Functional specification for a typical onshore wellhead control and monitoring system

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1.0 Introduction

This document specifies the requirements for a control and monitoring system for an onshore low-pressure, low-temperature oil and gas wellhead. The described system and associated devices shall meet the functional, operational, electrical, and environmental requirements as outlined in this specification.

1.1 System operational objectives

In general, the wellhead control and monitoring system shall meet the following operational and functional objectives:

- Control wellhead functions
- Monitor wellhead functions
- Minimize the effect of disturbances
- Maintain safe operation

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2.0 System functional objectives

2.1 The wellhead control and monitoring systems as proposed are required to have the capability of performing any of the below functions/applications as a component of the production automation objectives. It is understood that certain applications will require expansion modules and accessories to achieve functionality.

- Well monitoring and control
- Measurement monitoring
- Missing data collection
- Raw measurement reporting
- Plunger lift
- Pump-off control
- Compressor monitoring and control
- Tank monitoring
- Gas contract monitoring of nominations
- Operator notes
- Alarm and call-out management
- System-wide data playback control
- High availability
- Local disaster recovery
- System monitoring
- Backup
- Failover
- Server monitoring
- Communications monitoring
- Multi-tube measurement
- Real-time volume and energy metering
- Operations data and statistics
- ESP/PCP and SPS lift technology
- Rate/pressure control with DP overrides
- Downhole liquid level control
- Deliverability testing
- Custom controls and alarming
- Pipeline measurement and control
- Engineering data logger
- Exception-based alarming

3.0 Basic functional system design

To achieve these objectives, the wellhead control and monitoring system shall have a main control device, which shall be a:
- Remote terminal unit (RTU) or
- Small programmable logic controller (PLC)

3.1 The system shall be capable of communicating with common and generalized automation and SCADA protocols and interfaces such as:

- OPC
- Modbus
- DNP3

3.2 The system shall be capable of supporting languages defined by IEC Standard 61131-3, including ladder logic, structured text, function block diagrams, instruction list, or sequential function chart language.

3.3 The system shall be capable of communicating with legacy systems and components as listed below:

- ABB MicroFLO RTU
- Bristol 3310 RTU
- SCADAPack 32 RTU
- ROC 503 RTU
- AB ControlLogix PLC

4.0 RTU/PLC wellhead controller hardware and software system specifications

4.1 General description of the RTU/PLC controller

Main RTU/PLC controller: The RTU/PLC controller is a modular small-scale controller with integrated Ethernet connections. The system shall execute the control software; receive inputs through input modules or from the SCADA system via the wireless Ethernet; and send outputs generated by the control software to the output modules via RS-485 and SCADA system via the RTU Ethernet port. The system scan rate shall not exceed 100 msec under any operating conditions or program loading.

4.2 Description of the RTU/PLC controller-required functionality

4.2.1 The RTU/PLC will be required to communicate with both Modbus and Fisher ROC protocol formats that are utilized by standard remote flow meters. The RTU/PLC must
have the ability to store data in XML format, which will be logged by the PLOT software remotely.

4.2.2 The RTU/PLC must have the capability to be configured using standard off-the-shelf IEC 61131 tools.

4.2.3 The RTU/PLC will have the capability of communicating to a GPS module and inserted into the collected data of the XML file.

4.2.4 The RTU/PLC processor will perform a safe system startup, efficiently operate the wellhead, and when required, shut down the system. These operations will be performed safely and reliably by controlling all sensor inputs, relay outputs, analog outputs, Modbus communication to various devices, and the main power supply, which communicates over an RS-232/485 interface.

4.2.5 The RTU/PLC will have the capability of performing a safe system startup, efficiently operating the wellhead, and when required, will allow for a safe shutdown of the wellhead both locally and remotely.

4.2.6 Controller configuration software:

- The wellhead control panel shall be supplied with programming software.
- Programing of the main controller shall be via the controller’s Ethernet port.

Standard control blocks
- PID control block
- Velocity PID control block
- Ratio control block
- Bias control block
- User calculation control block
- Dead-time compensator control block
- Lead/lag control block
- High select block
- Low select block
- Control summer block
- Supervisory control output block
- General output block
- Velocity dead-time compensator control block
- Smart average block
- General summer block
- General divider block
- Digital input block
- General multiplier block
- Simple lead/lag block
- Input selector block
- Moving average block
- Linear input with checking block
- Linear input block
- Set-point loader block
- Set-point transfer block
- Manual loader block
- PV loader block
- Manual flag block
- Process flag block

4.2.7 Report generator: The system will support a report generator package, which prints customized reports containing both fixed (text) and variable (data) information. An individual report is specified using a standard editor to enter the report definition in a “what you see is what you get” manner, similar to a word processing package. The text of this file uses special identifiers to distinguish process data from fixed text.

The user has access to a library of standard data manipulation functions to process data in his report. Reports may be tested in an offline mode before integration into the process control system.

Reports may be scheduled at fixed times, fixed intervals, or on demand through an interactive online display. Copies of reports may be filed to disk for archival purposes as well as printed to paper.

5.0 Programming environment and performance requirements

5.1 IEC 61131 control performance

The RTU/PLC controller is consistently configured and programmed in accordance with IEC 61131 using the automation software. The system can be operated via the network (Ethernet). The powerful processor can be programmed in all five IEC 61131 programming languages and ensures quick control-task processing.
5.2 Integrated Ethernet connection
The integrated Ethernet connection (via twisted-pair cable) ensures Ethernet connectivity. Throughout the Ethernet network, the controller can be accessed via TCP/IP or UDP/IP.

5.3 Integrated communication functions
Integrated communication functions enable direct and effective data exchange via Ethernet. The Ethernet network provides universal options for communicating with the controller. Using the IP_USEND and IP_URCV communication blocks, information, such as the necessary coupling variables, can be exchanged between controllers via Ethernet. This enables distributed, modular automation solutions to be configured. The existing IEC 61131-5 blocks have therefore been extended to include a transparent TCP/IP mode and a transparent UDP/IP mode.

5.4 OPC functionality
When using the OPC server provided, the controller data are available in the Ethernet network in a standardized format and can be used for the different visualization packages.

5.5 Modbus functionality
The RTU/PLC shall support Modbus RTU and TCP function block libraries for master/slave or client/server communications.

5.6 RS-232/485 interface
This interface can be used to either assign the IP address of the controller and to access the controller using the diagnostic tool or to communicate with serial I/O devices via functional blocks. The controller cannot be programmed via the RS-232/485 interface.

5.7 Parameterization memory/SD card
All controllers must be capable of being operated using a plug-in parameterization memory in the form of an SD card. This memory can be used to save programs and configurations that belong to your project; e.g., the visualization project.

6.0 IEC 61131 configuration software specifications

6.1 The following IEC 61131 guidelines must be followed:
- Representing the project tree according to the IEC 61131 software model
- Using of the project tree according to the Windows® Explorer
- Displaying of the different project parts by different views
- Reusability of function blocks in user and firmware libraries
- Know-how protection using password handling or firmware libraries
- Integration of several controllers in one project

6.2 IEC 61131 programming languages:
Following functions must be available:
- Instruction List (IL)
- Structured Text (ST)
- Function Block Diagram (FBD)
- Ladder Diagram (LD)
- Sequential Function Chart (SFC)

All programming languages can be mixed within one project.
7.0 Communication and interface functionality

7.1 The wellhead control panel shall be supplied with an Ethernet switch connected to the RTU/PLC, which allows communication via Modbus RTU or Modbus TCP to an external SCADA system (by others).

7.2 The wellhead control panel shall be supplied with two (2) wireless Ethernet transmitters. One Ethernet transmitter shall allow the RTU to communicate locally with an operator interface, as per section 4.10, and the second Ethernet transmitter shall be capable of creating a mesh network with adjacent wellhead transmitters in the area up to a distance of 1 km in all directions. The local Ethernet transmitter shall be 802.11b-compliant, and the “meshing” Ethernet transmitter shall operate at a frequency of 900 MHz.

7.3 The wellhead RTU/PLC shall allow full read/write access via Modbus RTU or Modbus TCP.

7.4 The vendor shall ensure that the RTU wireless Ethernet is secure and only allows communication with authorized devices. The system shall be capable of interfacing to a third-party SCADA or DCS system.

7.5 The following items summarize the features and functionality of the interface software:

- Periodically read analog data and associated data quality
- Periodically read discrete data and associated data quality
- Read data individually and as a block, to minimize time delay and CPU usage
- Write analog output values, such as set points, on demand using the system output queue
- Periodically monitor the interface status and take appropriate action if an error or abnormal condition occurs

7.6 The interface will be subject to the following limitations:

- It will not validate a point value against the engineering unit range specified in the SCADA database. This validation will be done within the database.
- It will not monitor the status of the other nodes within the SCADA system network.

8.0 Operator interface requirements for the wellhead

8.1 At the pad site, the RTU/PLC shall be capable of communicating wirelessly to an operator interface to a distance of 10 meters. The interface will be in the form of a PDA or laptop (by others). The RTU/PLC shall contain an internal web page, which can be accessed by a web browser on the operator interface to display process information and perform control and configuration functions.

8.2 The internal web page shall display the following information:

- A well overview page displaying all wellhead process data
- An alarming page displaying all active and unacknowledged alarms
- An alarm acknowledgement function

8.3 The internal web page shall also allow the operator to change process set points at the local pad site.

The operator’s interface for the wellhead control system will be implemented using a standard software package supplied with the RTU/PLC.

8.4 The control system vendor’s scope of work is to configure the points and build the graphics, control functions, and the data logger.

9.0 Field installation specifications for system hardware control panel enclosure

9.1 The control panel will be installed outdoors, with no further protection from the weather. The vendor shall supply enclosures or panel boxes with a minimum rating of IP65. The enclosures shall be supplied fully fitted with the controller’s required terminals, internal wiring, and other associated hardware; fans and ducting; and power supply hardware. The panel shall be supplied with a sunshade.
9.2 A typical panel layout is outlined below:

9.2.1 Cable entries
All cable entries shall be via a bottom-mount removable gland plate. The gland plate shall be made from a non-ferrous material and be earthed to the enclosure.

9.2.2 Wiring
Internal panel wiring shall be installed in accordance specification supplied with the package and AS/NZS 3000:2007.

9.2.3 Terminals
Panel terminals shall be installed in accordance with client specification supplied with the package.

9.2.4 All terminations shall be mounted on TS32 rail or equal. Terminal rails shall not be mounted on the panel sides.

A minimum distance of 80 mm shall be maintained between a terminal strip and its associated ducting/trunking, and a minimum distance of 50 mm shall be maintained between terminal strips and the bottom and top of the enclosure.

9.2.5 Terminals carrying 240V AC or higher mains power shall be segregated from each other and from other terminals and shall carry a warning label.

9.2.6 Power supplies
The supply voltage to the wellhead control panel shall be 24V DC. This power supply is provided by a 24 V DC UPS and shall be provided by others. The vendor shall advise the power requirements and maximum demand of the control panel.

9.2.7 The vendor shall provide a main incoming isolation circuit breaker and any other necessary circuit breakers required for internal power distribution.

9.2.8 Earthing
The control panel shall be supplied with an earth bar. The earth bar shall be color-coded as per AS/NZS 3000:2007.

9.2.9 Panel labels and ferrules
Panel labels and ferrules shall be in accordance with the client specification supplied with the package.

9.2.10 Field I/O: typical
The control panel shall allow for terminating the following I/O, plus provision for a minimum 20% spare. Individual instrument cables will be installed for each device.

9.2.11 All analog inputs shall be loop-powered via a nominal 24V DC supply. The minimum input impedance shall be 250 ohm, to allow use of an external HART communicator.

9.2.12 All digital outputs shall operate 24V DC field devices, each of maximum 12W power consumption.

9.2.13 The vendor shall design the system based on the I/O count. The vendor shall supply intrinsically safe (IS) barriers for each instrument as indicated.

10.0 Control system environmental
Temperature ranges vary widely, and this is a rugged environment with many production fields being in extreme locations. The system shall be designed for operating temperature ranges from -20 to 60 degrees Celsius (from -4 F to 140 Fahrenheit).

10.1 Electronic components and modules
Oil and gas production environments are often in areas of high humidity, and marine coating is recommended for electronic components and modules. The process environment, in addition to the temperature ranges, requires conformal coating of circuit boards. This silicon coating of all circuit board circuitry provides corrosion protection of the circuit board from trace amounts of H2S, etc.

10.2 Silicone coatings range from elastoplastic, which is a tough, abrasion-resistant material, to soft elastomeric materials. Silicone is typically used in high-temperature environments. It has good moisture and humidity resistance. It has good thermal-shock resistance due to its flexibility and is also easy to apply and repair. Its moisture resistance is similar to urethane and acrylic, and Dielectric withstand is lower than for the other coatings (1100 volts/mil). Flexibility of coating allows for much thicker film build than comparable acrylic or urethane coating. Its typical temperature range is from -65 to 200 degrees C.
11.0 Control system electrical and zoning requirements

The system shall be designed as follows:

- Zoning is always Class I, Division 2, Groups A, B, C, D. All electrical components utilized and developed for this application must have: UL, FM, CSA, GOST, ATEX, IEC ex, and/or other reputable certifications not listed.
- IEEE 472 and ANSI 37.90 compliant
- CSA Class I Div 2, CE compliant
- ATEX (For international customers)

12.0 Typical wellhead automation system diagram
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