Sør-Norge Aluminium AS

Topic	**2 – Purchasing terms**			
Specification	**2.3 – Electro Technical Specification**			
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Buyer in this document is Sør-Norge Aluminium AS.

Electromagnetic fields

Electromagnetic fields shall conform to the limits stipulated in directive 2013/35/EU.
The electromagnetic fields are created by the DC power to the reduction cells inside and near the potroom.
The magnetic fields are and will be affected by steel parts brought into the field. Steel parts inside the magnetic fields will be affected by mechanical forces. Seller shall include this effect in the functionality requirement of equipment / installations delivered.
The electromagnetic fields created by the DC power busbars between potroom and rectifier buildings, and AC power supply to the rectifiers shall be calculated by Seller of this equipment as part of the delivery. The rectifier Seller shall establish the magnetic fields DC and AC (harmonic) inside the start section of the potroom (between first / last cell and end wall of potroom building).
Note: Maximum exposure for authorized personnel is 2T (20,000 G).

Areas where high-intensity static magnetic fields (0-1 Hz) occur shall be marked on drawings and with warning signs at two levels:

- 3 mT (30 G): Access for authorized personnel only
- 0.5 mT (5 G): No access for persons with pacemakers or other electronic implants.

By emergency cut out of the potline or outage of power supply (DC supply) the magnetic field will change from 100% to 0% during the electrical time constant for the potline. It is the responsibility of Seller to include this effect in the design (induced voltage and current in circuits in nearby current loops).

1. GENERAL INFORMATION ABOUT BUYER'S ELECTRICAL INSTALLATION

Stationary and transient voltage and frequency deviations shall be in accordance with local authority regulations, grid owner requirements and the requirements given in IEC.
The main figures are:

- Stationary voltage deviations can be up to +5 %/-5 %
- Maximum transient voltage deviation: + 10 / –10 %

Consumer side shall not cause more voltage transients than maximum 3 % drop at the main busbars and 15 % at consumer terminals.

1.1 High Voltage Installation

Voltage above 1000V AC, and above 1500V DC.

300kV.
The Main Supply for Buyer has a voltage of 300kV which is supplied from the central power grid. The central power grid consists of two lines from Blåfalli Switching Station and a subsea cable from Stord.

24kV.
The unregulated supply has a voltage of 24kV. This supplies the rectifier and the regulating transformers. The output to SKL/KE is also connected here. The neutral point is insulated. Maximum Ik is 31.5kA.

Phase Compensating
2 ea. capacitor batteries of 65MVAr are connected to 24kV unregulated distributions.
The capacitor batteries are switched in through 2 steps. When connecting, powerful switching transients occur, in particular at the 400V level.

20kV
The general plant supply has a voltage of 20kV, which normally is supplied from one of two 30MVA regulating transformers. The neutral point is insulated.
The Buyer's transformer stations are supplied with regular 20kV via ring cables from the plant supply in 20kV buildings.
The Maximum Ik for 20kV in the transformer station is 12kA.

Short circuit yield can be stated for each item on request from the Buyer's electro department.

6kV
Some motors to air compressors, in addition to electro boiler for heating of water are executed for 6kV. IT distributing system.

1.2 Low Voltage Installations

Voltage below 1000V AC and below 1500V DC.

There are low voltage switchboards in the transformer stations which are supplied from distribution transformers with a ratio of 20/0.400 kV or 20/0.690kV.

In general, 3 phase 400V is used as distribution system (TNCS-System) for motors and other 3-phase loads. ***230V*** direct connection between Phase and N is used for lighting.

As an exception, 3x690V is used for larger motors and heating installations. IT distributing system. Control voltage (usually ***230V*** AC) is supplied by a control power transformer (secondary side). The control power transformer (primary side) is connected to 400v (between two phases).

Ground fault monitoring shall be installed on the ***230V*** side when using control power transformers. For PLC installations, etc., a ground fault alarm shall be presented via the control system. For smaller installations, a signal lamp indicating ground faults can be installed in the cabinet door.

For local fault message/alarm, the following system is used:

- Fault present: Flashing red light, possibly also an acoustic alarm.
- Alarm deactivated: Continuous red light.
- Fault removed: Light off

For some installations, transferring some or common alarms to the gate guard is also desirable. This can be done in the current system or agreed separately.
Buyer's rectifier installation for electrolysis produces some overharmonic oscillations back to the power grid.

Short circuit performance at the secondary side of the distribution transformer is in the range of 30kA. This can be stated separately for each point on request from the Buyer's electro department.

2. NORWEGIAN REGULATIONS, DIRECTIVES AND PARTICULAR REQUIREMENTS

2.1 General

All assembly and installation shall be performed in accordance with current publications from DSB:

- Regulation on safety at work on and operating electrical installations, with instructions. (FSE)
- Regulation on Electrical Low Voltage Installations, with instructions.
- Regulations on Electrical Supply Installations. (FEF)
- Regulations on qualifications for electrical professionals, with instructions. (FKE)

Before the work commences, Seller shall send a message to the Buyer's expert manager of operations.

After delivery, the installation shall be CE-marked in accordance with current directives.

- Machine Directive
- Low Voltage Directive
- EMC Directive

Plants and products shall be delivered with the conformity declaration. The necessary verification documents shall be delivered with the conformity declaration. Ref. NEK 400-6.
Unless other written agreements have been made, all material shall be delivered in accordance with the Buyer's standard (item 5).

If the work has been performed in conflict with current regulations or Buyer's specifications, the error must be corrected. Seller shall cover all costs in connection with correcting such errors.

2.1.1 Workmanship requirements

2.1.1.1 Energy efficiency

All main equipment, buildings and utilities shall be designed with regards to energy efficiency. The contract object shall be optimized for minimum energy consumption while performing its given task. Items that shall be implemented during design of the contract object includes:

- For single loads / machines with greater consumption than 100,000 kWh / year, there should be installed an energy meter.
- Lighting control by movement sensors or timers for area lighting.
- Where it is appropriate, LED should be used as light sources.
- Automatic shut off of general heating / cooling systems, trace heating etc by temperature sensors.
- Energy recovery in drives for lifting and hoisting applications.
- Automatic shut off of pumps, fans, vacuum cleaners and other utilities when not needed.
- At systems with frequent start / stop of engines, it must be installed soft starters.
- Waste heat recovery shall be considered for all production equipment.
- Compressed air consumption shall be minimized.
- Electric cable and bus bar dimensioning shall be done with emphasis on minimum power loss.

2.1.1.2 Electrolysis

In the Electrolysis it is important that the earth potential is not exposed due to electrical hazards that may occur.
In faulty situations, reinforcement in concrete structures may have a voltage of several hundred volts!

All equipment installed in the electrolysis or in connection with concrete structures must therefore be installed insulated from reinforcement in concrete structures.
Insulation details around the assembly of all equipment must be approved by Electrical Competent Operation Manager.

2.1.2 Codes and standards

The list of codes and standards provided below cover the most frequently used references for this specification.

This list is not complete. It is the responsibility of Seller to conform to the appropriate national and international standards according to the contract object.

List of Electrical/Automation codes and standards

Doc. No.	Title
FEF 2006	Forskrift om elektriske forsyningsanlegg med veiledning
FEL	Forskrift om elektriske lavspenningsanlegg
FEF	Forskrift om elektriske forsyningsanlegg
FEU	Forskrift om elektrisk utstyr

Doc. No.	Title
NEK 400:2014	Elektriske lavspenningsinstallasjoner (Electrical Low Voltage Installations)
NEK 420	Elektriske anlegg i eksplosjonsfarlige områder med gass og støv. (Electrical installations in potentially explosive atmospheres with gas and dust)
NEK 440:2015	Stasjonsanlegg over 1 kV (Power installations exceeding 1 kV)
EN 50173	Information Technology – Generic Cabling System
EN 50205	Relays with forcibly guided contacts
IEC 60034	Rotating electrical machines
IEC 60071	Insulation co-ordination
IEC 60076	Power Transformers
IEC 60076-6	Power transformers, Reactors
IEC 60076-7	Power transformers. Loading guide for oil-immersed power transformers
IEC 60076-11	Power transformers. Dry-type transformers
IEC 60146	Semiconductor Converters
IEC 60183	Guidance for the selection of high-voltage A.C. cable systems
IEC 60204-1	Machine safety – electric equipment in machines (equivalent: CENELEC EN 60204-1)
IEC 60204-11	Safety of machinery - Electrical equipment of machines - Part 11: Requirements for HV equipment for voltages above 1 000 VAC or 1 500 VDC and not exceeding 36 kV
IEC 60296	Fluids for electrotechnical applications. Unused mineral insulating oils for transformers and switchgear
IEC 60298	A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IEC 60331	Tests for electric cables under fire conditions. Circuit integrity
IEC 60332	Tests on electric and optical fibre cables under fire conditions
IEC 60364	Low voltage electrical installations (CENELEC HD 384)
IEC 61439	Low voltage switchgear and control gear assemblies
IEC 60529	Degrees of protection provided by enclosures (IP code)
IEC 60584-1	Thermocouples EMF specifications and tolerances
IEC 60617	Graphical symbols for diagrams

Doc. No.	Title
IEC 60694	Common clauses for high-voltage switchgear and control gear standards
IEC60794	Optical fiber cables
IEC 60871-1	Shunt capacitors for a.c power systems having a rated voltage above 1000 V. General
IEC 60947-1	Low voltage switchgear and control gear
IEC 61000-6-2	EMC requirements
IEC 61034	Measurement of smoke density of cables burning under defined conditions
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IEC 61140	Protection against electric shock - Common aspects for installation and equipment
IEC 81346	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations
IEC 61378-1	Converter transformers – Part 1: Transformers for Industrial applications
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61511	Functional safety. Safety instrumented systems for the process industry sector.
IEC/TR 61641	Enclosed low-voltage switchgear and control gear assemblies - Guide for testing under conditions of arcing due to internal fault
IEC 61800-5-2	Adjustable speed electrical power drive systems. Safety requirements-Functional
IEC 62061	Safety of machinery. Functional safety of safety-related electrical, electronic and programmable electronic control systems
IEC 62271-1	High-voltage switchgear and control gear - Part 1: Common specifications.
IEC 62271-100	High-voltage switchgear and control gear - Part 100: Alternating-current circuit-breakers
IEC 62271-102	High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches
IEC 62271-200	High-voltage switchgear and control gear. Part 200: A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV.
ISO 3511	Symbolic representation for process measurement control functions and instrumentation

Doc. No.	Title
ISO 13849 Part 1 and 2	Safety of machinery. Safety-related parts of control systems.
ISO 14119	Safety of machinery -- Interlocking devices associated with guards -- Principles for design and selection
NFPA 72	National Fire Protection Association Standard 72, National Fire Alarm Code
89/336/EEC	EMC Directive
94/9 EC	ATEX Directive

2.2 FIRE PROOFING OF CABLE PENETRATIONS AND SECTIONING

2.2.1 Approved fire proofing materials shall be used for fire proofing.
Furthermore, the proofing shall be of the same fire class as the part of the building where the proofing is being done, when nothing else is prescribed.

2.2.2 Cable Routing.
Cable trays/bridges shall be completed in front of the penetration to insure good proofing and access.

2.2.3 Penetrations for piping and ventilation.
Seller will clarify how penetrations will be proofed.
Joint foam or building foam must not be used.

2.2.4 Marking.
The places where the proofing are done shall be clearly marked in accordance with instructions from Buyer's officer in charge.
These shall be marked with information about the fire proofing company and the date of the fire proofing.

2.3 PAINT WORK, CORROSION PROTECTION, ETC.

2.3.1 This shall be performed in accordance with ***Specification for surface treatment Part 2.7.***

2.3.1.1 Objective.
The norm has been set to obtain a consistent and correct treatment in terms of quality of the surfaces of aluminum and steel constructions. The implemented systems will cover various environments and usage areas and any deviations from the norm shall be agreed separately.

2.3.1.2 General.

Buyer will, when necessary, specify the painting system in his inquiry. The products of the specified manufacturers shall be used unless otherwise described or agreed in writing beforehand.

2.3.1.3 Standards.

Pre-treatment	-	ISO 8501-1
Chemical purity	-	ISO 8502-1 to 4
Surface texture	-	ISO 8503-1 Ry 2 – 3
Adhesion test	-	ISO 4624

2.3.1.4 Deviations.

Deviations from the norm must be approved in writing from Buyer.

2.3.1.5 Source.

This description is, for the most part, worked out in accordance with Norsk Hydro's norm EH-015, and ***Buyer's specification for surface treatment Part 2.7***

2.3.1.6 Abbreviations.

PUR	-	Polyurethane
ISO	-	International Standardizing Organization
TFT	-	Dry Film Thickness indicated in µm. (micron)
YL	-	Air quality and supply in the work environment
RAL	-	International color code. ***Buyer's specification for surface treatment Part 2.7***

3. WORKMANSHIP REQUIREMENTS

3.1 HIGH VOLTAGE

3.1.1 Contactor Cabinet, Control Cabinet, Measuring Fields, etc.

Description in item 3.2.1. with under items shall be followed unless otherwise agreed.

3.1.2 High Voltage Equipment

3.1.2.1 Bus Bars

At delivery of bus bar installations, these shall be adapted to existing grounding systems, and delivered with appropriate grounding appliances.
Due to the high current in the rail systems, the nuts and bolts on the rails shall be made from stainless steel ***A2 80 quality grade.***

3.1.2.2 High voltage cabinets / Power Switches / Knife Disconnectors.

Compact cabinets or cabinets for switch trolleys may be used in transformer stations. Short circuit current for the cabinet shall be minimum Ik=12.5kA. The switches shall be rated In=630A.

In the main power supply installation (24kV), cabinets for switches mounted on switch trolleys with short circuit current of minimum Ik=31.5kA, and switches for 2500A are required.

In 20kV buildings, switches for regulated 20kV distributions (20kV) shall have minimum short circuit current of Ik=12.5kA and In=1250A, or as agreed otherwise.

Buyer is planning to use SF6 power switches.

Secondary loops for current transformers should be with short circuit proof cabling and shall not be routed outside the substation.

Transducers shall be used for routing of secondary current values to control rooms or control stations. Transducers shall be powered from the control systems auxiliary power supply.

Current and voltage transformers shall be dimensioned for all fault situations in question.

3.1.2.3 High Voltage Cables.

All high voltage cables shall be diffusion sealed, for 24kV, and shall be able to cut test before and after routing, or as agreed otherwise.

3.1.2.4 End Termination.

Here it may be differentiated between indoor and outdoor types, depending on where the installation is mounted. Conventional end terminations or terminations of a ”touch proof” type can be used indoors.

3.1.2.5 Transformers.

To be produced and delivered in accordance with IEC 60076-1 and IEC 60076-2.

All distribution transformers shall have oil insulation, preferably with ***environment friendly oil/vegetable oil.*** Data sheet for the transformer oil shall be referenced in all offers to Buyer.
Dry isolated transformer shall be approved by Buyer in each case.

Accessories shall be agreed for each case. Such accessories shall monitor oil temperature, gas pressure and oil level.

All transformers shall be delivered with swiveling wheels.
Vector group shall be specified and approved by Buyer.

Distribution transformers have normal vector group DyN5.

The temperature indicator on the transformer shall be readable from the inspection point. All transformers shall be mounted with signs indicating all substantial transformer performances, volume and weights. All signs and indicators shall be readable when the transformer is in operation, without endangering the personnel.

For distribution transformers that do not have standard performance, and power transformers rated at over 1600kVA, a special agreement is required.

Short circuit performance at the secondary side of the distribution transformer is in the range of 30kA. This can be stated separately for each point on request from Buyer's electro department. Connection points for grounding devices shall be installed in transformer cells.

3.1.3 Installation and Mounting of High Voltage Supply Installations.

Installation plan and test plan shall be presented for Buyer in a reasonable time before the installation commences.

3.1.3.1 Bus Bars.

The torque shall be documented for all screw connections. The standard being used shall be documented. On the plant, every connection shall be "checked off".

If specified, documented resistance measurements shall be performed for bus bar deliveries in addition to insulation measurements. Place mounted bars and pre-fabricated, insulated bus bars shall be tested with 50kV for one minute.

3.1.3.2 High voltage cabinets / Power Switches / Knife Disconnectors.

Simplified user manual in Norwegian for switches and guards shall be presented before the installation is powered up.

For all high voltage areas, there shall be signs mounted which show manufacturer, year of production, performance, voltage and short circuit currents. A short user instruction shall also be placed on the front of installed devices. All text shall be in Norwegian.

3.1.3.3 Cable Laying, High Voltage Cables

High voltage cables must be attached with approved cable fasteners and the laying shall be documented.

Calculations regarding short circuit power and dimensioning of fastenings shall be presented to Buyer.

When feasible, the high voltage cables shall be routed on separate cable trays/paths. In case high voltage cables are routed on the same cable tray as low voltage cables, Buyer shall be contacted, and the distance between the cable paths shall be made in accordance with regulations.

3.1.3.4 Termination and Connection

Crimping of cable lugs/connection sleeves on aluminum cables shall be applied with "dorpress". Terminations and joints on Cu cables shall be applied with hexagonal press.

Buyer shall verify terminations and joints before mounting cable lugs when cables are made ready for mounting, and with jacket cut. Each joint/termination shall be documented in writing. End terminations shall be carried out in accordance with the manufacturer's standard mounting instructions.

Thermotape/thermos strips shall be mounted on all end terminations. Temp. range: 70-110°C.

There shall be a marking that shows the mounting date under each end termination.
Cable lugs shall be tightened with the torque stated in the end documentation.

3.1.3.5 Transformers and Mounting.

Measuring transformers for high voltage shall, to the extent possible, be adapted to the maximum current load for the transformers.

For transformers with output up to 800 kVA, the measuring transformer shall have a ratio of 30/5 A. For transformers up to 1600kVA, current transformers with a ratio of 50/5 A shall be used. In general, distribution transformers larger than 1600kVA shall not be installed.

Details are required on the grounding of transformers in transformer cells. There shall be a minimum of 2 secondary windings (one for measuring and one for protection). The class must be agreed in each case. ***Measuring transformers shall be grounded and documented in accordance with the manufacturer's specifications.***

3.1.3.6 Requirements for Security System and Locking

All completed high voltage components or installations shall be lockable. Officer in charge shall approve the arrangement.

LOTO (Lock Out Tag Out) is a security system for removing all energy in machines and to prevent accidental switch-on/startup of machines. All installations shall be arranged for such a system. Buyers officer in charge shall be contacted for approval of the design.

3.1.4 Transport and Packing

Transport and packing of high voltage components shall have packaging made from durable materials. Components that are delivered in larger crates shall be individually secured, and be surrounded by shock absorbing material when necessary. Components that are not moisture proof shall be packed accordingly. If the components contain any oil, the oil MSDS shall be included in the delivery documents.

3.2 LOW VOLTAGE

3.2.1 Distribution Boards, Contactor Cabinets, etc.

In addition to Buyers specifications, NEK-EN-60439 applies.
Short circuit performance at the secondary side of the distribution transformer is in the range of 30kA. This can be stated separately for each point on request from Buyer's electro department.

3.2.1.1 Cabinet types – Density – Color, etc.

380V distribution boards in transformer stations shall be equipped with ABB "Slim-line" fuses unless stated otherwise.

Regarding other cabinet types, density requirements, color, etc. see Buyer's standard unless otherwise agreed (see item 5.4.).

3.2.1.2 Space for 15% expansion

After the cabinets are installed, and the installation is commissioned, there shall be free space for **at least** 15% expansion. This is applicable to room for components, extra cable glands and connection strips. Power supply and control current transformers shall be dimensioned for 15% extra load.

3.2.1.3 Grounding – Neutral Conductor in Distributions

All distribution cabinets shall have separate bars / connection clamps for grounding and neutral conductor. Ground and neutral bar shall be mounted close to the output clamps. They shall be readily accessible after the cables are mounted. Each cable connection shall have their own connection clamp both to ground and to neutral conductor bar.
All control cabinets shall have grounding bars at the cable entry point to the cabinet. All groundings and shields on ingoing and outgoing cables shall be connected to this bar. It is important that the ground conductor on the cables inside the cabinet is as short as possible to limit EMC problems.

3.2.1.4 Connection and Marking of Cables

The main rule is that output cables are connected to terminal strips. Other systems shall be agreed upon with Buyer. Only one conductor in each terminal.

The cables shall be marked with the same cable number on both ends. The conductors shall be marked with terminal numbers. The cables shall have sufficient stress relief at the entry point of connection boxes with the aid of cable glands, or other standardized systems. Cable marking system shall be agreed upon with Buyer.

Cable lugs and Connection Crimping of cable lugs/connection sleeves on aluminum cables shall be applied with "dorpress". Terminations and joints on Cu-cables shall be applied with hexagonal press. Cable lugs shall be tightened with the torque stated in the final documentation.

3.2.1.5 Placing and mounting of terminal strips

Terminal strips that are closer to the floor than 50 cm shall be mounted at an angle of 60°. Terminal strips shall be numbered consecutively from left to right or from top to bottom. Terminals in measurement loops shall be measuring terminals (see item 5.2.7.35). Measurement terminals shall be equipped with sockets for 4 mm banana plugs.

Different voltage levels shall have their own terminal strips. This is also applicable for strange voltages even where only one or two terminal strips are in question.

3.2.1.6 Cable Connections Control Power

Cable connections for control power shall be multistranded, with a minimum cross section of 0.75 mm^2. The conductors shall be placed in plastic conduits. The conductor ends shall have connection sleeves at the connection point. The conductor ends shall be marked with marking sleeves that state their respective component's connection number, i.e., on relay/contactors: A1-A2, 13-14 etc. This ensures easy replacement of components without having to use a diagram. Connection sleeves with

plastic tabs shall not be used as marking sleeves. For internal connections, there shall not be more than two conductors in each connection point on components and one conductor in terminal strips.

3.2.1.7 Cable Conduits – Free Capacity

The plastic conduits shall not be filled more than ***75***% when the installation is ready for commissioning. Whenever possible, the control power conductors shall be kept separate from the main power. A plastic hose shall be used for the protection of connections between cabinet and cabinet doors (RITTAL or similar).

3.2.1.8 Component Mounting and Marking

All components shall be mounted in such a manner that they can be readily replaced. They shall be marked with position numbers in accordance with the drawings. Black letters on a white background shall be used on signs/mark. The signs shall be mounted in the bottom of the cabinet, or special marking bars, - **not on the component or the plastic conduits**. Contacts and relays can also be marked with a ”light proof” marker on the marking signs from the factory. PLC I/O shall be marked on the front with text.

3.2.1.9 Operation Signs Shall Have Norwegian Text

Operation signs shall have Norwegian text.

3.2.1.10 Operation Order

a) Increase, from bottom to top, or from left to right.
b) Reduce, counter clockwise from top to bottom, or from right to left.
c) Start/stop button: Location of start/stop buttons should preferably be vertical. Start button on top and stop button at the bottom. If the start/stop buttons are placed horizontally, the start button shall be placed on the right-hand side and the stop button on the left-hand side. For normal operations, all switch levers shall be in vertical and middle positions, respectively.

3.2.1.11 Color Requirements for Indicator Lights and LEDs.

Signal Lights		
RED	-	Alarm
GREEN	-	Ready for start
WHITE	-	Operation Light
Push Buttons		
RED	-	Stop or Off
GREEN	-	Start or On

For others, in accordance with the current IEC-norm.

The Supply Voltage to signal lights/LED indicators shall be 24V.
For installations with more than 5 signal lights/LEDs, there shall be controls for lamp testing.
Incandescent lamps shall not be used.

3.2.1.12 Requirements for Conductor and Cable Colors

Neutral Conductor shall, in accordance with regulations, have a light blue color.
The Neutral Conductor shall always have the same insulation as the phase conductor. (Cu-shield shall never be used as Neutral Conductor). N and PE shall only be connected (with a detachable connection piece) in the first distribution.

The ground conductor shall be colored yellow/green in accordance with regulations. No other connections shall be colored yellow or green.

PEN-conductors shall be colored yellow/green/blue.

In cabinets, black conductors shall be used for (L^1, L^2, and L3) outer conductors. Control power conductors, ***230V AC*** on the secondary side of the control power transformer shall be colored red. For 220V DC, the color violet shall be used (TP 90). 24V DC is performed with blue cable. For power transformer loops, the cross section must be adapted to Buyer's requirement for loop resistance. Minimum cross section is 2.5 mm². Black conductors are used both for power and voltage transformer loops.

Conductors with strange voltages and voltage from other installations shall be colored orange.

When using TP-conductors, reduced cross sections are not acceptable for what concerns conductivity and temperature. PN and TP are regarded as being equal, and shall be mounted in accordance with regulations as PN conductors. For machine installations, either 24V DC or 230V AC control power is used. For 24V DC control power, the negative pole shall be connected to ground.

Voltage Level	**Cable Color**	**Note**
24V DC control power	Blue	
230V AC control power, insulated	Red	
220V DC	Violet	Control installations in 20kV building
Power measurement	Black	Normally up to 5A
Voltage measurement	Black	Normally 100V
400V phase voltage	Black	
690V phase voltage	Black	
Strange voltage	Orange	Independent of voltage level
Neutral conductor	Light Blue	

3.2.1.13 IP Class Protection

All voltage-carrying parts must be protected against accidental touching, minimum IP 20.
Buyer shall agree on protection classes for surroundings and environment in case of doubt.

3.2.1.14 Cabinet Locks

In locked rooms with distribution boards, all cabinets shall be able to be opened or closed without using keys or special tools. Outside of locked rooms with distribution boards, the cabinets shall be opened using keys only.

3.2.1.15 Fuses

Automatic fuses are used up to and including 63 A (C-char). Automatic circuit breakers for important control power circuits shall be equipped with signal contacts. For larger loads, load disconnectors or power switches shall be used. Automatic circuit breakers or melting fuses shall <u>not</u> be used for 24V DC supply to PLC inputs/outputs. See next section.

3.2.1.16 PLC Controls

All PLC controls shall have own Ethernet section for connection to PLC network, separated from eventual I/ network.

Controls, including PLC, shall preferably be placed in separate cabinets with their own power supply, etc. The PLC should be mounted on a carrier plate. 24V DC supply to PLC inputs/outputs shall be guarded by an electronic over-current guard. Signals from over-current guards shall be connected to alarm/indicator lights.

3.2.1.17 Lights in Cabinets

As a main rule, fluorescent lights with door switches shall be mounted in tall cabinets (2m or taller). Other systems shall be agreed with Buyer. The installation in the cabinets shall be connected to special, separate terminals, which are intended for ***230V*** *strange* voltage.

3.2.1.18 Energy measurement

Energy measurement shall be delivered with machines. Shall be agreed with Buyer.

3.2.1.19 Fire detection

Buyer uses, among others, aspiration plants as fire detection. In connection with major deliveries of cabinets, adapting for aspiration planta is of interest. Agreed with Buyer.

3.2.2 Installation and Mounting on Machines

3.2.2.1 Norwegian Regulations for Electrical Low Voltage Installations, including Instructions must be followed when using NEK-400. (EN 60364)

3.2.2.2 Machines - Control

Electrical cabinets for machines shall be placed in a separate, electrical room. Input signals to PLCs placed on the machine itself shall be connected to distributed I/O units on the machine. ET200S/ET200SP on Profibus DP/Profinet and/or Asi bus shall be used as distributed I/O.

Motor starter equipment shall be placed in electrical cabinets in the electrical room and be controlled from output cards on the PLC. 400V and 690V cables from motors and other power consumers shall be routed directly to the contactor cabinet.
The control of solenoid valves for air and hydraulics shall be carried out with ET200S/ET200SP units in cabinets next to the cabinets for solenoid valves. Exceptions from this may be allowed where there are few valves and a short distance to the electrical cabinets. This must be agreed with the Officer in charge.
The positioning of the machines shall be performed with laser. The laser shall be mounted on the fixed part. When laser cannot be used, absolute sensors connected to Profibus DP shall be used.

3.2.2.3 Requirements for Safety System

All machines shall be manufactured in accordance with the Machine directive. Buyer shall approve SIL-classification.

LOTO (Lock Out Tag Out) is a security system for removing all energy in machines and to prevent accidental switch-on/startup of machines. All installations shall be arranged for such a system. Buyer's officer in charge shall be contacted for approval of the design.

3.2.2.4 Placement of Components

Each of the components that are part of the control system shall have a favorable position for replacement, maintenance, and to avoid mechanical damage. Solenoid valves shall preferably be mounted together in special cabinets, control voltage, preferably 24V DC, or as agreed upon. Manufacturer, see item 5.2.6. Solenoid valves shall not be placed in the electrical cabinets. All equipment must be mounted and protected against oil spills, water, snow and frost.

3.2.2.5 Marking of Components and Equipment

All equipment shall be clearly marked with position no. in accordance with the drawings. Engraved signs with black letters on a white background shall be used. The signs shall not be placed on the component, but on a mounting plate or construction part that is not being removed during normal maintenance work.

3.2.2.6 Ventilation Installations

All controls are agreed upon (see item 5.2.9).
Electrical heating batteries shall be designed as convection heat batteries, not using radiation heat.

3.2.2.7 Soft Starters

Soft starters shall be used instead of star/triangle start. Soft starters shall be used for motor drive on conveyors / chain belts. For installations where frequent motor start/stops because of energy conservation is desired, soft starters shall be installed.

3.2.3 Cable Routing - General

3.2.3.1 Cable Trays

Cable trays of type WIBE, hot dipped or corresponding quality, shall be used. Outdoor- and in specific areas indoors, stainless steel cable trays should be used. Otherwise must be agreed with Buyer. Routing choices shall be agreed for each single case. When the installation is being commissioned, there shall be 25% free room on the cable trays.

3.2.3.2 Cable Fastening - Strips

Outdoors, in pot-rooms and Foundry, acid proof steel strips shall be used for cable fastening. Plastic strips made from UV proof material is otherwise accepted. This is also applicable for fastening of cable marks.

3.2.3.3 Marking of Cables.

All cables shall be marked in both ends with their respective cable numbers in accordance with drawings/cable lists.

3.2.3.4 Cable Dimensions.

It is Seller's responsibility to choose correct cable dimensions according to load, short circuit performance, elongation ratio, and voltage drops. ***Calculations of short-circuit and dimensioning shall be documented in writing. Unless otherwise agreed upon, Febdok shall be used. Febdok database files are to be delivered electronically with all files open for editing.***

3.2.3.5 Capacity of Supply Cables.

Cables shall be delivered in accordance with item 5.2.2. Supply cables/power cables shall be dimensioned **for minimum 20%** over-capacity. Different voltage levels shall normally not be present in the same cable. Any deviations from this shall be agreed with Buyer's electro department beforehand.

3.2.3.6 Cable Routing on Trays.

Power and signal cables on the same tray shall, when possible, be placed in separate paths.

3.2.3.7 Cable to Machines

For machines, cables of type PFSP or similar, shall normally be used.
Motor cables shall be of type PFSP or similar. This is a cable that is shielded and has an operation voltage of 1kV.

4. REQUIREMENTS FOR DOCUMENTATION AND TRAINING

4.1 Drawings and Descriptions

All drawings and technical descriptions shall have Norwegian or English text. Operations and maintenance instructions, etc. shall have Norwegian text.

Drawing basis and documentation, in addition to marking of installations and components shall be in accordance with NEK 144. (EN 60617 / EN 61346)

Electrical components in machine installations shall be marked with a letter for the type of component used and also be marked with a number for the side and power path where it can be found on the electrical drawings.

4.2 For each installation the following documentation shall be delivered:

4.2.1 Installation Drawings

Can be prepared in standard formats A3 to A0. The drawings shall show the position of electric components, equipment and cable connections in plants/buildings. The numbering and marking must be consistent with the associated diagrams and drawing basis.

4.2.2 Arrangement Drawings

Can be prepared in format A4 to A1. The drawing(s) shall show internal construction, placement and marking of equipment in distribution boards, consoles, etc.

4.2.3 One-Line Diagram

Can be delivered in the following formats; A4 and A3. The drawing shall represent one single one-line diagram without control current. One-line diagrams for transformer stations (distribution stations) shall be delivered, as well as for installations with voltages above 400V.

4.2.4 Current Flow Diagram

The following formats are accepted: A4 and A3. The drawings shall be divided into:

a) Main Current
b) Control Current
c) Alarm, error messages
d) Electrical schematics/hydraulic diagrams, i.e. hydraulic diagrams with electrical components (solenoid valves, end switches, etc.) clearly marked with reference to electrical schematics.
e) Electrical schematics/pneumatic diagrams, similar to electrical schematics/hydraulic diagrams.
f) Diagrams for instruments, control and electronics.
g) Associated connection tables and terminal lists.

4.2.5 Drawings, etc., for PLC/Computer Controlled Plants

In addition to the mentioned current flow diagram, diagrams of inputs/outputs for PLC units and an overview of used card types and outputs/inputs must be included. Furthermore, a program for the concerned PLS-system is delivered. The PLC programs shall be developed on PC, program version in accordance with agreement.

The program shall be transparent so that troubleshooting installations (processes) is made as simple as possible. Both program structure and program must be documented in Norwegian or English.

After the installation is commissioned, Seller is responsible for providing Buyer with the copy latest program version.

4.2.6 Apparatus List (parts list)

Format: A4

In the apparatus list, all the electrical and electrically controlled apparatuses in the installation shall be included. The list shall include:

a) Quantity
b) Marking/Position
c) Manufacturer
d) Description, type, ordering data
e) Reference to current flow diagram
f) Notes with distributor/Seller

4.2.7 Cable List

Format: A4

In the list, all cables that are part of the group or installation in question shall be included. The cable list shall include the following:

a) Connection from (denomination / reference) in accordance with IEC norm)
b) Connection to (denomination / reference) in accordance with IEC norm)
c) Number of conductors
d) Conductor cross section
e) Type
f) Length
g) Cable no.
h) Note
i) Voltage Level

4.2.8 Spare Parts

The offer shall include necessary spare parts and prices. In the general offer on spare parts for the installation, electrical components shall also be included. These shall be listed with references as for the parts list, item 4.2.6.

Any spare parts that are ordered in the main order shall be available when a plant is commissioned.

The spare parts list must include a complete type denomination and manufacturer.

4.2.9 Description.

For all plants, the following descriptions shall be included before commissioning:

a) Technical description of the installation's function theory with reference to the electrical documentation
b) Functional descriptions and technical documentation on the components used
c) Maintenance instructions for the same components shall be specified in a list with intervals.
d) The necessary documents for verification in accordance with NEK 400-6.

4.2.10 Drawing Copies.

2 sets of drawing copies shall be delivered to Buyer within a reasonable time frame before the installation starts. ***1 set with updated drawings shall be available to Buyer (at the plant) at all times, from the start of installation until final documentation has been delivered.***

4.2.11 Updated Drawings – AutoCad.

Seller of the installation shall deliver **2** sets of updated drawing copies with dates and signatures after commissioning. The drawings and documents shall also be delivered electronically in the AUTOCAD format (DWG format). Each sheet as one file. For drawing no. XXXXX sheet 1, the file name shall be XXXXX-1.DWG.

4.2.12 Deadline for Delivery of Drawing Documentation

Unless otherwise agreed, the As Built-documentation shall be delivered to Buyer no later than one month after plant commissioning.

4.2.13 Requirements for Storage of Drawing Copies

Copies of the original drawings, as built, shall be available from Seller for at least 10 years.

4.2.14 Professional Workmanship on Installations.

Buyer's approval of presented drawings and documentations does not excuse Seller from the responsibility to deliver a professionally executed installation, and to follow current regulations and Buyer's specifications.

4.2.15 Copying.

All copying expenses as mentioned in item 4.2.10 and 4.2.11 will be charged to Seller.

4.2.16 Assignment of Drawing and Object nos.

Seller shall contact Buyer to have Buyer's drawing numbers and object numbers assigned. Both text files and drawings shall be registered with Buyer's drawing numbers. The drawing numbers and the sheet numbers shall be unique.

4.3 Training

4.3.1 A training plan shall be prepared for operation and maintenance. The training plan from Seller shall be in place before commissioning, testing, and start of operations for machine or installation. The training plan shall be approved by Buyer and shall cover maintenance and operation.

5. BUYERS STANDARD (MATERIAL LIST)

5.1 High Voltage

5.1.1 Apparatus Cabinets and Switches

Material **MANUFACTURER TYPE**

5.2.1.1	**High Voltage Switch Cabinet**
	ABB, Schneider, Siemens; in accordance with agreement
5.2.1.2	**Load Switch**
	Air insulated or as an SF6 switch
5.2.1.3	**Power Switch**
	SF6 switch, fixed in combination with disconnecting switch, or on a switch trolley.

5.1.2 Cable and end terminations

Material **MANUFACTURER TYPE**

5.1.2.1	**24kV Cable for Outdoor Installation**
	TSLF Al or Cu, twisted 1-conductor. Pirelli, Nexans, General Electric. Others in accordance with agreement
5.1.2.2	**24kV End Terminations and Joints**
	Elastimold, Raychem. Types in accordance with agreement

5.1.3 Transformer

Material **MANUFACTURER TYPE**

5.1.3.1	**Power transformers**
	Agreed with Buyer
5.1.3.2	**Special Transformers**
	Agreed with Buyer
5.1.3.3	**Distribution Transformers**
	Standard outputs up to and including 1600kVA. Voltage ratio 20000/400V or -/690V, connection Dyn5. ABB, France Trafo, Møre Trafo, Siemens, Norsk Transformator

5.2 Low Voltage

5.2.1 Fuse Parts

Material **MANUFACTURER TYPE**

5.2.1.1	**Load Disconnecting Switch**
	Load disconnecting switch 3NP Siemens AS Load disconnecting switch SLP, XLP ABB
5.2.1.2	**Load Switch**
	Load switch 3KL50-3KL61 Siemens AS
5.2.1.3	**High Power Cartridges**
	High power cartridges 3ND, 3NA Siemens AS
5.2.1.4	**Power switch and engine protection switches**
	Power switch 3 VF, 3 RV, 3WN Siemens AS
5.2.1.10	**Automatic circuit breakers AC, *Residual current circuit breaker 5SU***
	Automatic circuit breakers for AC ***5SY*** (440V AC) Siemens AS B and C Characteristic.
5.2.1.11	**Automatic fuses DC**
	Automatic circuit breakers for DC S 280UC (220V=) ABB Stotz
5.2.1.12	Electronic protection for 24V DC PLC inputs/outputs.
	Siemens Sitop diagnosis module, part no. 6EP1961-2BA00

1.2.2 Cable

Material **MANUFACTURER TYPE**

In compliance with Officer in Charge, non-halogenated cables shall be used in some areas.

5.2.2.1	**Screened house wiring cable**
	Screened house wiring cable/aluminum sheath PR/***IFLI*** 1.5, 2.5, Odin Kabel, Draka, Nexans, Tec Con. Only allowed for installation in offices, mess rooms, etc.
5.2.2.2	**1KV w/shield**
	1 KV w/shield PFSP/***IFSI*** 1,5, 2,5. Nexans, Tec Con. Copper cables shall be used up to and including a conductor cross section 35 mm². If there is a need for cables with a larger power conducting ability, cables with aluminum conductors may be used.
5.2.2.3	**Flexible Cable**
	Flexible cables on/for cranes and power chains in accordance with agreement. For example, Ølflex. Cables to be hauled shall be approved for this use.
5.2.2.4	**Plastic Insulated Conductors**
	Plastic insulated PN 750V, multiple strands Only allowed in piped installations and as internal connections in cabinets.
5.2.2.5	**Low current cable – ground and industrial buildings**
	Low current cable A-09EEBP-45D or IXLI + LIYCY In ground and industrial buildings.

5.2.2.6	**Extension cables and supply cables for portable apparatus**
	Rubber cable NMHVO
5.2.2.7	
5.2.2.8	**Plastic insulated conductor – control power *230V AC***
	Plastic insulated conductor 7) TP 90 violet Used for control power, ***230V AC.***
5.2.2.9	**Compensating cable – temperature measurements**
	Compensating cable PSP type K Gefran Used for temperature measurements.
5.2.2.10	**Fiber Cable**
	Fiber cable 62,5 / 125µ. Number of fibers in accordance with agreement
5.2.2.11	**Cable for Data Communication**
	Cable for data communication Category 5 E **Note!** Cables for data installations and similar, to be agreed with Buyer's electro department before ordering.

5.2.3 Motors

5.2.3.1 3-phase Engines 50 Hz

Efficiency Class, Degree of Efficiency and Losses shall be stated, and comply with current EU directives.
NB! Protection of motors is IP 54.

Engines from 22 kW upwards must be for 400V or 690V. This must be agreed in each case.

Engines from 50 kW and upwards must have vibration measurement (SPM) mounted.
When using a frequency converter on such motors, insulated bearings must be installed.

5.2.3.2 Frequency Converters and Soft Starters

Material **MANUFACTURER TYPE**

5.2.3.1	**Frequency Converters**
	The manufacturers Siemens Sinamics and ABB may be used. Others must be agreed with Buyer.
5.2.3.2	**Soft Starters**
	The manufacturers Siemens 3RW40/3RW44 and Stadt may be used. Others must be agreed with Buyer,
	Motor starter
	Siemens Sirius 3RA6 compact feeders

5.2.4 Control cabinets, distribution boards and connection cabinets

Material **MANUFACTURER TYPE**

5.2.4.1	**Terminal box – OUTDOORS**
	Terminal box (outdoors and in harsh environments) Rose Polyester/Rose aluminum. GA boxes: RITTAL Boxes/cabinets outdoors and in harsh environments, degree of protection: IP65
5.2.4.2	**Terminal box/cabinets – INDOORS**

	Terminal box/cabinets (inside of RITTAL type KL AE RITTAL normal industrial atmosphere) Boxes/cabinets in normal industrial atmosphere, degree of protection: IP55

5.2.4.3	**Control cabinets – INDOORS**
	Control cabinets RITTAL type AK, AS, PS, RITTAL ES, TS8, KS Relay control cabinets, degree of protection: IP55
5.2.4.4	**Control cabinets – OUTDOORS**
	Control cabinets outdoors, to be agreed with Buyer. ***Acid proof or UV-resistant synthetic material.***
Surface Treatment:	
Standard hardened varnish RAL 7032	

5.2.5 Contactors, relays, timer relays

Material **MANUFACTURER TYPE**

POS	Material	TYPE	MANUFACTURER
Contactors			
5.2.5.1	Contactors	SIRIUS 3 RT, 3TF	Siemens
Control relay			
5.2.5.5	Control relay	3RH	Siemens
5.2.5.6	Control relay (switch contact for socket PLC-BSC-24DC/21)	REL-MR-24DC/21 item no. 2961105.	Phoenix
5.2.5.7	Control relay base	PLC-BSC-24DC/21 part no. 2966016.	Phoenix
5.2.5.8	Control relay (optical coupler to base PLC-BSC-24DC/21)	OPT-24DC/24DC/2 part no. 2966595	Phoenix
5.2.5.9	Control relay (optical coupler 24V DC in 230V AC output.	EMG 17-OV-24DC/240AC/3 part no. 2954235	Phoenix
Bimetal relay			
5.2.5.10	Bimetal relay	3 RU11, 3RB10	Siemens
Timer relay			
5.2.5.15	Timer relay delayed closing	3RP	Siemens
5.2.5.20	Timer relay delayed opening	3RP	Siemens
Ground fault relay			
5.2.5.30	Ground fault relay	IRD420-D4-2	Bender
Operation Parts			
5.2.5.50	Operation Parts	Dim.: Ø 22 mm	
Push Buttons			
5.2.5.51	Push Buttons	3SB3	Siemens
Signal Lamps			
5.2.5.53	Signal lamps/LED		Siemens
Switches			
5.2.5.55	Switches		Siemens
Accessories			
5.2.5.57	Accessories		Siemens
Encapsulated operation parts			
5.2.5.58	Encapsulated operation parts		Siemens

Service/LOTO switches			
5.2.5.59	Service switch	3LD	Siemens
5.2.5.60	Service switch		ABB/Phillip Hauge
Safety Equipment			
5.2.5.61	Safety relay	Preventa XPS-AF	Telemecanique
5.2.5.62	Safety relay	SIMATIC safety PLC	Siemens
5.2.5.63	Safety switch for gates and doors	AZ335-12zk-M20	Schmersal
5.2.5.64	Safety switch for gates and doors	XCS	Telemecanique
5.2.5.65	Light barrier	M2000	Sick
5.2.5.66	Light barrier	MSL	Sick

5.2.6 End switches, initiators, photocells, solenoid valves

Material **MANUFACTURER TYPE**

POS	Material	TYPE	MANUFACTURER
End switches			
5.2.6.1	End switches	Only to be used where photocell/initiator cannot be used	Siemens
5.2.6.5	End switches	Only to be used where photocell/initiator cannot be used	Telemecanique
Initiators			
5.2.6.10	Initiators	With plug connection M12	Turck
Photocells			
5.2.6.11	Photocells	With plug connection M12	Sick/Telco
5.2.6.14	Photocells	With plug connection M12	Datalogic/ Telemecanique
Solenoid valves			
5.2.6.15	Solenoid valves - Hydraulic		Bosch Rexroth
5.2.6.16	Solenoid valve - Pneumatic		Bosch Rexroth
Ultrasound sensor			
5.2.6.17	Ultrasound sensor	RU30-M30-APBX-H1141	Turck
Other types/manufacturers shall be agreed with Buyer's electro department.			

5.2.7 Terminal strips, connection parts, etc.

Material MANUFACTURER TYPE

POS	Material	TYPE	MANUFACTURER
Terminal strips			
5.2.7.1	Terminal strips	WDU 2.5/35	Weidemüller
5.2.7.2	Terminal strips	WDU 4/35	Weidemüller
5.2.7.3	Terminal strips	WDU 6/35	Weidemüller
5.2.7.4	Terminal strips	WDU 10/35	Weidemüller
5.2.7.5	Terminal strips	WDU 16/35	Weidemüller
5.2.7.6	Terminal strips	WDU 35/35	Weidemüller
5.2.7.7			
5.2.7.8	Terminal strips	WDU 70/95	Weidemüller
5.2.7.15 (*)	Terminal strips	WDK 2.5. 800V	Weidemüller
Grounding terminals			
5.2.7.16	Grounding terminals	WPE 2.5/35	Weidemüller
5.2.7.17	Grounding terminals	WPE 4/35	Weidemüller
5.2.7.18	Grounding terminals	WPE 10/35	Weidemüller
5.2.7.19	Grounding terminals	WPE 16/35	Weidemüller
Zero terminals			
5.2.7.25	Zero terminals	NT 2.5/35	Weidemüller
5.2.7.26	Zero terminals	NT 6/35	Weidemüller
Measuring terminals			
5.2.7.35	Measuring terminals w/4mm socket		
	Current	LT WTL 6/2	Weidemüller
	Voltage	LT WTL 6/1	Weidemüller
Mounting rail			
5.2.7.40	Mounting rail	TS 35x15	Weidemüller
(*) Only allowed in PLC cabinets			
All terminal strips for mounting rail TS 35 Any other terminal strip types shall be agreed with Buyer in reasonable time before installation commences.			

5.2.8 Lighting Equipment

Material MANUFACTURER TYPE

POS	Material	TYPE	MANUFACTURER
Street/Road Lighting			
5.2.8.1	Armature	To be agreed with Buyer	
Lighting for industry halls			
5.2.8.2	Armature	To be agreed with Buyer	
Lighting for workshops and similar			
5.2.8.3	Armature	To be agreed with Buyer	
Lighting outdoors and in harsh atmospheres			
5.2.8.5	Armature	To be agreed with Buyer	
Lighting for offices and similar			
5.2.8.5	Armature	To be agreed with Buyer	
Note! For larger lighting installations, light calculations and choice of armature must be submitted to Buyer for approval.			

5.2.9 Programmable Controls

Material MANUFACTURER TYPE

5.2.9.1	**PLC**
	Programmable controls PLC.
5.2.9.2	**PLC - Manufacturer**
	The plants shall be controlled by PLC. The PLC shall be manufactured by Siemens Simatic S7-300 series or S7-1500 series.
5.2.9.3	**PLC**
	The PLC shall have free I/O capacity of minimum 15% for future expansions. When using S7-300, the I/O cards shall be of the following types: DIGITAL Input card 6ES7 321-1BH02-OAAO ANALOG Input card 6ES7 331-7KF02-OABO ANALOG Output card 6ES7 332-5HD01-OABO DIGITAL Output card 6ES7 322-1BHO1-OAAO 0.5A DIGITAL Output card 6ES7 322-1BF01-OAAO 2A When using S7-300, the CPUs shall be of the following types: CPU 313C 6ES7313-5BE01-0AB0 CPU 313C-2DP 6ES7313-6CE01-0AB0 CPU 314 6ES7314-1AF10-0AB0 CPU315-2DP 6ES7315-2AG10-0AB0 CPU317F-2DP 6ES7317-6FF00-0AB0 When using S7-1500, the digital I/O card must have 16 channels and 24V DC. Analog cards must have 4 or 8 channels. When using more modules than there is space for in central rack, then the next rack must be distributed I/O (ET200M, ET200MP).

	Use of other cards must be agreed with Buyer.
5.2.9.4	**PLC – Distributed I/O**
	Electrical cabinets for machines shall be placed in a separate electrical room. Input signals to PLCs placed on the machine itself shall be connected to distributed I/O units on the machine. ET200S/ET200SP on Profibus DP/Profinet and/or Asi bus shall be used as distributed I/O. The control of solenoid valves for air and hydraulics shall be performed with ET200S units in cabinets next to the solenoid valve cabinets. Exceptions from this may be allowed where there are few valves and a short distance to the electrical cabinets. This must be agreed with Buyer's officer in charge. Motor starter equipment shall be placed in electrical cabinets in the electrical room. For motor starters, soft starters and frequency converters, long distance receipt should be possible. For ASI bus units directly on the equipment, Compact model K45 4x Inputs 3RK1200-0CQ20—0AA3 shall be used. ET200S / ET200SP modules must only be for 24V. Each module must not have more than 8 channels. Profibus PA shall be used as instrument bus.
5.2.9.5	**PLC – Operator Panel**
	Siemens Simatic HMI panel shall be used for local operation and viewing of alarms and process values.
5.2.9.6	**PLC – Display control system PC**
	InTouch from Wonderware shall be used as display control system on PC. The communication between PLC and PC shall be done on Ethernet. PC shall have Applicom PCIE2000ETH card and Ethernet card for communication with Buyer's other network. Use of colors in display control shall be agreed for each case. Requirement for PC that shall into Buyer's network must be cleared.
5.2.9.7	**PLC – Cable**
	Between PLC and terminal strips, 0.75 mm² fine-stranded connection conductor (TP 100) with marking sleeves on both ends shall be used. Same color marking as in item. 3.2.1.12. Cabling modules and multi conductor cables can also be used. These shall be of the type Phoenix.
5.2.9.8	**PLC – Cabling and Routing**
	Different voltages shall not be present in the same control current cable. Inputs and outputs shall not be laid in the same cable with lengths that exceed 100 m. Input and output cables shall be protected. The shield shall be grounded in both ends. Control current cables shall not be placed together with power cables (>10A) with lengths over 10 m.
5.2.9.9	**PLC – Solenoid valve**
	Solenoid valve voltage 24V DC.
5.2.9.10	**PLC - Programming**
	Programming of PLC shall be performed in IEC 61131-3 FBD. The choice of other programming languages to be agreed with Buyer's officer in charge. The programmer shall be able to communicate in Norwegian or English.

	All program blocks, networks in program blocks and variables (I,O,M,T,DW, etc.) that are used in the program shall have explanatory text in Norwegian or English.

5.2.10 Instrumentation

5.2.10.1 Instrumentation

All measured values shall be digitalized and register into a control system in order to log and remotely read the values. Preferably, the values must be 4-20 mA or Profibus PA.

Instruments, printers, regulators, measurement value converters, impulse transmitters, effect and energy meters, etc. with performance and manufacturer as agreed with Buyer.

Current Manufacturers:

EQUIPMENT	MANUFACTURER
Laser	Manufacturer Sick type DME300-211P, TR ELECTRONIC type LE-100.
Absolute sensors	TR ELECTRONIC type CE-65-M, Fraba posital or Siemens on Profibus DP/Profinet
Measurement value converters	PR Electronics or in accordance with agreement
Energy measurer	Siemens Sentron PAC 3200 w/Ethernet. 7KM2112-0BA00-3AA0
Final choice of instrument equipment following discussion with Buyer.	

5.2.10.2 Thermal Elements

Thermal elements shall be NiCr-Ni with standard compensation cable up to cold solder point (FEC norm). Calibration class and certificate must be agreed with Buyer.

5.2.11 Heat Control

5.2.11.1 Thyristor Regulators

Manufacturers used are Eurotherm and Stadt