions:
- Short-circuit protection [50/51],
 - Earth-fault protection [50N/51N],
 - Thermal overload protection [49],
 - RTD/thermistor inputs [49/38],
 - Unbalance protection [46],
 - Extended start-up protection [48],
 - Locked rotor protection [51LR-50S],
 - Protection against exceeding the start-up number limit [66],
 - Motor protection for motors with a rated power equal to or higher than 2000 kW shall be equipped with a differential protection [87],
 - Event log,
 - Interference log,



- Remote communication port (RS 485),
- Local communication port (RS 232).

13.5. The microprocessor protection for the MV transformer bay shall be equipped with following protection functions:

- 3-phase directional overcurrent protection [50/51],
- Overload protection [49],
- Earth fault directional overcurrent protection [50N/51N],
- Watt-metric earth fault protection [32N],
- Phase under/over voltage protection [27, 59],
- Voltage-controlled overcurrent protection [51V],
- Winding over-temperature protection,
- Output latching relays [86],
- Circuit breaker state control,
- Output relay testing,
- Measurements,
- Event log,
- Interference log,
- Fault log,
- Remote communication port (RS 485),
- Local communication port (RS 232).

13.5.1. Reserve protection

- 3-phase overcurrent protection feed from separate current transformers and separate power supply.

6.3. MEDIUM AND LOW VOLTAGE SWITCHBOARDS

1. Medium and low voltage switchboards and the devices installed in them shall meet the requirements specified in Polish regulations and standards as well as the Client's requirements.
2. The switchboard supply system should be designed on the basis of a single sectional bus bar system. Individual sections of the switchboard should be evenly loaded.
3. Each section of the bus bars of the MV or LV switchboard shall be equipped with surge arresters installed in withdrawable units of the switchboard, connected through fuses. The fuses shall switch off damaged surge arresters without causing any disturbance to the continuity of the supply of the loads.

6.3.1. MEDIUM VOLTAGE SWITCHBOARD DESIGN

1. Medium voltage switchboards should meet the requirements of the following regulations as well as the Client's requirements.

PN-EN 62271-200	High-voltage distribution and control apparatuses. Alternating current switchboards in metal shields on rated voltage of over 1 kV to 52 kV inclusive.
PN-EN 50181	Plug-in type bushings above 1 kV up to 52 kV and from 250 A to 2.50 kA for equipment other than liquid filled transformers.

PN-EN 60243-1	Electric strength of insulating materials - Test methods - Part 1: Tests at power frequencies.
PN-EN 60255	Measuring relays and protection equipment
PN-EN 60445	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors.
PN-EN 60073	Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators.
PN-EN 60529	Degrees of protection provided by enclosures (IP Code).

2. Medium voltage switchboards should be built on the basis of:
 - 12 kV indoor, compartment, double-segment, free-standing switch bays, certified for arc-protection.
 - Apparatus adapted to short-circuit resistance determined by the withstood rated 1-second current with the value of 31.5 kA or higher.
3. The switchboards should be designed with a power reserve of 20% of the total power installed in the switchboard.
4. Medium voltage switchboards should be equipped with:
 - Withdrawable circuit breaker units,
 - An interlocking system to prevent incorrect manipulation,
 - A safe drive for the cable earthing switch integrated with mechanical interlocks,
 - Primary voltage indicators (reactance capacitive indicators),
 - Continuous current measurement for outgoings of each switching bay,
 - Automation, control, protection, signalling and measurement systems,
 - Systems for the interoperation with monitoring systems: DCS, NRB for remote control of switches, monitoring the positions of switches, event and interference logging and balancing electrical energy.
5. Circuit breakers for medium voltage switchboards should be selected for:
 - 12kV rated voltage,
 - Rated current equal to 1250A,
 - Rated symmetrical breaking short-circuit current equal to or higher than 31.5kA.
6. The medium voltage switchboards shall be provided with a standardised power supply one-line diagram to be placed on the front plate of the bay along with a description of the apparatus installed in the bay.

6.3.2. LOW VOLTAGE SWITCHBOARD DESIGN

1. Low voltage switchboards and low voltage controlgear shall meet the requirements specified in the regulations below and those specials of Client.

PN-EN 60439	Low-voltage switchgear and control gear assemblies.
PN-EN 60947	Low-voltage switchgear and control gear.
PN-EN 60445	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals,



	conductor terminations and conductors.
PN-EN 60243-1	Electric strength of insulating materials - Test methods - Part 1: Tests at power frequencies.
PN-EN 60073	Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators.
PN-EN 60529	Degrees of protection provided by enclosures (IP Code).

2. Low voltage switch stations shall be designed based on switch bays:
 - Modular, indoor, free-standing,
 - Withdrawable or fixed units, depending on the type of the loads.
3. Switchboards shall be designed with a power reserve of 20% of the total installed power of the switchboard.
4. Switchboards shall be adapted to the operation with monitoring systems (DCS /ESD, PLC, etc., NRB).
5. Supply and coupling switching bays of the low voltage switchboard shall be equipped with:
 - Automatic switching equipment,
 - Automatic control and protection systems to switch power supply units,
 - Three phase current and voltage measurement system.
6. Outgoing switching bays for motors with a power lower than or equal to 110 kW shall be equipped with:
 - Fuse switches disconnectors with power fuses,
 - A contactor for motors with a rated power lower than 45 kW, equipped with air insulation,
 - Vacuum contactor for motors with a power higher than or equal to 45 kW and lower than or equal to 110 kW.
 - Electronic motor protection,
 - Current measurement system,
 - Signalling systems for motor state and operation.
7. Outgoing switching bays for motors with a power higher than 110 kW shall be equipped with:
 - Circuit breakers with a built-in short-circuit protection system.
 - Electronic protection for the motor,
 - Current measurement system.
 - Signalling systems for motor state and operation.
8. Each outgoing module for the motor shall have a rear cable compartment with a width that ensures a free and safe access to the main terminals and auxiliary circuit strips. The auxiliary circuits of the module shall be led out to the auxiliary circuit strip in the cable compartment.

6.3.3. NRB SYSTEM (SCADA)

1. Electrical data acquisition should be performed by computer systems. The NRB system shall consist of following three modules:
 - **NRB-DCS** dedicated to the technological process operator. The NRB-DCS system shall meet the requirement of the Client's Technical Analysis Department.



- **NRB-RE** dedicated to the electrical industrial supply grid operator, Electrical Distribution Operator; it shall meet the requirements of the Client's Technical Analysis Department.
 - **NRB-UR** dedicated to the electrical branch end-user of the production plant connected to company local computer network (Ethernet); it shall meet the requirements of the Client's Technical Analysis Department.
2. The NRB-RE, NRB-UR, NRB-DCS system modules (servers, RTU's, communication links, end user application software) shall meet the requirements of the Client's Technical Analysis Department. Servers hardware and system software shall comply with the Client's requirements for the IT industry.
 3. The list of signals is shown in:
 - Table 1. List of signals transmitted to NRB-RE system.
 - Table 2. List of signals transmitted to DCS/ESD, PLC, etc.
 4. The list of signals dedicated to NRB-UR depends on the installed equipment; on average about 10-signals should be considered for each electrical load.
 5. In the case of the necessity to install a fault logging system, the requirements shall be agreed with the Client's Technical Analysis Department.

6.3.4. GENERAL REQUIREMENTS FOR SCADA SYSTEMS (NRB)

1. Switchboard connections to NRB-RE system – a monitoring system for the power system – must allow for the transmission of control and monitoring signals.
2. The input signals to NRB-RE system shall be: potential-free contacts, analogue signals (voltage, current, etc.), serial interfaces RS485, RS232 or fibre optic connections. Dedicated signals for the NRB systems should be independent of the signals collected for other systems (DCS/ESD).
3. Primary communication protocol is IEC 60870 – 5 -103. Alternative MODBUS RTU is permitted.
4. Communication buses project with technical assumption:
 - a) In single buses is permitted to work maximum 8 devices
 - b) In single buses is permitted to work the same type devices
 - c) For low voltage switch board single buses should not cross other section of switchboard
5. The signals from the switchboards, panels and other devices powered by them shall be transferred to the NRB-UR system which includes a local server.
6. The input signals for the NRB-UR system shall be: potential-free contacts, analogue signals (voltage, current, etc.), serial interfaces RS485, RS232 or fibre optic connections. Dedicated signals for communication with the NRB systems shall be independent of the signals collected for other systems (DCS/ESD).



7. The server application will be installed on a virtual machine from the ICT resources of PKN ORLEN S.A.
8. The controller declared to single object of the NRB-UR system should be connected to LSK computer network at the nearest access point. It is required to establish a connection via the transmission channel with a transfer speed of 1000 Mbps
9. The NRB-UR system shall ensure bilateral transfer of data obtained from:
 - The installed SZR/PPZ automation, Electrical net analyser, frequency converter, softstart devices, UPS, Buffer feeders and protection systems through the use of remote relay communication in the NRB system.
 - The devices mentioned in the list of signals transmitted into the NRB system attached hereto.
10. Switchboard data connections shall work with local NRB-UR system unit. The NRB-UR system (central and local servers) must enable data management and collection, monitoring, measurement and visualisation of signals, etc.
11. The delivery of the switchboard covers the scope associated with the full integration of the data transmission system from the switchboard to the NRB-RE system, e.g. manufactured by Elkomtech S.A.
12. The communication to the NRB system shall be made using e.g. equipment produced by Elkomtech S.A. or other equipment which fulfil the specified requirements (e.g. Energotest-Energopomiar, Elektrotim, Mikronika).
13. The details of the NRB system, such as communication and definition of tests, will require consultation with the Client's Technical Analysis Department.
14. Scada application requirements:
 - a) Graphical representation of electrical net status with high update frequency. On circuit diagram and table must be presented parameters of telemechanic, binary signal, analog signal.
 - b) Graphic mapping technological/processing line.
 - c) Warning switched on in case of system state change and exceeding the alarm values.
 - d) Graphic, vector presentation of archived measurements.
 - e) Overall working time for electric drive counter. The system have to generate warning about exceeding the operating time limit for drive (User define limit time in star up phase). The system is enable to generation of summary reports for drives from a common section(Toverall,Tlimit).
 - f) Summary table of the present states of binary signals and measurements with the possibility of filtering by element address, type of measurements etc.
 - g) User have opportunity to use selectively filter of event log for individual stations, output electrical board field, and event types. Full eventlog/alarm history
 - h) Structure of the system element description corresponding to the technical documentation.
 - i) Prioritization of alarms/warning agreed upon with use.
 - j) The system have to create the possibility for generating a comprehensive report with the file extension supported by Microsoft office. Transparency of the file is strictly recommended.



6.3.5. REQUIREMENTS FOR NRB DCS (NRB)

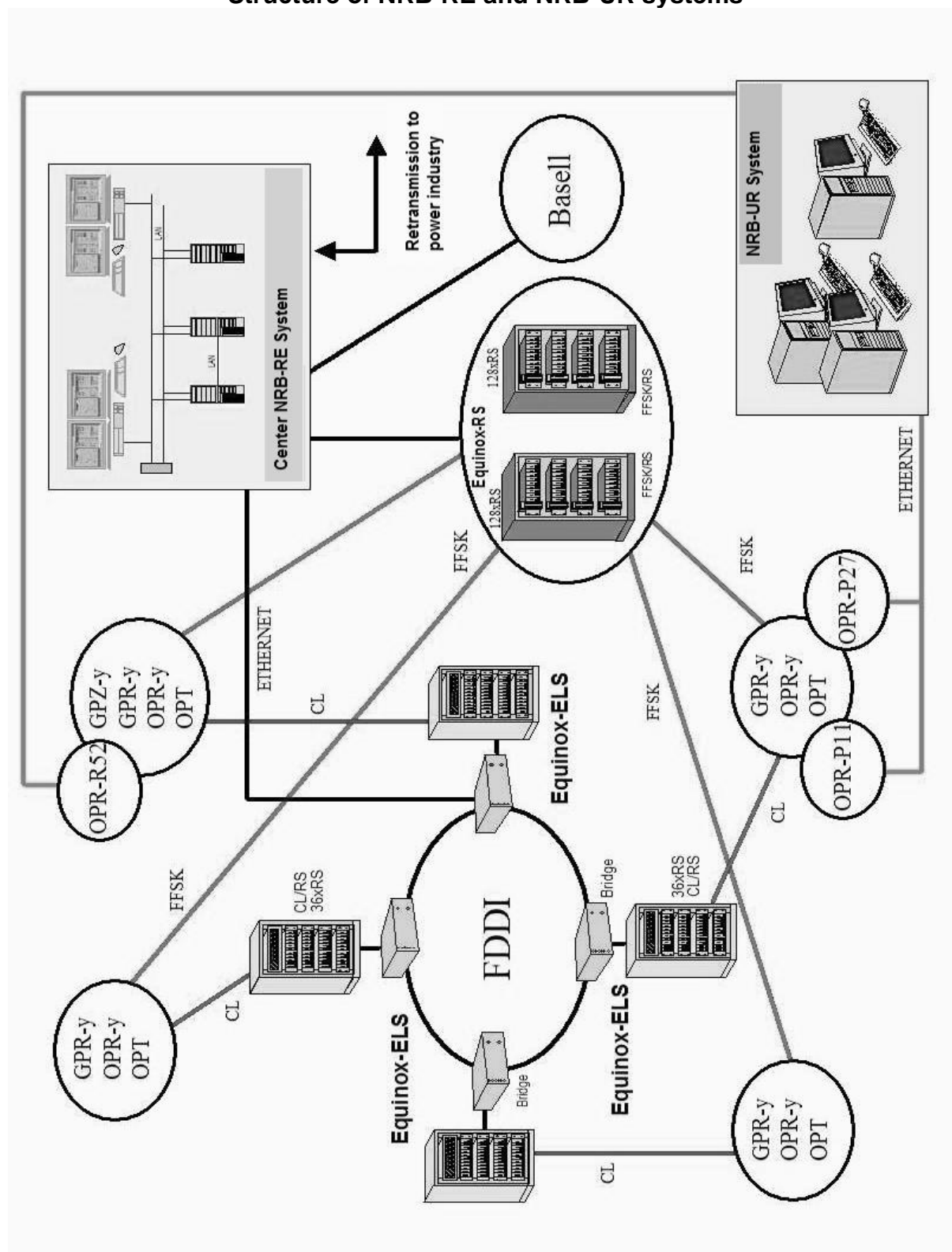
The basic functionality of the NRB-DCS system is measurements transmission between electrical switchboards and DCS system. Considering to admissible unobtainable of the NRBDCS system during the production installation operation, the signals transmission to the DCS system cannot affect to control systems, blocking systems of the production process. The NRB-DCS system controller should be a separate device, independent of the NRB-UR controller.

Transmission between the NRB-DCS controller and the DCS system should be realized as fiber optic connection via the MODBUS or PROFIBUS protocol. Relating signals and the communication protocol should be agreed each time by the Technical Analysis Department.

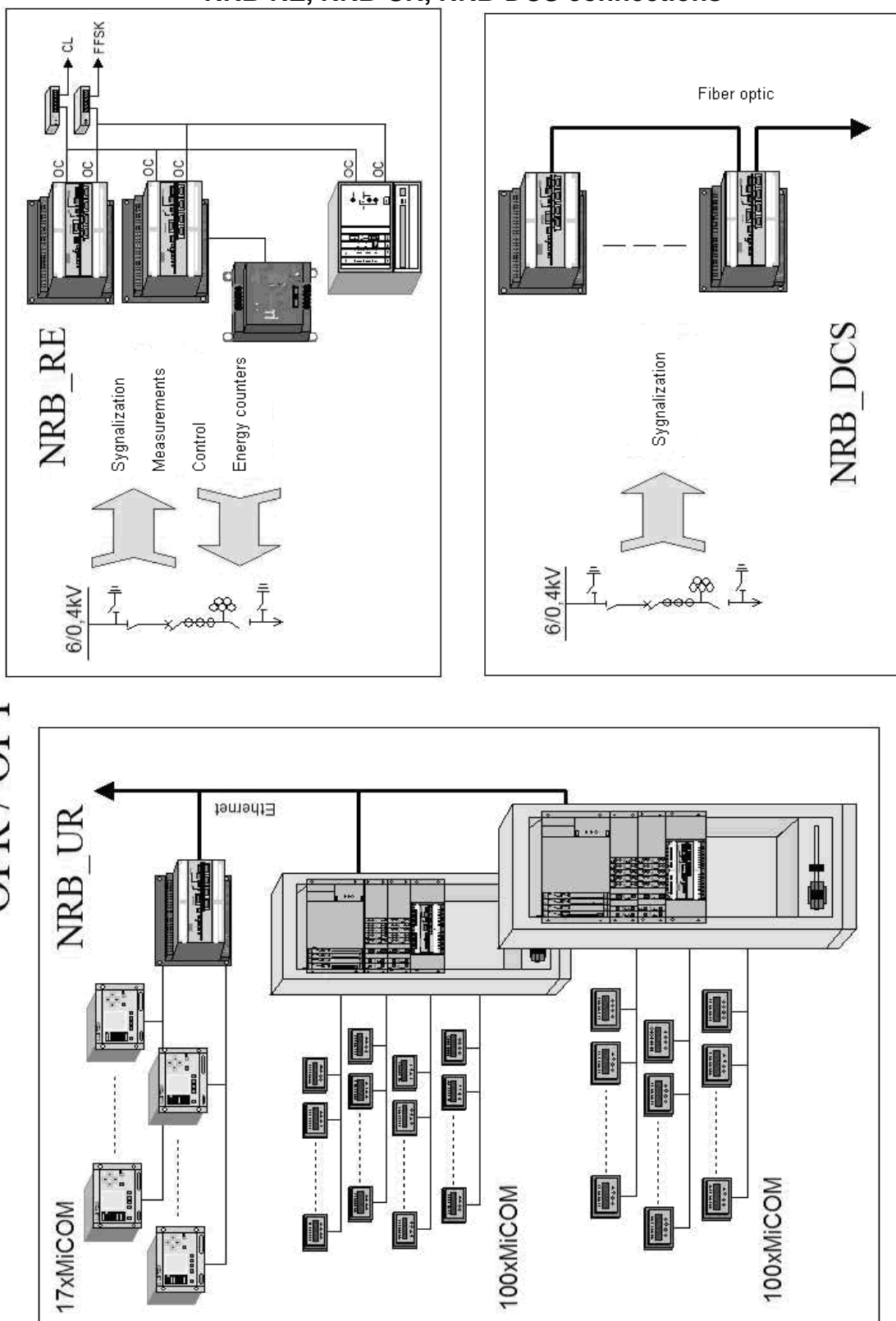
6.3.6. DETAILED REQUIREMENTS FOR SCADA SYSTEM (NRB)

1. The switchboard communication system shall ensure a high level of safety. The offer shall include optimisation of the switchboard communication system with solutions based on fibres or shielded twisted pair wiring
2. The delivery of the switchboard covers the scope associated with the full integration of the data transmission system from the switchboard to the NRB system. The communication to the NRB system shall be made using equipment which fulfil the specified requirements (e.g. Energotest-Energopomiar, Elektrotim, Mikronika, Apator Elkomtech). The details of the NRB system, such as communication and definition of tests, will require consultation with the Client's Technical Analysis Department..
3. Transmission between switchgear(the power system control application) and the NRB-RE system should allow the transmission of control and monitoring signals.
4. Input signals of the NRB-RE system will be: electrical potential-free contacts, analog signals (voltage, current, etc.). Signals dedicated to the NRB system should be independent of the signals collected for other systems (DCS / ESD) .
5. The supply of the switchgear includes the scope associated with the full integration of the data transmission system from the switchgear to the NRB system used in the existing infrastructure
6. Relating signals and the communication protocol should be agreed each time by the Technical Analysis Department.

Structure of NRB-RE and NRB-UR systems



NRB-RE, NRB-UR, NRB-DCS connections



	Automation & Electrical Department (SG)	<p style="text-align: center;">Electrical – General Requirements for New and Modernised Production Plants – Technical Annexes to Contracts</p>
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Table 1. List of signals transmitted to NRB-RE

No.	Description	Control, Signalling, Measurement
1	2	3
1.	Medium voltage switchboards	1. Control of incoming, coupling and capacitor bank bays from the NRB system 2. Two-bit position signalling for: circuit breakers, switch disconnectors, earthing switches, withdrawable switchboard units. 3. NRB level circuit-breaker control readiness signalling for: incoming, coupling and capacitor bank bays 4. Signalling of the lack of SZR system readiness, 5. Signalling for the shutdown of the motor bay by the DCS. 6. Signalling for direct current voltage 220 V drop below 0.9 Un in each battery bank feeding protection circuits. 7. Signalling from each section: <ul style="list-style-type: none"> ○ Warning: <ul style="list-style-type: none"> - Capacitors bank emergency shutdown, - Damaged overvoltage protection. ○ Failure: Electrical protection caused by electrical protective devices. 8. Measurement of phase-to-neutral voltages (L1, L2, L3) in bus bars of both sections 9. Electrical measurements using impulse counter
2.	Low voltage switchboards	10. One-bit position signalling for circuit breakers in incoming and coupling bays, 11. Signalling for the lack of SZR system readiness, 12. Signalling from each section: <ul style="list-style-type: none"> ○ Warning: <ul style="list-style-type: none"> - Capacitor's bank shutdown, - Damaged overvoltage protection. ○ Failure: <ul style="list-style-type: none"> - Signalling for a voltage failure on panels fed from the LV switchboard 13. Signalling from: UPS units, buffer power supply units, power controllers, soft start systems, frequency converters <ul style="list-style-type: none"> ○ Warning, ○ Failure. 14. Measurement of phase-to-neutral voltages (L1, L2, L3) in bus bars of both sections.

1. Binary signals shall be read with a signal resolution of 1 millisecond. The NRB shall be provided with appropriate graphic symbols to visualise the above signals.
2. The above signals may be made available from the NRB system through the in-house computer network to other services of Client.

	Automation & Electrical Department (SG)	<p style="text-align: center;">Electrical – General Requirements for New and Modernised Production Plants – Technical Annexes to Contracts</p>
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Table 2. List of signals transmitted to DCS System /ESD, PLC, etc./

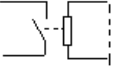
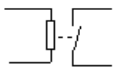
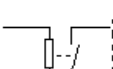
No.	Description	Control, Signalling, Measurements
1	2	3
1.	MV & LV switchboards	1. Circuit-breaker position state signalling for outgoing and coupling bays (one-bit system). 2. Protection activation signalling. 3. SZR/PPZ automation activation signalling. 4. Bus bar voltage measurement for both sections.
2.	Power transformers	1. Signalling for the exceeded winding temperature (first and second stage). 2. Current measurements.
3.	Motors	1. Motor state control and signalling (as needed, details shown in the figures below) <ul style="list-style-type: none"> ○ permit/stop, ○ start, ○ stop, ○ run, ○ available, ○ auto/manual. 2. Current measurement. 3. Winding, bearings temperature measurement: <ul style="list-style-type: none"> ○ warning, ○ failure. 4. Measurement of vibration parameters.
4.	Frequency converters, soft start systems	1. Signalling of the state of a frequency converter or soft start system: <ul style="list-style-type: none"> ○ warning, ○ failure.
5.	UPS power supply, buffer power supply units	1. Status signalling for UPS or buffer power supply units: <ul style="list-style-type: none"> ○ warning, ○ failure.
6.	Power Controllers	1. Status signalling for the power controller: <ul style="list-style-type: none"> ○ warning, ○ failure
7.	DC Network	1. Status signalling for the direct current network: <ul style="list-style-type: none"> ○ warning, ○ failure.

1. The above binary signals shall be read by the NRB system with a resolution of 100 milliseconds.
2. DCS shall be provided with appropriate graphic symbols to visualise the above signals.
3. Electric signals from specific plants shall be made available to the service through the factory computer network to the NRB system.

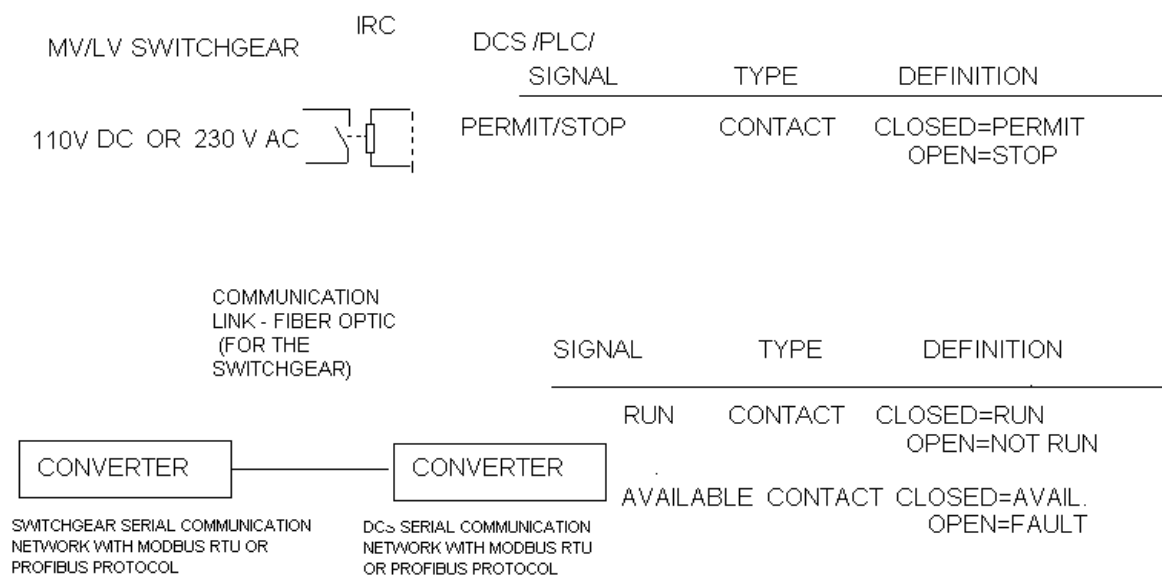
4. The list of signals transmitted to the DCS/ESD, PLC systems and the symbols used to visualise the signals shall be agreed with the Client.

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

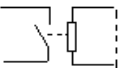
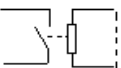

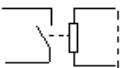

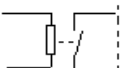
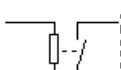
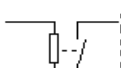


Additionally: current value or other parameters

Fig. 5 Signal transmission diagram. Drives not controlled by DCS

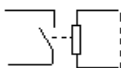
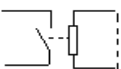

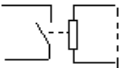
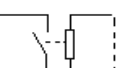



GROUP II - drives controlled from DCS

LV SWITCHGEAR

	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

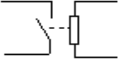
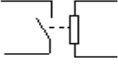




MV SWITCHGEAR

	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		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

Fig. 6 Signal transmission diagram. DCS controlled drive.

GROUP III - ESD controlled drives

<u>LV SWITCHGEAR</u>	IRC	DCS /PLC/		
		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 (note *)	CONTACT	CLOSED=PERMIT OPEN=STOP
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

* - Two separate contacts from TÜV certified relay

MEASUREMENT CIRCUITS (DEPEND ON NEEDS) FOR DCS

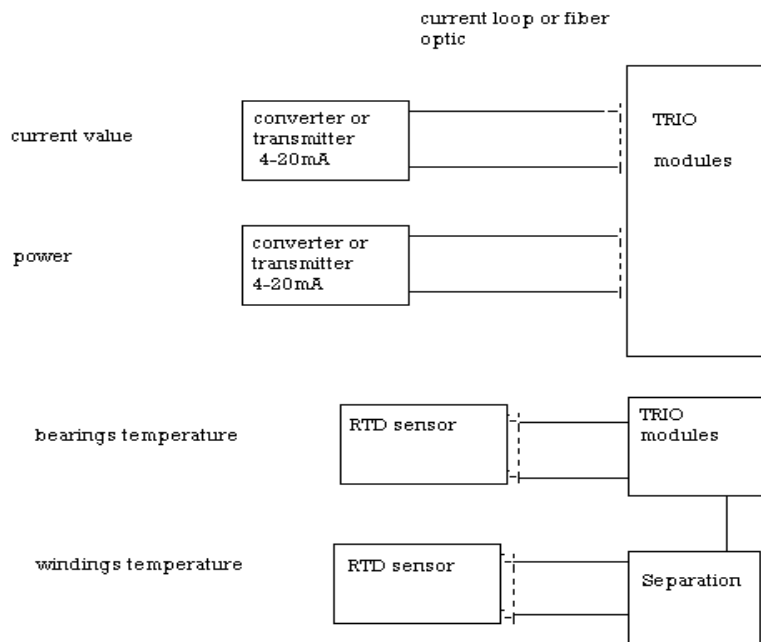


Fig. 7. Signal transmission diagram. ESD controlled drives



6.4. TRANSFORMERS

1. Transformers shall meet the requirements specified in the regulations below, taking into account the Client's requirements.

PN-EN 60076-11	Power transformers. Dry type power transformers.
PN-EN 60726	Dry type power transformers.
PN-EN 50464-1:2007E+A1:2012E	Three-phase oil distribution transformers 50 Hz from 50 kVA up to 2500 kVA with the highest voltage of the device not exceeding 36 kV - Part 1: General requirements

1.1 Dry isolation transformers.

1. Power transformers shall have the following parameters:

Connection group	Dyn5
Rated voltage	6300/400V, 6300/690V (HV/LV) 10500/400V, 10500/690V (HV/LV)
Voltage regulation	Primary side tap changers, in de-energized condition, in the range of $\pm 2 \times 2.5\%$
Short circuit voltage	6%
HV/LV insulation	Resin
HV/LV insulation temperature class	F
HV/LV winding material	Copper/Copper
HV insulation design	Vacuum flooded resin, flame-retardant
LV insulation design	Impregnated resin
Protection degree	IP00

Transformers with a rated powers selected from the main type series (... 630, 1000, 1600kVA) shall be used. Based on the technical and economic assumptions, higher values of rated power of transformers can be agreed on with the Client.

2. The transformers shall be equipped with necessary protections:
 - Instantaneous overcurrent protection against phase-to-phase short circuits,
 - Earth fault protection,
 - Winding temperature protection,
 - Main and standby time-delay overcurrent protection against external short circuits in the LV network.
3. The power transformers shall be equipped with double thermistor sensors with a positive temperature factor (PTC) that are installed in each phase of the LV winding.
 - The sensors shall be connected in series with the ends connected to the terminal strip.
 - The winding temperature protection shall be a two-stage design where: the first stage sends a warning signal and the second stage sends a signal to switch off the MV bay.

The signals about the exceeded first-stage and second-stage temperature shall be transmitted to the DCS system.

- The transformer cooling requirements and temperature protection settings shall be compliant with the manufacturer's recommendations.
- The auxiliary circuits of the winding temperature protection shall be supplied with the substation guaranteed voltage.

4. The neutral point of the transformer low voltage winding shall be directly grounded.
5. Power transformers shall be connected from:
 - high voltage side by a cable line or bus bar.
 - low voltage side by a bus bar.
6. Transformers shall be suitable for operating conditions in the spinning reserve mode, i.e. each of the two transformers shall be able to take over 100% of the load of the entire switching station.
7. The transformer load shall not exceed 50% of their rated power when operated in the normal mode.
8. Power transformers shall be situated in transformer chambers or in separated rooms.
9. It is permissible to use oil transformers for the technological loads for which it is necessary or technically justified.

1.2 Oil isolation transformers.

1. Power oil transformers shall have the following parameters:

Connection group	Dyn5 (0,4 kV) i YNyn0 (0,69 kV)
Rated voltage	6300/400V, 6300/ 690V (HV/LV) 10500/400V, 10500/690V (HV/LV)
Voltage regulation	tap changer with no voltage 7-position, mechanical construction, with manual drive, the ability to lock the position on each hook and permanent marking in the form: + 7.5%, +5%, + 2.5%, 0, -2.5% , -5%, -7.5%. Access to the switch lever, with the cover of the DN and GN connection cables closed
Frequency	50 Hz
Short circuit voltage	6,6 ÷ 7%
Place of installation	Inside / Outside
Maximum ambient temperature	40 °C
Cooling	ONAN with electric insulating oil, uninhibited, not containing PCBs and corrosive sulfur, meeting the requirements of the following standards: PN-EN 60156: 2008P
HV/LV winding material	Copper/Copper
Sheaths for DN and GN connecting cables	cable shields on the side DN and GN for protection against contact with a degree of protection of min. IP44



Isolation level G.N.	75kV
Isolation level D.N.	8 kV
The level of losses P_o i P_k	in accordance with the EU Commission Regulation No. 548/2014 regarding Directive 2009/125 / EC

Maximum ambient temperature: + 40 ° C.

Minimum ambient temperature: -30 ° C.

Contamination level: according to IEC 60815: strong soiling in the 3rd soil zone.

2. Transformer equipment:

- The transformer is required to have all copper windings
 - Handles for lifting and moving the transformer
 - Chassis with 4 wheels to move in both directions
 - Oil fill
 - Nameplate
 - Grounding terminal
 - Drain valve
 - Conservator of Buchholz relay between ladle and conservator,
 - Oil level indicator in the conservator - magnetic
 - Two-contact thermometer
3. Oil level indicator, protected against mechanical damage by a metal cover, placed on the cover of the transformer, in a manner that ensures readable reading of the oil level on each side of the transformer.
4. In addition to the requirements of the transformer tightness standard with overpressure that may occur during operation, no oil leakage is allowed.
5. A pressure relief valve that opens when the permissible oil pressure inside the ladle is exceeded.
6. Transformers should have earthing terminal for connection with a grounding conductor (steel sheeting dimension 30 mm x 4 mm). Require minimum 2 grounding points.
7. The lid should be fastened to the ladle with screws, it is not allowed to connect the lid with the ladle by welding.
Painting ladles, accessories and heat sinks with paints resistant to transformer oil and a high degree of chemical resistance in class C5-I, e.g. with a minimum thickness of 300µm (minimum 2 layers of 100µm undercoat and 2 protective layers of 50µm each). Protection only by galvanizing can not be used due to the possibility of the presence of ammonia and nitrogen oxides in the atmosphere. We also allow powder painting.
8. All tests, trials and their parameters - in accordance with current standards.
9. The tap changer should be rack mounted, built into the ladle with manual drive on the cover. The tap position indicator should be visible and legible. Switching in the potential-free state should be on the GN side.
10. In the case of transformers up to 250kVA, it is allowed to make transformers in a hermetic housing. Tray of the transformer in a hermetic, closed version, without a conservator and a



gas cushion under the ladle cover, equipped with a pressure relief valve. The lid should be fastened to the ladle with screws, it is not allowed to connect the lid with the ladle by welding. Compensation for changing the volume of electrical insulating oil in the transformer caused by the change of its temperature should be done by deforming the sealed ladle.

11. Technical project should present solution of sealed reinforced transformer tray's with capacity larger than transformer oil volume.. Transforemer tray drainage done as petroleum-derived separator (coalescing) with drain to industry savage system. Should be used separtaor with electrical signal system, enter the signal to common control system. Install normal closed shut-off valve (before separator), enter the status signal to common control system. Oil sump covered with crushed stone placed on steel grate. Protect with horizontal and vertical insulation(chemically-resist and waterproof).f
12. The foundation for transformer should be make as a rain-forced concret slab-rib block(vertical). Transformer chamber should be equiped with track and anchor system enabling motion of transformer out of building contour according to PN-EN 61936-1. Closer than 3 m from the buildings, reinforced concrete fire walls should be used.
13. Fire protection transformer stations:
 - Fire protection transformers installed outside with dry sprinkler installations. Starting the automatic sprinkler system, using a flood valve.
The foundations for the transformer should be made as a reinforced concrete slab-slab block consisting of a slab and vertical ribs.
The transformer tray made of tight ferroconcrete pipes should be provided for with a capacity greater than the capacity of oil from the transformer. Dehydrate the trays through a separator of oil derivatives (coalescent) to the industrial sewerage system. Use the separator with the work signaling system. Install shut-off valves normally closed with position signaling in front of the separator.
The bowl of the oil transformer must be covered with crushed stone placed on a steel grate and secured with horizontal and vertical insulation, chemical insulation and waterproofing.
The equipment of boxes with a track and anchor system enabling the transformer to be pulled out of the boxing construction outline in accordance with the PN-EN 61936-1 standard from 2011 below 3 m from buildings should be used reinforced concrete fire walls.
 - Fire protection indoor transformers should be made permanent gas extinguishing devices; the security method must be agreed with the Commander of the Factory Fire Service (ZSP) ANWIL S.A.
The technical documentation must also include calculations regarding the fire load of the transformer chamber (and the door) and checking against the construction requirements given in the Regulation of the Minister of Infrastructure of 12 April 2002 on technical conditions which should be met by buildings and their location.
Fire protection designs should be agreed with an expert on fire protection.

6.5. SPECIAL POWER SUPPLY SYSTEMS

6.5.1. SPECIAL LOW VOLTAGE POWER SUPPLY SYSTEMS



1. Special power supply systems shall be used for the following loads:
 - 230V guaranteed AC voltage supply system for the needs of the DCS control system and the control & instrumentation equipment in interlocking systems.
 - 3x400/230V guaranteed AC voltage supply system for the needs of electric motors required by the technological process.
 - 230V guaranteed AC voltage or 220VDC voltage supply system for the needs of emergency lighting.
2. Special power supply systems shall be based on buffer supply from batteries through the application of systems that enable uninterruptible switching to the operation on batteries.

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

The following shall always be agreed upon with the Client's Technical Analysis Department:

- Conditions for the mutual operation of the power generating sets with a separated power system supplied from the set.
 - Application system design for the power generating sets.
 - RFQ for the delivery of power generating sets.
 - Selection of power generating set supplier.
3. A special power supply system shall ensure an uninterrupted operation of selected groups of devices in the case of occurrence of bad supply voltage quality parameters (e.g. a loss of voltage in the main power supply network, etc.).
 4. The primary emergency power supply system for loads of:
 - the AC voltage is a UPS unit that utilises its own local battery bank or an external bank of batteries.
 - the DC voltage is a buffer supply unit (rectifier) with a battery bank connected to its clamps,
 5. Power electronic devices: frequency converters, soft start systems, power controllers, etc. shall be installed in separated cabinets or LV switching bays in accordance with the following requirements:
 - Power circuits and control & measuring circuits shall be so installed in accordance with the guidelines that ensure electromagnetic compatibility (required spacing shall be kept, shielding for power circuits shall be applied by placing in a separate compartment, etc.),
 - Power circuits shall be equipped with switch disconnectors that enable safe performance of the maintenance work,
 - The temperatures inside the cabinets or switching bays shall be kept below 30° C (e.g. through the application of ventilation),
 - The outside noise level at a distance of 1 meter to the cabinet shall be lower than 60 dB.
 6. The Contractor shall deliver the electronic power equipment documentation to the Client for approval no later than at the time of delivering the equipment for installation.
The electronic power equipment documentation shall include:

- The operating and maintenance manual in English and Polish containing, in particular, the details of power circuits, auxiliary circuits, etc.
 - The design documentation containing, in particular, the description of the application system, the layout of external connections of the electronic power equipment, a list of parameter settings, etc.
 - The documentation shall be delivered in printed and electronic versions – Acrobat Reader standard (.pdf).
7. All marking should be in Polish. In the case of a foreign manufacturer, it is permitted to use markings in English alongside.
8. Each device should be described using permanent label mounting in accordance with the diagram.

6.5.2. BUFFER POWER SUPPLY UNITS

1. Buffer power supply unit shall be adapted to supply direct current loads and charge buffer type battery banks.
2. The buffer power supply unit shall have the following characteristics and parameters:
 - High voltage stability (variability below 1%) and low rectifier output voltage ripples (below 0.5%) within the load range of 0 to 100%, and low voltage fluctuations of $\pm 15\%$ in the power supply network,
 - Ability to set an output voltage and a battery current limit,
 - Galvanic separation of DC and AC circuits,
 - Built-in electronic protection against short circuits and overloads,
 - A display that is easy to read and operate to indicate all output parameters and alarm conditions of power supply unit operation, as well as signalling for exceeded alarm parameters along with an alarm history with a real time stamps
 - Temperature-based adjustment of the buffer voltage,
 - External measurement of battery charging current,
 - High reliability.
3. Buffer power supply unit shall be equipped with the following systems:
 - RS 485 interface with software to ensure a full remote control of the power supply unit operation from a PC computer,
 - Thermometer probe (range from -10°C to $+40^{\circ}\text{C}$) together with a temperature-based battery charging voltage adjustment system,
 - Automatic battery circuit continuity supervision,
 - Continuous measurement of charge to and from the battery,
 - Quick battery charging,
 - Continuous earthing supervision,
 - A set of contacts for interoperation with the DCS, NRB systems.
4. The buffer power supply unit shall enable the expansion of the powered network system.
5. The buffer power supply units shall meet electromagnetic compatibility requirements specified in European directives and standards.
6. The level of higher harmonic interference determined by the THDi coefficient shall be less than 10% for the current consumed by the power supply unit.



7. The power supply systems shall be installed in low voltage switchboard cabinets that are an integral part of the TPS panel. Equipment that enables disconnection of the input and output of buffer power supply unit shall be used.
8. Buffer power supply units shall correctly operate in combination with capacitor banks that are connected to a joint switchboard.

6.6. UPS UNITS

6.6.1 UPS systems shall be used to deliver guaranteed AC voltage to:

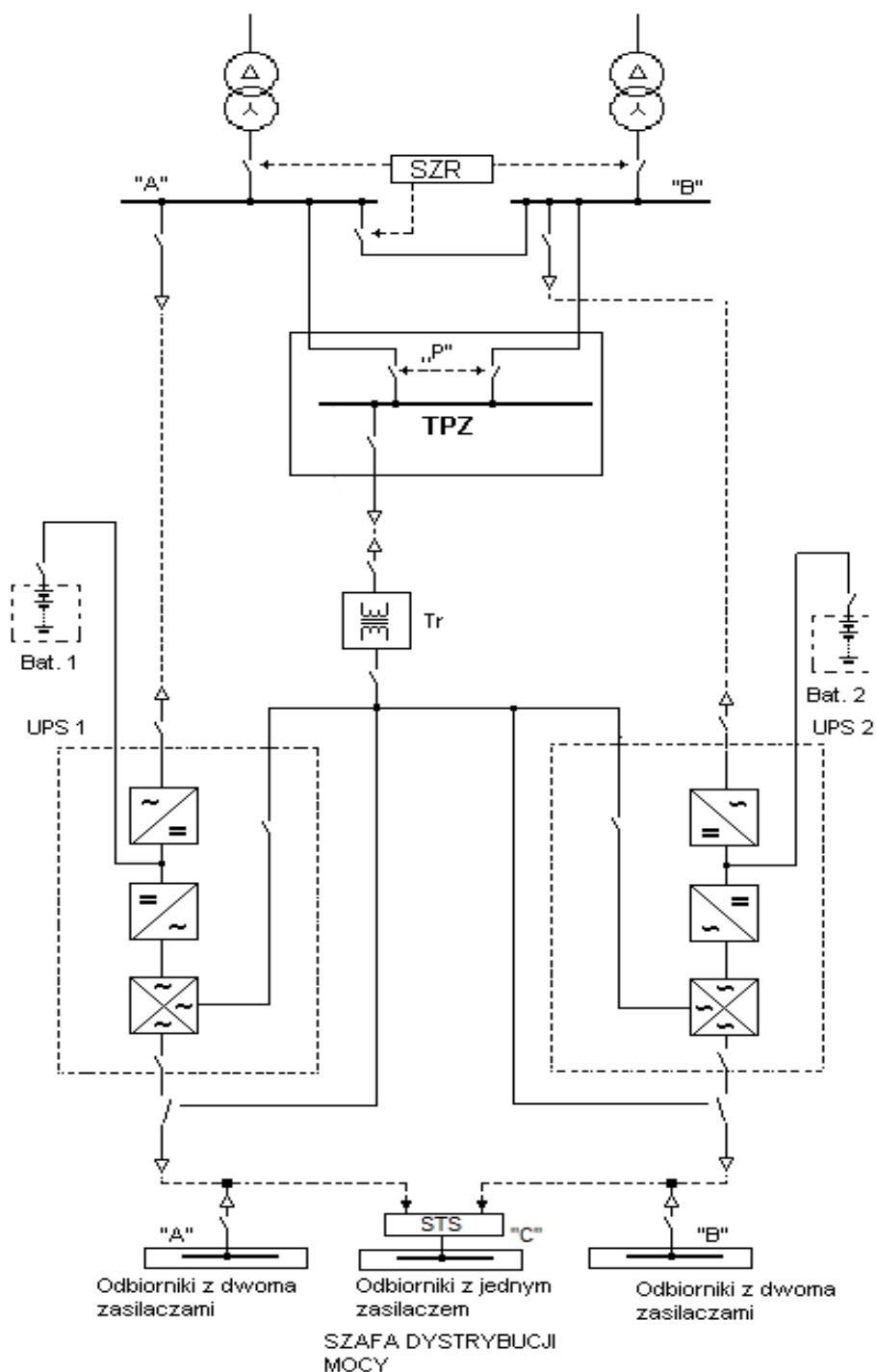
- DCS control systems and interlocking of automatics control and measurement systems.
1. All UPS systems shall be equipped with switchboard TP, enabling switching operations, including switching on bypass.
 2. UPS system dedicated to supply DCS systems and interlocking automatics systems and measurements shall be configured according to requirements, as below:
 - a) systems consisted of two UPS supply units and static-switch /STS/, applied as basic solution in new-designed or modernised production plants.

Two UPS supply units working independently, supply two independent bus-bar sections in power distribution cabinet (section “A” and section “B”). Through static-switch /STS/ supplied is third section of guaranteed voltage system. (section “C”).

Consumers equipped in two supply units should be connected to power distribution cabinet so, as one supply unit was connected to first section (section “A”), and second supply unit to second section (section “B”) of power distribution cabinet.

Redundant consumers shall be connected to separated bus-bar section of power distribution cabinet (section “A” and section “B”)

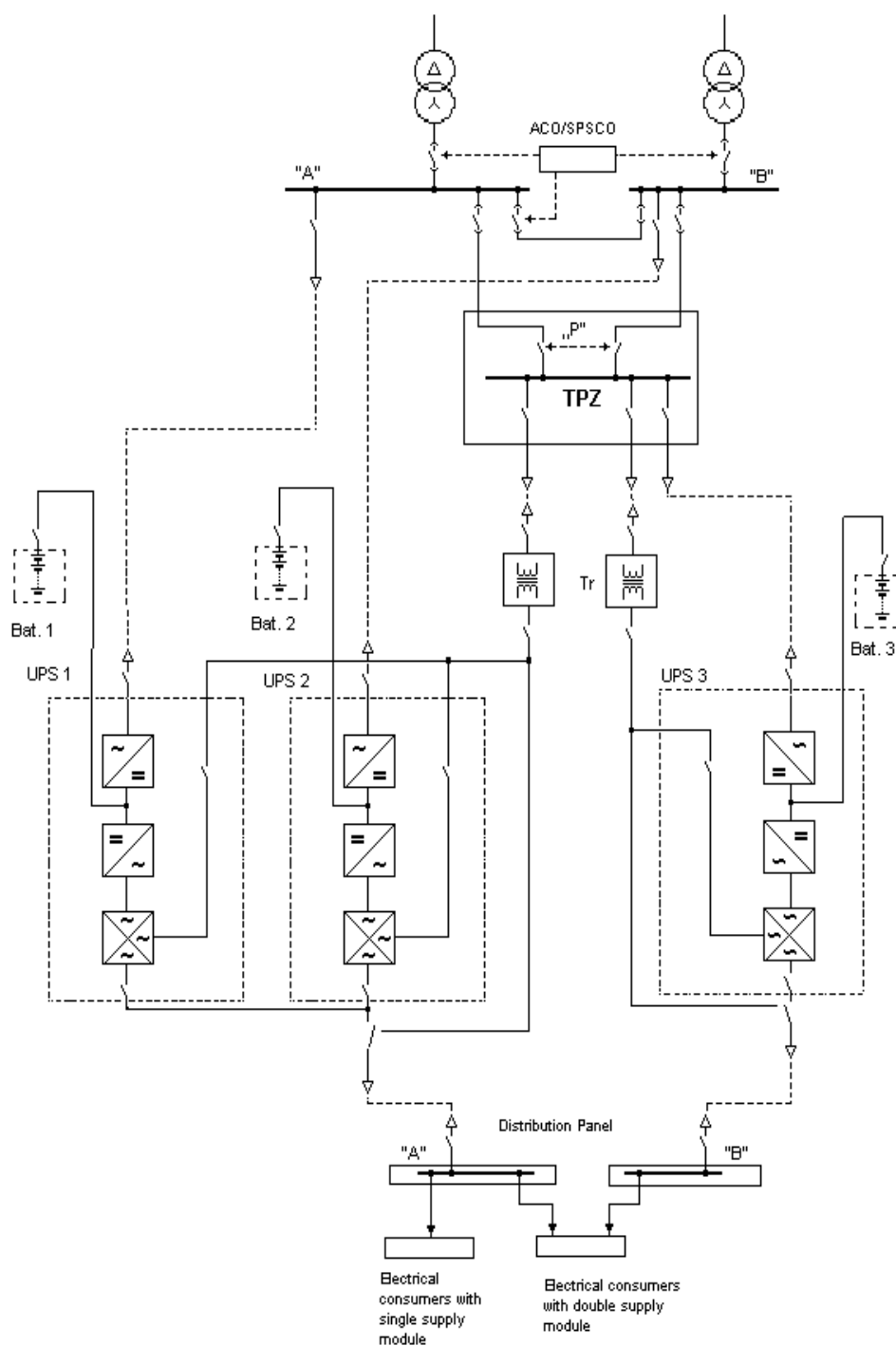
Consumers equipped with single supply unit and not-redundant shall be connected to third bus-bar section (section “C”) of power distribution cabinet, supplied via static-switch /STS/ located in TP switchboard.



Dwg. 2. Guaranteed voltage supply system for DCS system, alternative 2 – two UPS units and three guaranteed voltage bus-bars arrangement. Arrangement recommended for new designed or modernised production plants.



- b) Systems consisted of three UPS supply units, applied as alternative solution in new designed or modernised production plants.
- Two UPS supply units working as parallel, redundant unit, supply first guaranteed voltage section in power distribution cabinet. Third UPS supply unit supply second guaranteed voltage section in power distribution cabinet.
- Consumers equipped in two supply units should be connected to power distribution cabinet so, as one supply unit is connected to first section, and second one supply unit is connected to second section of power distribution cabinet.
- Consumers to be redundant shall be connected to separated sections of power distribution cabinet.
- Consumers equipped with single supply unit and not to be redundant shall be connected to first section of power distribution cabinet, that is fed by two UPS units operated in parallel, redundancy arrangement.



Dwg. 3. Guaranteed voltage supply system for DCS system, alternative 1 – three UPS units arrangement. Used as alternative solutions for ne designed or modernised production plants.

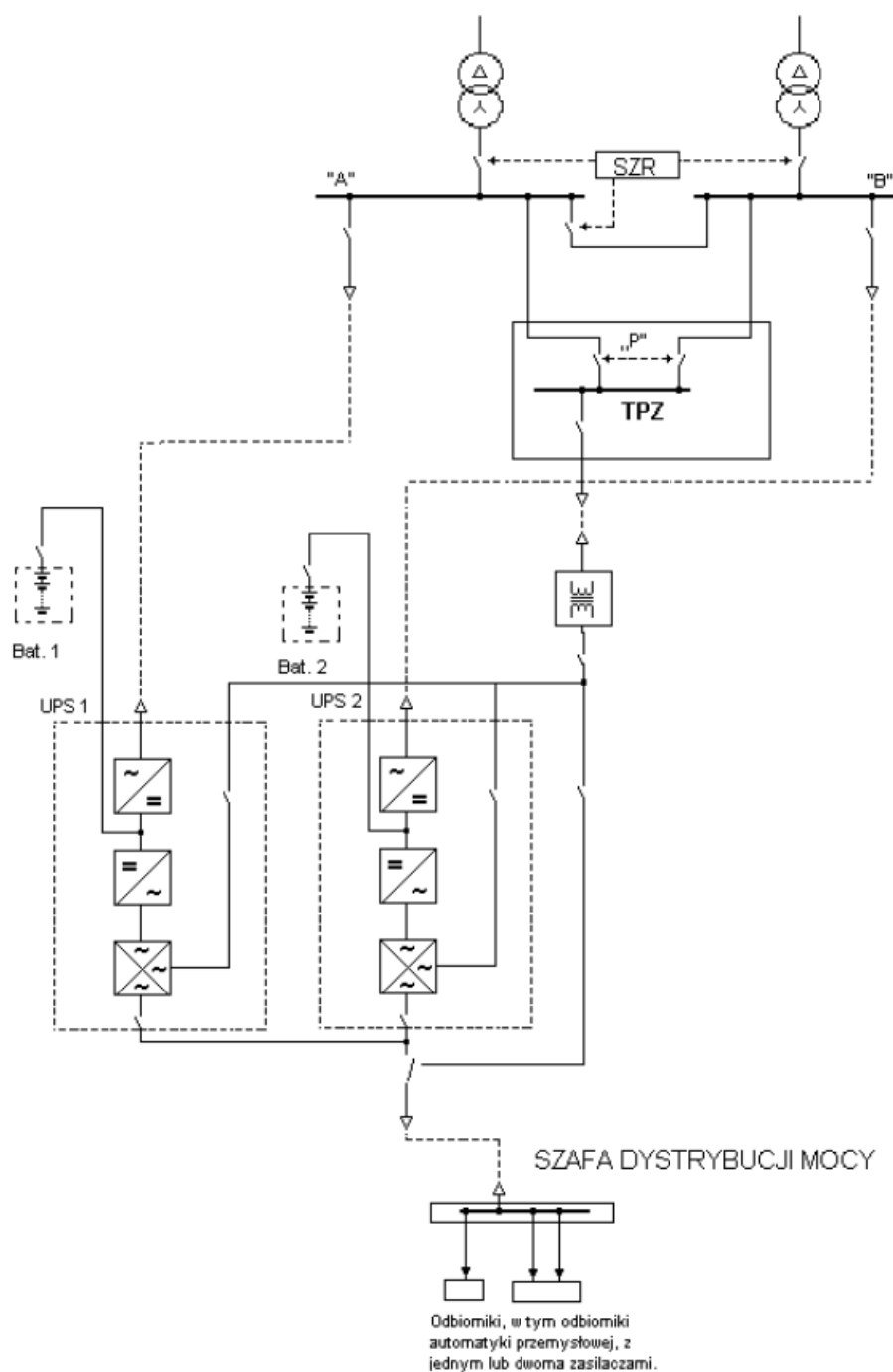


3. UPS system dedicated to supply DCS systems of discontinues process with single supply bus-bar or critical IT nodes shall be configured according to requirements, as below:

- a) Two UPS supply units operating in parallel, redundant arrangement.

Two UPS supply units operating in parallel, redundant arrangement fed single, common guaranteed voltage bus-bar in power distribution cabinet.

Consumers equipped with single power unit or equipped with two power units, in this configuration are connected to common guaranteed voltage bus-bar supplied through two UPS units working in parallel arrangement.



Dwg. 12. Guaranteed voltage supply system for DCS system of not continuous process
- two UPS supply units arrangement. Basic solution.

6.6.2 UPS supply units requirements

1. All UPS supply units shall meet the following requirements:
 - 1.1. UPS supply units shall meet electromagnetic compatibility requirements as specified in European parliament and Council directives in relation to resistance to outdoor interference and limitation of level of interference emission to the environment.
 - 1.2. Each UPS unit shall have the following parameters:

Mode of operation	Continuous operation, double conversion (True on line),
Efficiency	Higher than 85% for a 100% load,
Input voltage	1x 230V or 3x 400/230V,
Input voltage tolerance	from -15% to +10% of voltage,
Rated input voltage frequency	50Hz,
Input voltage frequency tolerance	from 0.5% to 8% of the rated input voltage frequency,
Output voltage	230 V or 400/230 V,
Output voltage stability	Statically +/- 1%, Dynamically +/- 2%,
Output voltage frequency	50Hz
Output real power factor	>0.95, independent of load
Stability of output voltage frequency	No less than $\pm 0.1\%$ when operated on battery,
Input current THD	Less than 10%,
Output voltage THD	Less than 3%,
Permissible noise level	Less than 60dB,
Crest factor	5:1,
IP protection degree	No less than IP20,
Autonomous time	Dependent on the application,
Maximum time of UPS output deenergisation	10 milliseconds,
Service access	Front service access only.

- 1.3. UPS units shall meet electromagnetic compatibility requirements as specified in European directives and standards.
- 1.4. Each of UPS units shall have an input system to guarantee the interference into the power supply network to be as determined by THD coefficient for a current less than 10%.

- 1.5. For UPS units of a rated power:
 - lower than or equal to 30 kVA at the input, harmonics filters shall be installed.
 - higher than 30 kVA at the input, a separation transformer with a 12 pulse rectifier and harmonics filters shall be installed.
- 1.6. 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.
- 1.7. Each UPS unit shall be provided with a separating output transformer.
- 1.8. UPS units shall be equipped with an internal protection against external short circuits and overloads.
- 1.9. Inputs and outputs of UPS units shall be protected against voltage surge by means of surge limiters that are compatible with: parameters of UPS units, power supply network for UPS units, and UPS fed equipment.

Surge limiters with replaceable modules, optical indicator and auxiliary contact shall be used. Fuses shall protect surge limiters.

There shall be ensured that fuse elements to protect surge limiters and surge limiter containing elements can be replaced during operation of UPS units.
- 1.10. 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.
- 1.11. UPS units shall be located in ventilated and air-conditioned rooms.
- 1.12. Each single UPS unit shall be provided with its own separate batteries set with a backup time of more than or equal to 30 minutes. The backup time may be extended if process required.
- 1.13. It is recommended to use external battery laid on rack.

Accumulator battery and cooperated with it UPS supply unit shall be connected via as short as possible cable line using fuse disconnectors.
- 1.14. The battery sets and UPS unit shall be interconnected with a short, if possible, cable distance, using fuses disconnectors.
- 1.15. Basic requirements for UPS unit:
 - 1.15.1. The UPS unit should have a semiconductor rectifier (with 100% output power) with galvanic isolation to the power inverter (100% output power).
 - 1.15.2. The UPS unit should be provided with a dedicated semiconductor charger for charging / recharging bank of batteries.
 - 1.15.3. Capacitors should be selected to a temperature from -40°C to +105°C.

- 1.15.4. Maximum operating voltage capacitor should be $0.8 \times U_n$ capacitor.
- 1.15.5. All electrics plate should be varnished on both sides.
- 1.15.6. UPS supply units should have a fan failure signal. It should be possible to replace the fan while the unit is running without shutting down the UPS
- 1.15.7. UPS supply system should have cable entries enclosure bottom. UPS supply unit should have the ability to work with disconnected battery.
- 1.15.8. Internal connections lines should be marked near the connections. Final devices and equipment should be described according to installation documentation.
- 1.15.9. UPS supply unit should have the ability to work with disconnected battery.
- 1.15.10. Transition of output voltage without synchronisation, in case of inverter failure. Time interval cannot be longer than 14 millisecond.
- 1.15.11. 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.
- 1.15.12. Signalisation of system operation state:
 1. Local (UPS unit) diode signalling of block scheme of the UPS elements and operation states and the display for (among other things) readings of measured available parameters, alarms and history events with real time stamp.
 2. 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.
 - Communication module servicing protocols IEC 61850 (fiberoptic or RJ45), IEC 60870-5-103 or alternative MODBUS RTU (RS485) cooperating with NRB system.
- 1.15.13. Alarm history with real time stamp (concerns UPS supply units and buffer supply units (battery rectifiers).
- 1.15.14. UPS supply unit should have dedicated signals of battery recharger failure.
- 1.15.15. Dedicated battery charger should have the possibility to set battery charging parameters.
- 1.15.16. Dedicated battery charger should have a current limitation module adapted to battery characteristic.

1.15.17. UPS supply unit should be equipped in service terminals allowing testing of UPS under load with supplying consumers via bypass.

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

- 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.
- 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).
- UPS supply unit should have ability to cooperation with supervisory systems (e.g. DCS, NRB) in necessary scope.

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

2. Static-switch requirements

External static-switch /STS/ is required for feeding bus-bar "C" in Power Distribution Cabinet.

Required is high overload of static-switch STS, no lower than overload of UPS supply units, which power it. To ensure fast disconnection by protections, in case of short-circuit required is overload min. 1500% \times I_n in time 20 millisecond.

Static-switch STS should be equipped in service bypass, enabling uninterruptible over-switching feeding of consumers on preferred power line. After switching-over of static-switch STS should it be insulated, in purpose to enable conducting service work.

Required is functionality of parametrisation of static-switch.

3. How to select UPS units (DCS).

3.1 The required UPS rated power shall be defined in the basic instrumentation, IT or electrical engineering, according to the application.

3.1.1 The above design shall contain data for each cubicle of the power distribution cabinet and data that are necessary to select an UPS unit.

3.1.1.1 The data sheet for each cubicle shall include at least the following information:

- a) Cubicle number,
- b) Active power and active power factor calculated for consumers that are fed from the related cubicle.
- c) Protection devices parameters (sort of protection, type of protection, rated current, etc.),
- d) Peak current value for consumers connected to the related cubicle,

- e) Time of flow of the above peak value current,
- f) Time of critical voltage decay that is characteristic for consumers that are connected to the related cubicle, which causes an emergency technological process shutdown.
- g) 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.
- h) Anticipated increase in active power demand considering expansion of the related cubicle.

3.1.1.2 The data that is necessary to select a UPS unit shall comprise at least the following information:

- a) Active power utilised by consumers that are connected to the power distribution cabinet,
- b) Active power factor for consumers that are connected to the power distribution cabinet.
- c) Time of critical voltage decay that causes an emergency technological process shutdown.
- d) Peak current value consumed by consumers that are connected to the power distribution cabinet,
- e) Time of flow of the above peak value current,
- f) Level of surge protection required for the power distribution cabinet
- g) Anticipated increase in active power demand considering expansion needs.

3.2. All outgoing circuits of the power distribution cabinet shall:

- a) Be protected against mechanical damage,
- b) Meet requirements for a correct operation of protective devices in relation to the purchased UPS units; e.g. meet UPS vendor specific requirements permissible drop voltage.
- c) Be marked in such a way that they can be distinguished from non-guaranteed voltage circuits.

3.3. Following the above basic engineering, the electrical engineer shall determine the rated power of UPS units, arrangement of operation of UPS units, power distribution cabinet and relations with power supply network, additionally considering the following:

- a) Power system parameters in point of UPS units' connection.
- b) 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).

- c) Protection against electric shock (shall be checked for UPS units powered from the electric power system and for UPS unit powered only from battery).
 - d) Voltage surge protection (proper graduation of voltage surge graduation shall be provided).
- 3.4. The power distribution cabinet shall have a high operational and consumers feeding reliability to be achieved by:
 - a) Very good insulation parameters of bus bars and outgoings.
 - b) Reliability of switching operations.
 - c) Convenient access to switches and protective devices.
 - d) Cubicle identification uniqueness.
 - e) the UPS power distribution cabinet (BUS A, B, C) should be equipped in fuse systems controlling the fuse insert with signaling to the DCS system.
- 3.5. During electrical design work phase, agreements shall be made with the Chief Electrical Engineer's Service with regard to:
 - a) arrangement of UPS units,
 - b) Power distribution cabinet,
 - c) RFQ for purchase of UPS units,
 - d) Selection of UPS unit vendor.

6.7. BATTERY BANK FOR GUARANTEED VOLTAGE SYSTEMS

1. Battery banks for the operation in conjunction with buffer power supply units shall be selected considering the rated voltage of the circuit and the operating conditions in the range from 85% to 110% of rated voltage value. Use lead-acid batteries with liquid electrolyte and gas recombination (large format positive board according to DIN40738). The efficiency of gas recombination for the maintenance voltage should be higher than 95%. A recombination system should be used with durability not less than for batteries. The producer of cells should also be a producer of recombination and plates.
2. Battery banks for the operation in conjunction with UPS units shall be selected in accordance with the requirements of UPS unit manufacturers.

Aging factor	1.25
Temperature factor (ambient temperature)	from +15 ⁰ C to +25 ⁰ C
Final discharge voltage	1.75V/cell
Cosφ (for the full load of the UPS system)	1



3. Battery banks shall consist of lead-acid cells:
 - Conventional batteries with recombination plugs,
 - Anwil allows VRLA batteries only in the case of insufficient space for classic batteries and after consultation with the GT Technical Analysis Department. VRLA batteries should be made with an adjustable safety valve with electrolyte trapped in separator with glass mat / AGM /.

The abbreviations used are in line with the indications given in the Eurobat.
4. Conventional batteries shall have the following characteristics:
 - Lead-acid batteries with liquid electrolyte (positive pasted plate).
 - The cells shall belong to the longest life category, i.e. over 18 years (15 years for monoblock).
 - Cell rated voltage shall be 2V.
 - The gas recombination efficiency for the preservation voltage shall be higher than 95%. The lifetime of the recombination plugs shall be at least equal to that of the batteries.
 - Battery enclosures shall be made of materials with self-extinguishing properties, shall be resistant to mechanical, thermal and electrical damage. The enclosure shall be sealed. The enclosures shall be transparent.
 - The poles shall be insulated.
 - The cells shall not require forced ventilation during operation.
 - The manufacturer of the cells shall be the manufacturer of the recombinators and plates, as well.
5. VRLA batteries shall have the following characteristics:
 - The cells shall belong to the longest life category, i.e. over 12 years /LL/
 - Cell rated voltage shall be 2V.
 - The poles should be insulated.
 - The cell case shall be made of self-extinguishing materials and resistant to mechanical, thermal and electrical damage. The enclosure shall be sealed. Handles shall be integrated into the enclosure and the fire resistance class in Euroclass System according to UL94 (Underwriters Laboratories Standard).
 - The cells shall not require forced ventilation during operation.
 - Continuous battery preservation voltage at normal temperature shall be in accordance with requirements of the battery manufacturer.
 - The manufacturer of the batteries shall be the manufacturer of plates, as well.
6. Batteries shall be provided with an installation, operating and maintenance manual. The manual should have a confirmation of battery conformity to the requirements indicated in the Eurobat guidelines (declaration, certificate, etc.)
7. The battery bank shall be placed on a rack in a separate electrical room that ensures an easy access to the battery blocks during operational activities. The battery room shall ensure special temperature conditions according to manufacturer's instructions for optimal battery life.
8. Appropriate temperature conditions shall be maintained in such room throughout the year.

9. The dedicated battery room shall be designed and operated in accordance with PN-EN-IEC-62485-2:2018. Safety requirements for secondary batteries and battery installations. Part 2: Stationary batteries.

6.8. DIESEL ELECTRIC GENERATOR

1. COMPRESSION IGNITION ENGINE:

- Turbocharged,
- Direct injection,
- Liquid cooling system,
- Rated engine speed: 1500 rev/min,
- Supply voltage of auxiliary circuits and engine additional system as 24VDC,
- Heating system for engine block providing engine start under 0 Celcius degree,
- Buffer power supply providing sterter batteries as state of charge,
- Heat exchanger assembly for disel-generator system,
- Starter batteries bank.

2. Generator:

- Singel-bearing, Self-inducted, Self-regulated, brushless, synchronous with external surge suppressor circuit,
- Wiring coil insulation class H,
- Rated voltage: 400V/230V AC,
- Voltage regulation control system,
- Harmonic contents THDi under 2% (free of load),
- Generator efficient in nominal load at 93.2%,
- Voltage stability: +/- 0,5%,
- Frequence stability: +/- 0,25%,
- Short term current capacity: 300%,
- IP23.

3. Generator assembly unit:

- Genarator unit at G3 class clasification, quality requirments for electrical supply.
- Generator unit based on steel frame, mechanical desing based on vibration absorber between frame and engine-generator assembly,
- Guaranted time (full tank) at full load minimum 24h,
- Run-up time (inculding synchronous) short than 60s,
- Interface including parameters of work from combustion engine and generator. System equipped with diagnostic unit presented warning, alerts, failitures and event history.
- Control unit treat as internal. Housing have to by antyshock and sealed,
- Control unit software should allow set up autonymous, periodic run-up test,
- Control unit software should allow manual generator run-up at full/minimal load, ,
- Generator unit system providing protection from::

- Combustion engine overheated protection,
- Lubrication oil's low pressure protection,
- Overspeed protection,
- Oil overheated protection,
- Coolant low level protection,
- Underspeed protection,
- Overvoltage protection,
- Undervoltage protection.

4. GENERATOR UNIT CHAMBER:

- 2 gate,
- Double-jacked tank equipped with breath flame arrester valve,
- Fuel pump,
- Mechanical design allow refueling from outside area on generator online mode,
- Inlet/exhaustion hoses thermal isolation,
- Mechanical air circulation,
- Inlet/exhaustion hoses equipped with environmental protection and noise muffler,
- Primary and Emergency lighting system,
- Voltage socket outlet system protected by overcurrent, residual current protection,
- Safety rules require maintenance area as 0,75[m] free space. Mechanical design allow free maintenance space to all assembly part.
- Generator unit have to ensure acoustic isolation,
- Mechanical design of generator unit treat as hermetic(fuel,oil coolant) U-shaped. Technical floor covered by environmental safe impregnation.

5. ADDITIONAL REQUIREMENTS FOR DESIGN OF GENERATOR UNIT (CHAMBER OF THE GENERATOR):

- System/Maintenance manual, polish language
- Technical datasheet, polish language
- Contractor should attach protocol from Test&Measure facilities. Protocol should include the test result from ventilation system, cooling system, oil system, fuel supply system, exhaust system, generator control system, emergency lighting. Contractor should present technical assumptions to T&M station and where is installed.
- Electrical installation corresponding to polish law,
- Corresponding to Directive: MD 2006/42/EC, EMC 2004/108/EC, LVD 2006/95/EC,
- Corresponding to norm: PN-EN 60204-1, PN-EN 60439-1,
- Anwil requirement to noise protection at 85db measure from 1m to source of noise corresponding to : NEE 2000/14/EC, 2005/88/EC,



6. WARRANTY:

- Warranty 24 month or 1000mh whichever comes first,
- The granted warranty should include all costs related to the required warranty inspections.

7. TECHNICAL DOCUMENTATION

7.1. CONTRACTOR'S OBLIGATIONS

1. The coordination of all the activities related to the subject matter of the project falls within the scope of the Contractor's obligations.
This includes the main scope of the procurement as well as the scopes arising from contracts with other Participants of the investment project.
The Client shall indicate Participants of the project at the Contractor's request.
2. The Contractor shall provide the ANWIL SA Project Manager with the necessary documentation for all the machines, devices and installations within the scope of a contract, as stipulated below:
3. Technical design containing:
 - List of contents,
 - List of used acronyms and symbols,
 - List of used standards and regulations,
 - The contents of the volumes with the design documentation from the perspective of the process, the plan of the plot or the technical requirements,
 - Technical specification,
 - Project assumptions,
 - All the calculations for the selection of machines, devices, settings of protective devices, parameterisation of machines and devices, etc.,
 - A complete list of motors, electrical accessories and equipment. This list shall include the following data:
 - Name of the device,
 - Its process symbol,
 - Technical parameters, including:
 - type,
 - name of the manufacturer,
 - rated voltage,
 - nominal power,
 - active power factor,
 - rated current,
 - starting current,
 - permissible frequency adjustment range,
 - designation of the explosion proof design certificate,
 - explosion proof design characteristics (Ex symbol, symbol of each kind of explosion proof design used, device group symbol, temperature class),
 - name of the testing station,



- additional marking required by European standards for a particular kind of explosion proof design,
 - additional marking required by product for particular kinds of explosion proof designs,
 - normal marking specified by production standards for a part or an Ex component which do not require verification by a testing station.
 - Diagram and layouts for the electrical connections of supply circuits, protective devices, control circuits, signalling circuits, measurement circuits, control typification diagrams, outflow lists,
 - Assembly diagrams,
 - Cable list,
 - Plans of the plot showing the layout and identification numbers of all the devices, underground and above-ground sleeve pipes and cable ducts or cable routes, earthing system, etc.
 - Diagrams showing the identifiers, starting location, ending location, cross-section and the type of cable, the diameters and numbers of all cable ducts,
 - A complete set of documentation amended at the construction stage for the preparation of as-built documentation,
 - Classification documentation for the potentially explosive areas,
 - Technical and maintenance documentation as well as operation, installation, user, maintenance and repair manuals,
 - Certificates, attestations, certifications issued by testing stations or other authorised bodies. Declarations of conformity issued by the manufacturers or their authorised representatives
 - Testing reports from manufacturers of the installed devices
 - All written arrangements made with the Client at the stage of design and construction shall remain in association herewith
4. Technical documentation for approval, review and commentary:
- Shall be issued in English and Polish,
 - Shall be divided into volumes, as stipulated below.

A different arrangement of volumes from the one presented below will have to be agreed upon with the Client.

7.2. DOCUMENTATION INDEX

VOLUME 1. GENERAL PART OF THE ELECTRICAL DOCUMENTATION

This part contains the following:

1. List of content
2. Standards and regulations
3. Basic information
 - Basic data
 - Design scope
 - Description of design solutions
 - Protection against electric shock
 - Protection against corrosion and fire
4. Power demand
5. Selection of transformers
6. Selection of static capacitor banks
7. Selection of battery banks
8. HV and LV power system calculations
9. Selection of bus bars and cables
10. Lighting calculations
11. Selection of fuses for three-phase power supply and lighting system
12. Selection of protective devices
13. List of spare parts, bearing and lubricant
14. General operation and maintenance manual
15. General recommendations and remarks
16. List of electrical loads
17. List of control requirements and typical control diagrams
18. Switchboard layout or one-line control diagram
19. Interconnection diagrams for electrical loads

VOLUME 2. ELECTRICAL STATIONS AND SUBSTATIONS

This part of design contains the following:

1. List of content
2. Standards and regulations
3. General specification
4. Power supply one-line diagram
5. MV switchboard one-line diagram
6. LV, contactor and control gear one-line diagram
7. Auxiliary LV switchboard one-line diagram
8. Control diagrams for HV and LV loads
9. Layouts of interconnections between HV switchboards/control system, supervision system
10. Electrical systems for buildings (electrical installations, lightning, earthing etc.)
11. Assumptions for the building permit and installations design
12. Symbols used on the diagrams
13. List of electrical loads



VOLUME 3. CABLES AND POWER INSTALLATION

This part of design contains the following:

1. List of content
2. Standards and regulations
3. General specification
4. Selection of cables
5. HV and LV cable route plans
6. Power installation plans
7. General plan of cables route
8. General plan of cable ladder routes
9. Symbols used on cable and ladder plans
10. Cable list
11. Electrical mounting details for electrical installations
12. Equipment and material list:
 - HV and LV cables
 - Cable route equipment
 - Junction boxes
 - Motor control stations and circuit breakers
 - Plugs and sockets
 - Cable conduits
13. Manufacturer's documentation.

VOLUME 4. MOTORS, UPS, FREQUENCY CONVERTERS, SOFT START UNITS, CRANES AND HOISTS.

This part contains the following:

1. List of content
2. Standards and regulation
3. General specification
4. HV motor specification
5. LV motor specification
6. UPS unit specification
7. Cranes and elevator specification
8. Frequency converter specification
9. Soft start specification
10. List of equipment and material
11. Electrical data sheets of motors, cranes, elevators, frequency converters, soft start units etc.
12. Suppliers' documentation.

VOLUME 5 LIGHTING AND 1 PHASE SOCKETS OUTLETS INSTALLATION

This part of design contains the following:

1. List of content
2. Standards and regulation
3. General specification
4. Lighting calculations
5. One-line lighting diagrams
6. General plan for the lighting system
7. Detailed plan for the lighting system:



- Ground floor and platforms
- Columns, tank, stack platforms
- 8. Symbols and markings
- 9. Electrical mounting details for the lighting system
- 10. List of equipment and materials:
 - Luminaires
 - Mounting and construction materials
- 11. Vendors' documentation

VOLUME 6. GROUNDING AND LIGHTNING INSTALLATION

This part of design contains the following:

1. List of content
2. Standards and regulations
3. General specification
4. General grounding plan
5. Underground grounding plan
6. Above ground grounding plan
7. Special grounding system for instruments
8. Electrical mounting details for grounding and lightning system
9. List of grounding materials

VOLUME 7. HEATING SYSTEM

This part of design contains the following:

1. List of content
2. Standards and regulations
3. General specification
4. Heating calculations
5. One-line heating diagrams
6. General heating plan
7. Detailed heating plans
8. Isometric drawings for heated pipelines and hook-ups
9. Symbols and markings
10. Electrical mounting details for the heating system
11. List of equipment and materials
12. Vendors' documentation.

VOLUME 8. TELECOMMUNICATION SYSTEM

This part of design contains the following:

1. List of content
2. Standards and regulations
3. General specification
4. Intercom installation block diagrams
5. Cable network plans
6. Intercom installation plans
7. Symbols used on telecommunication drawings
8. Specification of equipment and materials
9. Telecommunication equipment documentation



VOLUME 9. VENDORS' DOCUMENTATION

This part of design contains the following:

1. List of content
2. Documentation of the equipment installed in the electrical power station
3. Documentation for cables and power installation
4. Documentation for motors, UPS units, cranes, elevators, frequency converters, soft start units, etc.
5. Lighting system documentation
6. Telecommunication equipment and system documentation

VOLUME 10. EX SPECIFICATIONS, CERTIFICATES AND DECLARATIONS

This part contains the following:

1. List of content
2. Specification for electrical explosion-proof equipment based on the data from rating plates of the installed equipment, etc.
3. EC type examination certificates, EC declaration of conformity, etc.
4. Junction boxes, socket outlets and telecommunication, lighting and power equipment.

VOLUME 11 EXPLOSION PROTECTION CLASSIFICATION

This part of design contains the following:


1. List of content
2. Potentially explosive area classification
 - General notes
 - Standards and regulations
 - Description and classification sheets
 - Hazardous zone plans – views and cross-section
3. Explosion protection document.

VOLUME 12. INSTRUCTIONS

This part contains the following:

1. List of contents
2. Manuals for operation, control and maintenance, etc. issued by manufacturers or their authorised representatives in Polish and English.

The above-mentioned documentation shall apply a marking system in accordance with ANWIL SA.

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7.3. STANDARDS AND REGULATION

The application of regulations other than listed below shall require a written approval by ANWIL SA. The latest issues of the applicable standards and regulations shall be considered. Any possible questions or misunderstandings shall be clarified with the Client.

List of applicable standards and regulation:

NO.	STANDARD NO.	TITLE
1.	PN-EN 60079-0	Explosive atmospheres. General requirements.
2.	PN-EN 60079-1	Explosive atmospheres. Equipment protection by flameproof enclosure 'd'.
3.	PN-EN 60079-2	Explosive atmospheres. Equipment protection by pressurised enclosure 'p'.
4.	PN-EN 60079-5	Explosive atmospheres. Equipment protection by powder filling 'q'.
5.	PN-EN 60079-6	Explosive atmospheres. Equipment protection by oil immersion 'o'.
6.	PN-EN 60079-7	Explosive atmospheres. Equipment protection by increased safety 'e'.
7.	PN-EN 60079-10	Explosive atmospheres. Classification of areas.
8.	PN-EN 60079-11	Explosive atmospheres. Equipment protection by intrinsic safety 'i'.
9.	PN-EN 60079-13	Explosive atmospheres. Equipment protection by pressurized room 'p'.
10.	PN-EN 60079-14	Explosive atmospheres. Electrical installation design, selection and erection.
11.	PN-EN 60079-18	Explosive atmospheres. Equipment protection by encapsulation 'm'.
12.	PN-EN 60079-25	Explosive atmospheres. Intrinsic safe electrical systems 'i'.
13.	PN-EN 60079-30	Explosive atmospheres. Electrical resistance trace heating.
14.	PN-EN 60079-31	Explosive atmospheres. Equipment dust ignition protection by enclosure 't'.
15.	PN-IEC 60364 PN-HD 60364	Electrical installations of buildings. Low voltage electrical installations.
16.	PN-EN 61936	Power installations exceeding 1 kV a.c.
17.	PN-EN 50522	Earthing of power installations exceeding 1 kV a.c.
18.	IEC 60986	Short-circuit temperature limits of electric cables with rated voltages from 6kV (Um=7.2kV) up to 30kV (Um=36kV).
19.	IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1kV up to 30kV.
20.	PN-IEC 60092-353	Electrical installations in ships - Part 353: Power cables for rated voltages 1 kV and 3 kV



NO.	STANDARD NO.	TITLE
21.	DIN VDE 0278-623 DIN VDE 0278-623/A1	Power cable accessories with rated voltages U up to 30kV.
22.	PN-IEC 60332	Tests on electric and optical fibre cables under fire conditions
23.	PN-EN 61000-6-2	Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environment.
24.	PN-EN 61000-6-4	Electromagnetic compatibility (EMC). Generic standards. Emission standards for industrial environment.
25.	PN-EN 60034	Rotating electrical machines.
26.	PN-EN 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems.
27.	PN-EN 60950	Information technology equipment – Safety.
28.	PN-EN 12464	Light and lighting. Lighting of work places.
29.	PN-EN 12665	Light and Lighting. Basic terms and criteria and specifying requirements concerning lighting.
30.	PN-EN 1838	Application of Lighting. Emergency Lighting.
31.	PN-EN 60670-22	Fire boxes.
32.	DIN 1402-12	Trace cables and cables.
33.	PN-EN 13201	Road Lighting.
34.	PN-86/E-05003/01	Lightning protection of structures. General requirements.
35.	PN-EN 62305	Protection against lightning.
36.	PN-EN 61340	Electrostatics.
37.	CLC/TR 50404	Electrostatics. Code of practice for the avoidance of hazards due to static electricity.
38.	PN-EN 50272	Safety requirements for secondary batteries and battery installation
39.	PN-EN 60664	Insulation coordination for equipment within low voltage systems.
40.	PN-EN 60146	Semiconductor converters
41.	PN-EN 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals, conductor terminals and conductors.
42.	PN-EN 60446	Basic and safety principles for man-machine interface, marking, and identification. Identification of conductors by colours.
43.	PN-EN 60529	Degrees of protection provided by enclosures (IP code).
44.	PN-EN 60909	Short circuit currents in three-phase a.c. systems.
45.	PN-EN 60076-11	Power transformers. Dry type power transformers
46.	PN-EN 60726	Dry type power transformers



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NO.	STANDARD NO.	TITLE
47.	PN-EN 62271-200	High voltage switchboard and control gear A.C. metal enclosed switchboard and control gear for rated voltages above 1 kV up to and including 52 kV.
48.	PN-EN 61439	Low voltage switchboard and control assemblies.
49.	Dz.U.05.263.2203	Ministry of Economy on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive areas.
50.	Dz.U.07.155.1089	Ministry of Economy on the harmonisation of the laws of the Member States legislation relating to electrical equipment designed for use in specific voltage limits.
51.	Dz.U.07.82.556	Act on electromagnetic compatibility.
52.	Dz.U.10.109.719	Ministry of Internal Affairs and Administration of June 7, 2010 concerning fire protection for buildings and other building projects as well as sites.
53.	Dz.U.10.138.931	Ministry of Economy of July 8, 2010 on minimum requirements for the safety and health protection concerned workplaces exposed potentially at risk from explosive atmospheres.
54.	Dz.U.10.239.1597	Ministry of Infrastructure in concerning technical requirements, which shall fulfil buildings and their surroundings.

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8. LIST OF SUPPLIERS

1. A list of suppliers accepted by the CLIENT is shown in the table below:

NO.	MATERIAL	MANUFACTURER	SUPPLIER
(1)	(2)	(3)	(4)
I. CABLES AND CABLE ACCESORIES			
1.	Power, control, signalling cables	Z. K. BITNER Sp. z o.o. Telefonika Kable SA Nexans Helukabel Technokabel	Poland Poland Poland / Nexans Polska / Helukabel Polska / Technokabel
2.	Telecommunications cables	Z. K. BITNER Sp. z o.o. Telefonika Kable SA Nexans Helukabel Technokabel	Poland Poland Poland / Nexans Polska / Helukabel Polska / Technokabel
3.	Fibre optic cables	Z. K. BITNER Sp. z o.o. Telefonika Kable SA	Poland Poland
4.	Accessories, cable box, cable heads, HV	3M Pfisterer	Poland / Bernaś s.c. Germany
5.	Accessories, cable box, cable heads, MV and LV	Radpol 3M Pfisterer	Poland / Radpol Poland / Bernaś s.c. Germany
II. HV EQUIPMENT			
1.	Circuit breakers Switch disconnectors Measuring transformers	ABB Siemens AG Alstom	Poland / ABB Poland / Siemens Poland / Alstom T&D
2.	Disconnectors, Earthing switches	ZWAE	Poland / ZWAE
3.	Lightning arresters, surge arresters	ABB Zwar ABB	Poland Poland / ABB
4.	Electronic protective devices	Schneider Electric ABB Siemens AG	Polska / Schneider Electric Poland / ABB Poland / Siemens
III. MV EQUIPMENT			
1.	MV switchboards	ZARMEN Siemens AG ABB Schneider Electric	Poland Poland / Siemens Poland / ABB Poland / Schneider Electric




NO.	MATERIAL	MANUFACTURER	SUPPLIER
(1)	(2)	(3)	(4)
2.	Electronic protective devices	JM-Tronic Energotest Alstom T&D Protection ABB Siemens AG Schneider Electric	Poland / JM-Tronic Poland / Energotest Poland / Areva-TD Poland / ABB Poland / Siemens Poland / Schneider Electric
3.	Power circuit breakers	Siemens AG ABB Zwar Areva Schneider Electric	Poland / Siemens Poland / ABB Poland / Areva-TD Poland / Schneider Electric
4.	Current, voltage transformers	ABB Siemens AG	Poland / ABB Poland / Siemens
5.	Earth fault transformers	Energotest ABB Siemens AG	Polska / Energotest Polska / ABB Polska / Siemens
6.	Frequency converters	ABB Siemens AG Rockwell plc	Polska / ABB Polska / Siemens Polska / Rockwell
IV. TRANSFORMERS			
1.	Transformers	FT Żychlin ABB PE Transformatory Siemens AG P&S Zrew Schneider Electric	Polska Polska / ABB Polska / PE Transformatory Polska / Siemens Polska / Zrew Polska / Schneider Electric
V. LV EQUIPMENT			
1.	LV switchboards	Siemens AG ABB Schneider Electric Eaton Rockwell	Poland / Siemens Poland / ABB Poland / Schneider Electric Poland / Eaton Poland / Rockwell
2	Self ignition Generator unit	Horus Energia Sp. z o.o. EPS Energia Cummins Inc	Polska Polska Polska / Cummins
3.	Electronic protective devices	Energotest Schneider Electric ABB Siemens AG Eaton	Polska / Energotest Polska / Schneider Electric Polska / ABB Polska / Siemens Polska / Eaton



NO.	MATERIAL	MANUFACTURER	SUPPLIER
(1)	(2)	(3)	(4)
4.	Power circuit breakers	ABB Schneider Electric Siemens AG Eaton	Poland / ABB Poland / Schneider Electric Poland / Siemens Poland / Eaton
5.	Current, voltage transformers	Polcontact Lumel Apator	Poland Poland Poland
6.	Frequency converters	Danfoss / Vacon ABB Siemens AG	Polska / Danfoss Polska / ABB Polska / Siemens
7	Additional element	Finder Dold	Polska / Finder E. Dold & Söhne GmbH
8.	Modular and auxiliary equipment	ETI Polam APATOR ABB Schneider Electric Eaton GE Siemens AG	Polska / ETI Polam Polska / Apator Polska / ABB Polska / Schneider Electric Polska / Eaton Polska / GE Polska / Siemens
9.	ATS (SZR) systems	Energotest	Polska
VI. EXPLOSION-PROOF DEVICES			
1.	Explosion-proof luminaries	REMONTOWA CEAG GmbH R. STAHL CORTEM	Polska Poland / Eaton Poland / ASE Poland / Cortem
2.	Local control station	CEAG GmbH R. STAHL	Poland / Amabud Poland / ASE
3.	Intermediate boxes, sockets, plugs	CEAG GmbH R. STAHL	Poland / Amabud Poland / ASE
4.	Heating systems	Raychem / Pentair Hew-Kabel/CDT Thermon Europe Bartec Klöpper-Therm	Poland / Pentair Poland / ASE Poland / Amabud Germany Polska / Amabud
VII. POWER ELECTRONIC SYSTEMS			
1.	UPS units	MEDCOM APS Energia Gutor Electronics ABB (GE)	Poland Poland Poland / Siltec Poland / EST Energy



NO.	MATERIAL	MANUFACTURER	SUPPLIER
(1)	(2)	(3)	(4)
2.	Buffer power supply unites	MEDCOM APS Energia	Poland Poland
3.	Soft start systems	Fairford Electronics Siemens AG ABB Rockwell	Poland / CES Poland / Siemens Poland / ABB Poland / Rockwell
4	Lighting emergency system	CEAG GmbH HYBRYD	Polska / Eaton Polska
VIII. OTHER EQUIPMENT			
1.	Battery banks	Hoppecke Batteries Hawker plc GNB Panasonic plc Yuasa plc	Polska / Hoppecke Polska / Enersys Polska Polska / ETC Plus Polska Polska
2.	Capacitor banks	Taurus-Technic Elma Olmex Schneider	Poland Poland Poland Poland / Schneider Electric
3.	Lightning arresters, surge arresters	DEHN&Sohne Phoenix contact JEAN MÜLLER	Poland / Dehn Poland / Phoenix Contact Poland / Polska / JEAN MÜLLER
4.	Cable trays	EL-PUK Baks	Poland Poland
5.	Intercom system	Neumann Elektronik	Germany
6.	SCADA and PLCs	Elkomtech BRSP Mikronika GE Fanuc Siemens AG GE Rockwell Innsoft	Poland Poland Poland Poland / Siemens Poland / ABB Poland / Rockwell Polska / Innsoft
7.	Electric motors MV, LV	CANTONI (EMIT,CELMA) ABB Siemens / LOHER WEG SCHORCH	Poland Poland / ABB Poland / Siemens Poland / WEG Poland / SCHORCH

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NO.	MATERIAL	MANUFACTURER	SUPPLIER
(1)	(2)	(3)	(4)
8.	Terminals	WAGO Phoenix Contact Conta Clip Weidmuller	Poland / WAGO Poland / Phoenix Contact Poland / Conta Clip Poland / Weidmuller
9.	Industrial luminaires	REMONTOWA FAMOR Eletrometal ATM LIGHTING	Poland Poland Poland Poland
10	Emergency luminaires	MILO ELECTRONICS ATM LIGHTING CAEG GmbH HSK LEDY	Poland Poland Poland / Eaton Poland

2. It is advisable to include information in the offers concerning the conducted reviews, repairs, maintenance and renovations by agencies of companies located in the territory of Poland or Polish manufacturers.
3. If there is a company of the manufacturer or its authorised agency in the territory of Poland - designs, deliveries, activation of devices should be done by them. Otherwise, the Contractor should present a written statement of the Polish representative about a withdrawal in this respect.
4. The selection of the manufacturer and supplier shall be consulted with the Client's Technical Analysis Department based on:
 - Attestations,
 - Certificates,
 - References presented by a particular manufacturer, supplier.

9. CRITERIA OF ASSESSMENT OF EQUIPMENT SUPPLIED BY MANUFACTURERS

1. A guarantee period – the guarantee shall include a period for the entire installation or longer.
2. Time needed to repair damaged equipment – time required to remove a fault in equipment (from notification about the failure to the repair of the equipment) shall be as short as possible.
3. Guarantee services – Polish companies shall provide any warranty services, operating as the authorised representative of the manufacturer.
4. The scope of the guarantee services – the guarantor shall provide a schedule of services provided during the guarantee period with an indication of services free of charge.
5. Activities after the end of the guarantee period – the guarantor shall offer post-warranty services provided by Polish companies, operating as authorised representative of the manufacturer.



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6. Availability of spare parts – the guarantor shall ensure availability of spare parts for the longest possible period, with 10 years from the end of production being the minimum.