I&C Philosophy

CO_2 Capture – BOD & Tender Specifications

AEB Amsterdam

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Table of Contents

Abbreviations

Abbreviation	Definition
AEB	Afval Energie Bedrijf / Waste to Energy Company
AEC	Afval Energie Centrale / Waste to Energy Unit
BPCS	Basic Process Control System
CAP	Critical Action Panel
CCTV	Closed-Circuit Television
DCS	Distributed Control Systems
ESD	Emergency Shutdown
FGS	Fire and Gas safety system
HART	Highway Addressable Remote Transducer
HMI	Human Machine Interface
HRC	Hoog Rendement Centrale / High Efficiency (Power) Station
HVAC	Heating, Ventilation and Air Conditioning system
IMCC	Intelligent Motor Control Center
IMS	Information Management System
I/O	Input/Output
LOPA	Layer of Protection Analysis
MID	European Measuring Instruments Directive (2014/32/EC)
Nm3	Normal Meter Cubed per Hour, unit used to measure gas flow rate
OIML	International Organisation of Legal Metrology
PAGA	Personal Address and General Alarm system
PCS	Process Control System
PDCS	Power Distribution Control System
PLC	Programmable Logic Controller
PSD	Process Shutdown
SAS	Safety and Automation System
SIL	Safety Integrity Level
SIS	Safety Instrumented System
UCP	Unit Control Panel

Abbreviation	Definition
VESDA	Very Early Smoke Detection Apparatus system
VPS	Vibration Protection System
VSD	Variable Speed Drive

1 Introduction

AEB Amsterdam has the ambition to utilize post-combustion CO_2 capture to capture about 0.5 Mton of CO_2 from the flue gases of the Hoog-Rendement Centrale (HRC) and Afval Energie Centrale (AEC). Over the last few years AEB has carried out various feasibility/concept studies on various subjects. AEB has now initiated the next project phase by selecting a project partner (Worley/Advisian) to support the BOD and project/tender specification phase of the project.

2 References

Project specific Technical Requirements:

IEC 61131	Programmable Controllers
IEC 61511	Functional Safety – safety instrumented systems for the process industry sector
IEC 62443	Industrial Automation and Control System Security
IEC 60079	Electrical Apparatus for explosive gas atmospheres
IEC 60331	Tests on electric cables under fire conditions
IEC 60332	Test of the fire behavior on electric cables. (Flame retardancy)
NIST SP 800-82	Guide to Industrial Control Systems (ICS) Security
ISA TR-84.00.09	Cyber Security Related Functional Safety Lifecycle
2014/34/EU	ATEX Directive
2014/32/EC	MEASURING INSTRUMENTS (MID) DIRECTIVE (2014/32/EU)
MI-002	GAS METERS AND VOLUME CONVERSION DEVICES Gas meter is an instrument designed to measure, memorise and display the quantity of fuel gas (volume or mass) that has passed it. Conversion device is a device fitted to a gas meter that automatically converts the quantity measured at metering conditions into a quantity at base conditions.
OIML R137-1	Measuring systems for gas

In addition to above project-specific requirements, National and International recognized industrial codes and standards shall apply.

3 Plant Control

The CO_2 Capture plant shall be automated to the largest extent. Operator actions shall be limited to required actions for adjusting set points for plant optimization and safe performance and when required temporary manual control actions. Normal start-up and shutdown shall be automated to the extent that it can be performed from the Central Control Room (CCR). Any local control or operation will require Company approval. A manned-plant philosophy will be followed, meaning that it is assumed there is always an operator available.

DCS control and SIS safety systems shall be segregated as per IEC 61511 functional safety standard.

The plant has an existing central control room (CCR) with distance to the technical room and production facilities. The PCC plant shall be operated from CCR. Network connection between these rooms can be over several hundred meters and will be via dedicated and redundant (via two segregated routings) fiber-optic cabling.

4 Safety and Automation System Topology

The reference drawing "416041-47990-J.01-001- System Architecture" shows the proposed system architecture / SAS topology and provides an overview of the systems and their separation to comply with Cyber Security guidelines as stated in the guidelines/standards mentioned in Chapter 2.

4.1 Networks

The following networks are foreseen:

- Office network (level 4)
- Technical network and Demilitarized Zone (level 3)
- SAS networks (Control Network (DCS) and Safety Network (SIS)
- System Controllers (level 2)
- System I/O & Marshalling (level 1)
- Field instrumentation (level 0)

Networks shall be secured to prevent unauthorized access.

4.2 Operator and Engineering Stations

Sufficient operator workstations shall be provided for day-to-day and emergency plant operation. The exact number of operator workstations and number and size of screens will be as per client demands and will be defined in the Select Phase. Remote terminal server which can be accessed from the existing engineering stations shall be considered for the new PCC plant control systems. For quick plant overall status overview large screens shall be provided. Any data/control of non-level 1 systems shall be made available to the operators via serial link communication thru SAS. PLC's used for process control applications of package units, e.g. Demin water plant, must be interfaced directly to the 800xA HMI and shall be able to operate locally/remotely by the operators. Networks must be supervised by the network monitoring and supervision system. Only in case specific equipment/software is required a dedicated Engineering Management System may be provided e.g., for UCP, Vibration Protection System. Sufficient space shall be provided for integration/operation of telecommunication systems.

4.3 Safety Automated System

An integrated SAS shall be provided with the following, each with dedicated and separated systems:

- Safety Instrumented Systems:
  - Fire and Gas detection System
  - Emergency Shutdown System
  - Process Shutdowns System

- Process Control Systems
  - Process Control System
  - Power Distribution and Control System / Intelligent Motor Control Center

Other systems (non-SAS) that may be present:

- Package Control (Package Control requires Company approval)
- Vibration Protection System
- Variable Speed Drive

5 Field Instrumentation and Equipment's

5.1 Signal Transfer from Field to auxiliary(I&C) Room

For flexibility and to minimize multi-core cabling, cross-wiring and the number of junction boxes, Universal Remote I/O via Profibus DP/PA is the preferred method for signal transfer from field to auxiliary room where the DCS controllers are placed. Safety and F&G signals shall be hardwired from field to the auxiliary room. Communication between motors and controllers shall be also hardwired. MCC/switchgear internal temperature and other critical parameters shall be monitored in SCADA.

5.2 Signal Segregation

Signals shall be segregated for:

- Fire and Gas
- Emergency and Process Shutdown
- Process Control
- Power Distribution and Control
- Ex 'd' and Ex 'i'

Non-SAS signals may be combined as far as practical.

5.3 Instrument Scales

The Scales of instruments shall be graduated as follows:

- Temperature: Direct reading
- Pressure: Direct reading linear
- Flow: Direct reading
- Level: 0-100% of instrument span
- Others: Direct reading

The Unit of measurement shall be in Metric.

5.4 Instrument Transmission Signals

5.4.1 Signal transmission between field instruments and remote-control systems equipment e.g., DCS, SIS, F&G, UCP, PLC etc., shall generally be electric, as follows:

Table 5-1: Instrument Transmission Signals

I/O Description	Notes
Analogue Transmitters Temperature (other than temp. transmitters) Control Elements	 4-20mA, 2 wire, 24V dc, SMART ("HART") digital communication preferred. 3-wire PT-100 RTD or type K thermocouple (dependent on application) 4-20mA, 2 wire, 24V dc, SMART ("HART") digital communication preferred power sourced from DCS / SIS / UCP.
Digital Field Instruments Field switches	24V dc powered from DCS / SIS / UCP.
Digital ON/OFF Valve Valve open / close	24V dc powered from DCS / SIS / UCP (Solenoid sense for valve open/close control is dependent upon failure requirements vs switching requirements per application).
Motor Control Remote start / stop Running Indication, MCC Status, Alarms Motor Amps / kW / Volts	 24V dc, 1A dc (max), Relay Coil powered from DCS / SIS / UCP. Volt Free Contact, 24V dc powered from DCS / SIS / UCP. 4-20mA, 2 wire, 24V dc powered from DCS / SIS / UCP.

5.4.2 Signal segregation, cable screening and termination requirements are as per design basis.

5.4.3 Other signalling standards are subject to approval by client.

5.4.4 Signals between UCP and DCS / SIS shall be as follows:

Table 5-2: Signals between UCP and DCS / SIS

I/O Description	Notes
UCP Digital Output and corresponding DCS / SIS Digital Input	24V dc, 1A dc (max), Relay Coil powered from UCP. Volt Free Contact, 24V dc powered from DCS / SIS. Interposing relay located in UCP cabinet.
UCP Digital Input and corresponding DCS / SIS Digital Output	Volt Free Contact, 24V dc powered from UCP. 24V dc, 1A dc (max), Relay Coil powered from DCS / SIS. Interposing relay located in UCP cabinet.

I/O Description	Notes
UCP Analogue Input and corresponding DCS / SIS Analogue Output	4-20mA, 2 wire, passive 4-20mA, 2 wire, 24 V dc powered from DCS / SIS
UCP Analogue Output and corresponding DCS / SIS Analogue Input	4-20mA, 2 wire, 24 V dc powered from UCP 4-20mA, 2 wire, passive
Serial Communications Link between DCS / SIS and UCP	Modbus TCP/IP protocol. DCS / SIS configured as Modbus Master, UCP configured as Modbus Slave
Serial Communication between ABB 800xA and Procontrol P14 control systems	Modbus TCP/IP protocol

5.5 Instrumentation Cables

All the field instrumentation cables shall be selected and tested as per IEC standards. Cables for normal service shall be fire retardant acc. to IEC 60332. Cables for critical services (FGS) shall be fire resistant according to IEC 60331. Conductors shall comply with IEC 60228, insulating/sheathing materials with IEC 60092. Cables must be tagged and identified at both ends. Also, each core must be identified with cross ferruling. Cables shall be rated for the voltage (Umax) 300V. Cables laid in occupied buildings shall be halogen free. Analog and digital cables for the field installation shall be armored and screened as per AEB specifications.

Instrument Cable Jacket Colours:

	black	blue	red
All I.S. signals	☐	☒	☐
Fire system signals	☐	☐	☒
All other signals (Non-IS)	☒	☐	☐

5.6 Tagging & Numbering

All the instruments and junction boxes shall be identified with permanent tag numbers either screwed or riveted. If fixing to the instrument is not possible, it can be hanged using metal wire. All the SIS instruments and IS junction boxes must be identified with an additional label. The tagging and numbering philosophy must be done by ICS coding system. Available as 1.3 ICS-coderingA-TS-ICS-005 (AEB technical standard).

5.7 Packaged Equipment

To obtain commonality of instrument types, only instruments manufactured by approved SUPPLIER / VENDOR shall be adopted for packages. All instruments shall be supplied, installed,

and cabled to skid edged junction boxes by the package SUPPLIER/VENDOR. Separate junction boxes and cables shall be used for:

- PLC System
- F&G System
- Package UCP
- VPS system

5.8 Hazardous Area (ATEX) Requirements

Instruments located in hazardous area shall be certified to meet or exceed the electrical hazardous area classification. The method of protection and hazardous area certification requirements of instruments and related equipment's shall be defined in next phase. All electronic /electrical instruments and equipment shall be suitable for area classification as per IEC codes (IEC-60079) and shall be tested and certified by any recognized notified bodies of ATEX. All electrical and instrumentations Items that are supposed to be installed in hazardous area shall be ATEX certified by approved notified bodies.

All field instruments, junction boxes & field mounted panels shall be weatherproof to IP 65 minimum, and equipment mounted in control/equipment rooms and buildings which are classified as "safe areas" shall have as a minimum an Ingress protection rating of IP 42. All intrinsically safe analog input / output, digital inputs from the field (hazardous area) shall be provided with Galvanic Isolators in control panel.

5.9 General Requirements for Instruments

Separate transmitters shall be provided for (a) process control / monitoring and (b) shutdown functions, with each having separate process line tapping points and isolation valves. All electronic transmitters shall be fitted with an integral local indicator, with a read-out in engineering units. All electronic transmitters shall be 2 wire, 24 VDC loop powered, "SMART" type with HART protocol with 4-20 mA output. Materials for all wetted parts shall be min. 316 SS and the transmitters shall be able to withstand differential pressures equal to full line pressure without zero or calibration changes. The accuracy of transmitters shall be ± 0.3-1% of calibrated span or better. For transmitters ranges shall be selected to cover low & high alarm points. Transmitters for measuring different process parameters shall be selected based on their application on the process conditions.

All local gauge ranges shall be selected such that the normal operating point is between 50% and 75% of the scale range considering the specified minimum & maximum values. All field instrumentation and valves shall be installed in such a way that they are readily accessible from grade or permanent platforms which shall be 1.2 meters in height without obstructing the operation. Good access for operation and maintenance shall be provided for instruments and valves including automated valves.

Control valves shall be sized in accordance with IEC 60534-2-1. The actuator of control and On-Off valves shall be of pneumatic type. The shutdown valves shall be operated via solenoid valves.

Analyzer shall be installed in the field (Machine House) or in the designated sheltered area which must be defined in the next phase. Analyzer shall be able to diagnose instrument failure, analyser sample flow and utility gas pressure.

Two separate instrument-earthing systems shall be provided, namely Protective Earth and Instrument Earth. Protective Earth – Connections to earth for all electrical equipment, for personnel safety. Instrument earth may be again classified in to two based on IS & Non-IS signal earthing.

All the electronic instruments shall confirm to the Electromagnetic Compatibility (EMC) requirements of IEC 61000.

5.10 Fiscal Metering

The export CO_2 gas flow line from the proposed PCC plant requires an accurate (fiscal) metering for accounting purpose. This is accomplished by means of flow metering at the takeover point. The flow metering systems need to be approved for custody transfer. Other metering system requirements (utilities) shall be defined in next phase.

Measurements used for custody transfer between companies must meet requirements set by industry bodies such as API or ISO, and international metrology standards such as OIML. These requirements can be of two types: Legal or by Contract. Within the European Union this is legally regulated within the Measuring Instruments Directive 2014/32/EU (MID). OIML is the international norm on top of the European MID.

Gaseous CO_2 gas is not a combustible gas and therefore not regulated for custody transfer in MID. Common practice is to use MID certified equipment and follow the design rules according to MI-002. Officially the flow measurement of CO_2 gas is not part of MI-002. Because there is no other reference it is allowed (not wrong) to use MI-002 for CO_2 gas as well.

The metering systems shall be based on the guidelines as defined in the new Measuring Instruments Directive (MID) for fiscal measurement systems as best practice guideline.
The approved two inline flow meter types for custody transfer applications:

- Mass flow meter (Coriolis)
- Ultrasonic meter

Coriolis mass flowmeters calculates mass flow by measuring the effect the flow has on a vibrating pipe inside the meter.
Coriolis Flowmeters have distinct advantages such as:

- High accuracy
- No up-/downstream straight run requirements
- Real mass flow measurement as opposed to volumetric flow
- Reliability

Ultrasonic flowmeters measure the velocity of a fluid with ultrasound to calculate volumetric flow by either averaging the difference in measured transit time between pulses propagating through the fluid or by measuring the frequency shift of the pulses. Additional measurement of temperature and pressure is needed and connection to a dedicated flow computer for measurement as mass- or volume flow.

Ultrasonic flowmeters have distinct advantages such as:

- High accuracy
- High turndown/rangeability
- Minimal pressure Drop
- Possibilities of clamp-on meters
- Reliability

For the ultrasonic flowmeters there is always up-/downstream straight run requirements.

Flow computers are needed to meet the fiscal metering requirements. A flow computer uses the inputs from process measurements (flow, pressure, temperature) and algorithms to convert the measurements into volumes at base conditions.

Flow provers are needed in systems with pay- and check flowmeters in series.

The flow computers will be in the equipment room, connection to the field instruments (Flow, pressure, temperature) shall be hardwired. Connection of the flow computers to the plant DCS and ERP system is via digital (ethernet or RS485) communication.

5.11 Spare Philosophy

Following spare philosophy gives rough target values for the engineering of spares that shall be achieved in average for provision of customer.

	5%	10%	20%	30%	40%	50%
Multicore cables/Junction Boxes All wires shall be connected to Terminals	☐	☐	☐	☐	☒	☐
Instrument Cable Trays	☐	☐	☐	☐	☒	☐
Connections at instrument gas headers	☐	☐	☐	☐	☒	☐
Spare space in cabinets	☐	☐	☐	☐	☒	☐
Spare terminals in marshalling cabinets	☐	☐	☐	☐	☒	☐
CPU processing capacities (after FAT)	☐	☐	☐	☐	☒	☐
System I/O spares installed	☐	☐	☐	☐	☒	☐
System I/O spares non-installed (Space for future)	☐	☐	☐	☐	☒	☐

6 Telecommunication

Due to their nature telecommunication signals and their network shall be logically and physically separated from process control signals. The telecommunication system shall be developed in the Basic Engineering phase of the project when client specifications are available. The requirements for CCTV, PAGA etc., shall be defined in next phase.

7 Fire and Smoke Detection in Buildings

Fire and smoke detection shall be provided for the new buildings by means of:

- Addressable smoke detectors in the manned parts of the buildings which will interface to a Fire Alarm Panel which, in turn, will be interfaced with the plant Fire & Gas System.
- A VESDA system will be proposed for the auxiliary and possible the electrical switch rooms. The VESDA system will be interfaced with the plant Fire & Gas System
- Specific needs will be developed in the Basic Engineering phase.

8 Network

Three levels for data access shall be present. Levels shall be separated by protocol and firewalls in accordance with NIST SP 800-82 and ISA TR-84.00.09.

8.1 SAS Network

The SAS network allows signal exchange and access on Process Control level. This network has the highest access protection and will be separated for Control and Safety (separated by a Firewall). It is used for non SIL signal exchange between level 1 (I/O) and level 2 (controller) systems. SIL signal exchange shall be hard wired.

8.2 Technical Network

The technical network allows signal transfer from SAS network via secure access and transfer of non-SIL signals from level 2 systems e.g., Package Control. SIL signal exchange from level 2 systems shall be hardwired to the Process Shutdown System. A "Demilitarized Zone" will be implemented for the shared parameter access and will be separated by a firewall.

8.3 Office Network

The office network allows via an additional secure interface access to necessary data from technical network for information management purposes. This network is separated by firewall from external networks.

9 Critical Action Panel

For manual shutdown of the CO_2 Capture Plant (PCC) or selected parts thereof a Critical Action Panel (CAP) may be provided (to be defined in next project phase). The CAP will act via the relevant logic solver.

10 Interfaces

To allow proper plant operation from the Control Room, interface signals will be required. Depending on type of signals, the required segregation requirements shall be considered for interfacing with:

- AEC/HRC plant systems
- Utilities
- Other areas

Type and amount of interface signals cannot be defined yet, needs to be agreed in next phase.

11 Dedicated Systems

11.1 Fire and Gas Detection System

The dedicated Fire and Gas detection system shall interface with:

- ESD System
- PAGA to warn people in case of fire or gas detection (details to be defined in next phase)
- HVAC in case of gas detection in HVAC air inlet

11.2 Emergency Shutdown

The ESD system is a part of the plant safeguarding system (SIS) with a purpose to keep the process within the design envelope and to prevent the escalation of abnormal conditions into a major hazardous event. Basically, the system consists of field-mounted sensors, valves and trip relays, system logic for processing of incoming signals, alarm, and HMI units. The system can process input signals and activate outputs in accordance with the Cause & Effect charts defined for the installation. Also, the ESD system can be initiated from non-process input signals and will force total or partly plant shutdown on signals from:

- Critical Action Panel (when provided)
- Fire and gas detection
- Manual switches in the field

11.3 Process Shutdown

Process shutdown (PSD) system is also a part of the plant safeguarding system (SIS) with a purpose to minimize the frequency and consequences of excursions outside the facility operating envelope. The PSD initiates actions automatically to limit consequences of process safety parameters being reached and will always keep the process in a safe condition in accordance with the applicable cause and effect matrix chart.

PSD and ESD can be considered as effects, which are triggered by certain causes, the PSD and ESD are levels of shutdown which discriminate between the seriousness of the causes leading to the appropriate effects. This shall be defined in next phase.

11.4 Basic Process Control System

The BPCS (DCS) controls the behavior of the process based on process initiators and activators. Normally the BPCS will operate fully automatic and will require minimal operator actions.

11.5 Power Distribution and Control System

The PDCS control and monitors the electric power distribution e.g., incoming feeders, breakers, consumers, motor starters, variable speed drives.

11.6 Other Systems

Other systems (level 2) will be controlled and monitored via serial link. ESD and PSD signals shall be hard wired.

These systems comprise:

- Package control systems
- Intelligent Motor Control Centre (IMCC)
- Vibration Protection System (VPS)
- Variable Speed Drive (VSD)
- Fiscal metering

12 Plant Monitoring

12.1 Information Management System (IMS)

System performance and process equipment condition, availability, running time etc. shall be monitored and data stored to provide diagnostics, maintenance requirements and history reporting. The system shall have possibilities to automatically generate maintenance programs. In case condition limits for maintenance are reached operator warnings shall be issued.

12.2 System Performance and Maintenance

Apart from data handling in IMS required equipment testing as an outcome of SIL classification, should be automated as much as possible e.g., valve stroke testing, use of smart valve positioners. Reports of these tests shall be automatically generated.

12.3 Transmitter Validation

In case due to separation requirements transmitters for both PSD and BPCS are installed for the same process parameter signal validation shall be performed by comparison of both transmitter signal values.

13 SAS and HMI

HMI graphics shall be according to AEB technical standard. HMI design shall be in line with the latest IEC guidelines. In case a frame agreement between Company and the selected SAS supplier exists the AEB standard hardware and software shall be used.

14 Availability

The Process control system shall be designed in conjunction with the process equipment (redundancy, automatic /manual change over) and maintenance requirements to meet the overall availability requirement. This implies both availability (DCS) and spurious trips (SIS) shall be considered.

Definition of required availability needs to be defined in next phase and must be aligned with the operation and maintenance philosophy of the plant.

15 Cyber Security

A Cyber Security Risk Assessment (like a LOPA analysis for safety) shall be done in the next phase of the project to ensure proper security complying to industry requirements and standards. Plus Network Design shall be followed.
Key deliverables will be:

- Client ICS Cyber security procedures
- Client Risk Management plan
- Project pertinent current Risk Assessment (if any)
- List of reserved documents
- Design Cyber Security Plan

16 Remark for Chapters 12 to 15

For the CO2 Capture plant, the Company has not made any specific decision to how the plant monitoring, automation and maintenance shall be performed. This will be further defined prior to next phase.