

DEP SPECIFICATION

INSPECTION AND FUNCTIONAL TESTING OF INSTRUMENTS

DEP 62.10.08.11-Gen.

February 2011

(DEP Circular 11/12 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for inspection and testing of instruments, before and after installation, during the construction and start-up phases of new plants or after planned shutdowns. It also covers requirements for storage and hydrotesting of instrumentation systems in the field. It defines activities and requirements to confirm that instrumentation conforms to the Principal's requirements and is installed and functioning according to the approved engineering/construction drawings and data.

This DEP also addresses the development of a Quality Plan for instrumentation.

The following stages of activities are covered in this DEP:

1. Factory Acceptance Test (FAT) and Site Acceptance Test (SAT).
2. Check on incoming instruments and installation materials, including storage.
3. Pre-installation inspection.
4. Inspection of Systems, System Cabinets, and Cable Tray and Wiring Systems
5. Post-installation inspection
6. Pre-loop check
7. Loop check
8. Instrument System Checks
9. Hydrotest and line flushing support activities
10. Process tubing leak test
11. Pre-start-up activities

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual DEM 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated November 2003; see (1.5) regarding the changes.

**Amended per
Circular 11/12**

A number of editorial (non-technical) changes have been made throughout this DEP.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
BPCS	Base Process Control System – system which responds to input signals from the process, its associated equipment, other programmable systems and/or an operator and generates output signals causing the process and its associated equipment to operate in the desired manner but which does not perform any safety instrumented functions with a claimed SIL $\geq$ 1.
Bus	An H1 Foundation Fieldbus cable between a host and field devices connected to a single H1 segment.
Calibration	Adjustment of an instrument's ZERO and SPAN by observing the changes in its output caused by manual changes to its input. Both the input and output signals are monitored with test equipment that is more accurate than the instrument being calibrated. Calibration also includes setting switch set points by using test equipment.
Calibration Check	Testing of an instrument's calibration during the pre-loop and loop check processes. This is done with test equipment monitoring the instrument's inputs and outputs. Typically, a device's calibration is checked at 0%, 50% and 100% of span.
Commissioning, Foundation Fieldbus	Putting into service the Foundation Fieldbus devices connected on the segments, and downloading the offline configuration to these devices. Electronically, the device is placed into service. Note that the device may still require operational activation as part of the Process Commissioning and Startup.
Configuration	Manual or bulk entry of engineered parameters or programs into a microprocessor-based device (e.g., Foundation Fieldbus device).
Configuration Download	Data transfer of engineered parameters or programs from an electronic file into a microprocessor-based device (e.g., Configuring a Foundation Fieldbus or HART device from a portable PC or DCS Data Management System).
DCS	Distributed Control System

Term	Definition
Device Coupler / Segment Protector	Segment connection device that connect FF devices in the field to the H1 segment and can provide a current-limited (i.e. short circuit protection) junction. The common FF name is device coupler or segment protector for non-intrinsically safe (non-IS) spur output and Multi barrier or Field bus barrier for IS spur outputs.
Engineering Work Station (EWS)	Necessary hardware and utility software designed to perform PES configuration; typically it is based on a PC platform.
Fail-safe	Capability of a device or system to go to a predetermined safe state in the event of a failure or malfunction.
Fault tolerant	ability of a functional unit to continue to perform a required function in the presence of faults or errors.
Factory Acceptance Test (FAT)	A set of predefined test procedures conducted at the supplier's works after the system has been assembled, and before the system is shipped to Principal's site. The FAT is when the system is demonstrated to meet the functional, integrity and performance requirements. It is not the tests that the Supplier is expected to carry out prior to the visit by the Principal for the FAT.
Fieldbus	Digital, two-way, multi-drop communication link among intelligent measurement and control devices. It serves as a local area network (LAN) for advanced process control, remote input/output and high speed factory automation applications.
Field Inspection	Verifying that field instruments are installed and configured according to the Principal's requirements.
Final Control Element	Device that provides the physical action on the process or process equipment that is necessary to achieve the desired action. For safety-instrumented systems (SIS) the final control element takes action on the process to achieve the safe state. Examples include control valves, shutdown valves, motor starters for pumps, etc.
Fire and Gas System (FGS)	The Fire and Gas system, as a term in this document, encompasses the fire and gas detection equipment, signal processing, monitoring, alarming and voting. The FGS's function is to generate confirmed fire initiators for ESD (Emergency Shutdown) and personnel safety functions.
FTA	Field Termination Assembly
Function Block Diagram (FBD) Language	A graphical programming language (for application software) using function block diagrams for representing the application program for a PES.
Function Test	Simulation of the transmitter process variable input to demonstrate the operation of the loop. A function test is not a precise calibration check and accuracy of $\pm 5\%$ is typically sufficient. Generally, the instrument's output is not monitored with test equipment. Control valves are function tested in a similar manner by manually moving the appropriate controller output and observing the actual valve position.

Term	Definition
H1	Foundation Fieldbus network operating at 31.25 kbit/s.
HART®	The Highway Addressable Remote Transducer Protocol (HART) is a digital industrial automation protocol and is considered a de-facto standard for digital communications with 4-20 mA smart process instrumentation. HART® is a registered trademark of the HART Communication Foundation.
Historical Trend	A graphical display on the HMI which allows the operator to view historical data available along with real-time data.
Human Machine Interface (HMI)	The means by which information is communicated between human(s) and the PAS (for example, monitors, indicating lights, push-buttons, horns, alarms). The HMI is also known as the operator interface.
Inputs and Outputs (I/O)	Inputs and Outputs to a system (PES, DCS etc.). Some typical I/O types include 4–20 mA analog input/output, 24 VDC discrete input/output, and are to/from field instrumentation or other systems.
Inspection of Instruments	Verification that instruments and instrument systems comply with requirements..
Instrument Asset Management System (IAMS)	DCS-based asset management system that facilitates configuration, diagnostics and troubleshooting on Smart field devices (e.g., Emerson AMS, Yokogawa PRM).
Instrument Loop	Several instruments that are pneumatically, electronically or software connected to provide control, indication, alarm, or shutdown function.
Instrumented Protective Function (IPF)	A function comprising one or more sensors, a Logic Solver and one or more Final Elements whose purpose is to prevent or mitigate hazardous situations and that have SIL 1, SIL 2, SIL 3 or SIL 4. An IPF is intended to achieve or maintain a safe state for the process, in respect of a specific hazardous event. In IEC 61508 and IEC 61511, an IPF is referred to as a Safety Instrumented Function (SIF).
Instrumented Protective System (IPS)	The electromechanical, electronic and/or programmable electronic Logic Solver component of the Instrumented Protective Function, complete with input and output equipment. In IEC 61508 and IEC 61511 an IPS is referred to as a 'Logic Solver'.
Instrument System	PLC Systems, Instrumented Protective Systems, Tank Gauging Systems, or Complex Control Loops that contain more than one instrument loop.
In-situ Calibration/Testing	Calibration and testing carried out directly on the plant.
Integrated Factory Acceptance Test (IFAT)	A FAT that includes 3 rd party systems not supplied by the supplier that hosts the FAT and that aims to demonstrate correct functioning of interfaces to these 3 rd party systems..

Term	Definition
Line Monitoring Device	A device capable of or needed to detect loss of circuit integrity.
Logic Solver	The portion of either a BPCS or an SIS that performs one or more logic function.
Loop Check	Procedure used to demonstrate proper operation of an instrument loop for formal acceptance of the loop by QA/QC.
Main Automation Contractor (MAC)	Manufacturer/Supplier of the DCS, IPS, and FGS systems including its, configuration. Also referred to as the Manufacturer/Supplier in this DEP.
MOS	Maintenance override switches used to override IPF sensors to enable maintenance or on-line functional testing.
OLE for Process Control (OPC)	The OPC Specification is a non-proprietary technical specification that defines a set of standard interfaces based upon Microsoft's COM/DCOM technology. The application of the OPC standard interface makes possible interoperability between automation/control applications, field systems/devices and business/office applications.
On-line Process Stream Analysers	Instruments which monitor the specific properties of process streams other than flow, level, pressure or temperature. They are also referred to as Quality Measuring Instruments (QMIs).
Operation Override Switch (OOS)	Operational override is a short-term (typically less than 2 hours) deactivation of a safety input or output device for operation start-up purpose.
Operator Interface	See HMI.
Equipment Package	Single or combined units of equipment supplied by a Vendor which include instrumentation or to which instrument requirements may apply.
Peer-to-Peer Communications	Communications between two processors via the system's data highway or another communications link.
PLC	Programmable Logic Controller – a microprocessor based control system that is customarily used to perform complex, discrete switching logic.
Pre-Loop Check	Procedure used to identify/solve problems prior to the loop check.
Process Automation System (PAS)	Process Automation System – consisting of the BPCS, IPS and FGS.

Term	Definition
Process Commissioning and Start-up Activities	Operational activation of instruments and instrument systems under operating conditions. It often includes handing over the instruments and systems for continued use to the operating and maintenance departments. This activity also includes the tuning of control loops, seal liquid filling of impulse lines, commissioning of Advanced Process Control (APC), surge and condition monitoring applications and final adjustment of settings for all items.
Process Instruments	All instruments used in process and utility units, including process stream analysers.
Programmable Electronic System (PES)	System for control, protection or monitoring based on one or more programmable electronic devices, including all elements of the system such as power supplies, sensors and other input devices, data highways and other communication paths, actuators and other output devices.
QA (Quality Assurance)	Activity performed by the Principal (and managing contractor if applicable) to assure that the field contractor is adequately performing Quality Control.
QC (Quality Control)	Work process performed by installation contractor's instrument inspectors, and the processes they use to determine and approve quality.
Real-Time Trend	A graphical display on the HMI that allows the operator to view real-time data commencing from when the trend is initiated on the display.
Redundancy	Use of multiple elements or systems to perform the same function; redundancy can be implemented by identical elements (identical redundancy) or by diverse elements (diverse redundancy).
Remote I/O	The opposite of centralized I/O: a system where the I/O modules are located remotely to the processor, usually in the field close to the process elements being controlled / monitored.
Safety Instrumented System (SIS)	Instrumented system used to implement one or more safety instrumented functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s) [IEC 61511]. In summary, an SIS is a collection of IPFs (including sensors and final elements) that together protect a process unit or major piece of equipment.
Segment	The complete single H1 Foundation Fieldbus network from the Host FF interface card to the Field devices. Segment length can be extended by Repeaters to form a longer H1 Fieldbus.
Segment Trace	Signal waveform as presented on an oscilloscope or other graphic wave form device that depicts the shape characteristics of the signal present on a segment.
Shop Inspection	Activities performed before the instruments are installed in the field.

Term	Definition
Site Acceptance Test (SAT)	A set of predefined procedures conducted at a job site after the system has been reassembled, and sometimes with testing of modifications to the software tested at FAT. For this document, SAT includes all system testing and verification prior to start of loop check. Sometimes referred to as the SIFT (Site Integration Functional Test).
Spur	H1 branch line connecting a single FF device to a Device Coupler or a Fieldbus barrier.
Special Systems	Special instrument systems often dedicated to equipment packages. For example speed control systems, surge control systems, weigh cell systems, vibration monitoring systems, and slide valve hydraulic control systems.
System Architecture or Architecture	Arrangement and functional connectivity of BPCS and SIS hardware and related I/O, HMI, Historian and third party subsystems.
System Check	Procedure used to demonstrate proper operation of an instrument system for formal acceptance of the system by QA/QC. Procedure involves tests that are developed during design.
Terminator	Impedance-matching module used at or near each end of a transmission line that has the same characteristic impedance of the line. Terminators are used to minimize signal distortion and reflection, which can cause data errors by converting between current variations and voltage variations. H1 terminators also have another even more important function. They convert the current signal transmitted by one device to a voltage signal that can be received by all devices on the network and they make sure that the signal level is at the right level. If one terminator is missing, signal level will be too high; one extra terminator and signal level becomes too low. An H1 network shall have two (2) terminators.
Topology	Shape and design of the Fieldbus network (e.g., tree, spur, combination tree/spur, daisy chain, etc.).
Utility software	Software tools for the creation, modification, and documentation of application programs and configuration parameters running in a PES.
Valve Signature	Graphical representation of the performance characteristics of a valve as it is stroked from open to close and close to open.
Work Pack	A group of post-FAT software and/or hardware changes organized into a single package for purposes of identification, tracking and subsequent implementation and testing after FAT is complete.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (17).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated November 2003. The following are the main, non-editorial changes.

Old section	New section	Change
	All	Inclusion of SHALL [PS] requirements and segregation of the DEP contents into Specification, Informative, and Practice documents.
	All	Inclusion of relevant sections and appendices from Engineering Guides and General Specifications 16GS-903 (Field Inspection and Loop Checking of Instrumentation), Material and Equipment Standard 16-3.02 (Instrumentation Field Checkout and Testing), and GS.09.53311 (PAS Systems Acceptance Testing).

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

**Amended per
Circular 11/12**

Dual units have been incorporated throughout this DEP.

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. QUALITY PLAN

A comprehensive Quality Plan for the inspection and functional testing of instruments shall be prepared in accordance with ISO 9000, or equivalent, covering as a minimum:

- a) Inspection and functional testing scope, a list of inspection and loop testing requirements;
- b) The criteria that are used to decide whether or not a particular activity is to be carried out;
- c) Pass/fail criteria for both hardware and software testing;
- d) Vendor inspection and test procedures and instructions;
- e) Vendor assistance that may be required to test and commission instruments, instrument systems, or Equipment Packages;
- f) Skills and competences required for the inspection and loop testing work;
- g) Communications and communication means (radio, intercom etc.) required for inspection and loop testing;
- h) Test equipment to be used and their traceability to standards (Appendix 2);
- i) The quality documents (i.e. procedures, specifications (e.g. DEPs), acceptance criteria and work instructions) to be used and to be completed in assuring quality in each activity. All documents and drawings that are used shall be listed and properly controlled. The scheme shown in Appendix 1 may be used to prepare the Quality Plan;
- j) The ISO 9000 or equivalent Quality Plan of instrument vendors;
- k) The organisation and reporting hierarchy of all involved in inspection and loop testing;
- l) The independency of the organization responsible for signing off on the FAT, field inspection and testing, or SAT from the organization performing the work. For instance the supplier or company that has a financial relationship with the supplier who programs the IPS cannot sign off on the IPS FAT;
- m) Time schedule and approval milestone also considering activities that interface with other disciplines that e.g. carry out radiography inspections, pressure tests and flushing;
- n) Progress reporting;
- o) Audits by the Principal of Contractor's inspection and loop testing activities.

3. GENERAL REQUIREMENTS

1. Instrument staff doing the loop checking shall be provided with the following:
 - a. Training on the systems and technology that are being used;
 - b. Suitable test equipment. See (Appendix 2) for a typical, non-exhaustive list of test equipment;
 - c. System administration support. This DEP uses the term DCS Supplier as the party who is responsible for the DCS system configuration while inspection and loop testing work is on-going;
 - d. Specialist support for the systems involved (e.g., Fieldbus, HART, Instrument Asset Management System, IPS, etc.).
2. Inspection Sheets, Loop Check Reports, and Fieldbus Reports:
 - a. The contractor shall develop inspection sheets and Loop Check Report forms based on this DEP (Sections 8 through 12), the project PAS technology used, and the Quality Plan;
 - b. Inspection findings shall be recorded in a traceable manner. The inspection sheets and Loop Check Reports may be used for this purpose;
 - c. A Loop Check Report shall be completed for each instrument loop documenting the work carried out in accordance with this DEP;
 - d. A common database such as "SmartPlant Instrumentation (SPI or INtools)" may be used to generate these sheets automatically. If another instrument database is used at site or on the project, the inspection and loop testing results may be stored in it. The same database may be transferred to the Instrument Maintenance Management System. The database may also be utilised to produce progress reports. Instrument specification sheets in the database should be updated to "Issued for Construction" status, prior to use during the loop check process
 - e. For FoundationTM Fieldbus work, refer to DEP 32.30.20.13-Gen, FoundationTM Fieldbus – Design and Configuration for the required deliverables.
3. Existing instrument loops that are modified in a project shall be subject to Pre-Loop Check and Loop Check.
4. Loop Check Reports shall be completed to include manufacturer, model, and calibration of the existing instruments to be monitored and tested.
5. Instruments shall conform to Supplier's published specifications. Instruments that do not meet Supplier's specifications shall be returned to the Supplier or repaired.
6. Permanent instrument tags may be installed during pre-installation inspection or when the device is installed.
7. The following items shall be carried out when construction is still on-going, i.e. before the activity is completed:
 - a. Cable trench inspection;
 - b. Underground cable inspection (to be inspected before back-filling);
 - c. Earthing integrity tests;
 - d. Point to point wiring checks;
 - e. Inspection of in-line instruments e.g. orifice plate dimensions;
 - f. Field junction box inspection;
 - g. Instrument cabinet inspection;
 - h. Validate that the straight length requirements for flow meters are met;

- i. Inspection of process connections, including QMI sample take off and return arrangements;
 - j. Instrument accessibility;
 - k. Ensuring that welding activities shall not affect the electronic instruments already installed.
8. Whenever possible, the use of the Instrument Asset Management System during instrument testing should be maximized.

4. FACTORY ACCEPTANCE TEST (FAT), INTEGRATED FAT (IFAT), SITE ACCEPTANCE TEST (SAT)

Contractor shall list and agree with Principal those instruments and instrument systems that need to be subjected to a FAT and SAT.

Specific FAT requirements for F&G systems are detailed in DEP 32.30.20.11-Gen. section 10.2.

4.1 PROCESS AUTOMATION SYSTEM FAT

4.1.1 DOCUMENTS REQUIRED FOR FAT

The documentation required for a FAT may vary depending on the size and complexity of the PAS. The following documentation should be available for the FAT:

By the Supplier:

- a) Pre-FAT testing results;
- b) FAT procedure. Version control shall be implemented to assure that the latest test plan is being used;
- c) System architecture overview "block diagram";
- d) System loading (station/controller/gateway) for the system. The loading should contain all the system features that are to be included in the system functionality (e.g. IAMS - Instrument Asset Management System, ESP – Ensure Safe Production);
- e) PAS DCS/PLC architecture drawing(s);
- f) PAS HMI architecture drawing(s);
- g) PAS Network architecture drawing(s), including network addresses and component names;
- h) PAS Panel general arrangement drawing(s);
- i) PAS Panel power distribution/wiring drawing(s);
- j) Agreed Sub-system layout across processors.

By the Contractor:

- a) P&IDs / PEFSS;
- b) Equipment room layouts;
- c) Hardwired interface detail;
- d) Safeguarding Cause and Effect Diagrams;
- e) I/O Taglist (Master Instrument List – SPI - Smart Plant Instrumentation);
- f) I/O and/or Fieldbus segment loading schedules;
- g) Range, alarm and trip schedule (RATS List);
- h) Process Control Narratives and Complex Loop documentation;
- i) IPF Requirement Specification documentation as listed in DEP 32.80.10.10-Informative, Section 5.;
- j) Third-Party Interface documentation - Communications layout, including Cable Schedule (Fibre/Ethernet);
- k) High level Functional Design Specification.

4.1.2 REVISION CONTROL

The Supplier shall have a robust revision control process for revision approvals and implementation tracking, and this should include maintaining backups of all application software. All software changes requiring changes to Cause and Effect shutdown logic or trip set points SHALL [PS] only be programmed when authorized according to the project's Management of Change procedure.

At every download of compiled code to a processor, regardless of whether on-line or off-line changes are made, a backup shall be made by the Supplier of the application software. Prior to a download, the Supplier shall backup "tuneable parameters", and check for any discrepancies, to ensure that parameters are not accidentally set back to previous values by the software download. The backup of "tuneable parameters" set in the running application software (e.g. alarm levels, PID tuning) shall be regularly backed-up to the source code.

4.1.3 FAT STAGING AND TESTING PLAN

4.1.3.1 OVERVIEW

The PAS staging consists of assembling the complete system, interconnecting all system components, communication networks and servers and powering the system up.

The PAS shall be staged at the Supplier's facility, unless the project specifically specifies another location. Safeguarding logic SHALL [PS] be verified (including correct operation of MOS functionality, automatic and manual operational overrides, and fault degradation) and shall be witnessed by certifying authorities, if applicable. System configuration and performance requirements SHALL [PS] be verified. All testing documents shall be signed off and dated once satisfactory operation is demonstrated.

4.1.3.2 FAT EXECUTION

The Supplier is responsible for conducting the FAT and demonstrating that the system is configured and functioning according to the design requirements.

4.1.3.3 REMEDIATION

The Supplier shall have a remediation plan in place. The plan shall include generation of a full and complete Non-conformance Report (NCR) for incomplete tests or identified deficiencies. This NCR list shall be maintained and updated by the Supplier as remedial actions are completed. The Principal and Supplier shall agree to classifications for deficiencies prior to the start of the testing.

4.1.3.4 HARDWARE PRE-TESTING

The Supplier shall perform an internal hardware test of all hardware in advance of the Principal's hardware FAT. Similar internal testing shall be completed prior to installation of post-FAT changes whether implemented in office-based work packs or on-site. The Supplier shall prepare and submit to the Contractor a pre-FAT certificate for the activities to be covered by the FAT, and this should be based on the checks the Supplier has carried out on the hardware. Detail of hardware testing requirements may be found in section 4.1.3.6.

4.1.3.5. BASE DESIGN DOCUMENTATION

Before commencing testing, it shall be confirmed that the correct revision of all design documentation has been used to configure the system. The revisions of all documents shall be recorded in the FAT test report. As staging progresses, these documents must be used to check the completeness of the Supplier's work. At the end of each task, appropriate documents/drawings shall be checked or marked (e.g. with yellow highlighter and red "as-built" documentation mark-ups) to provide easy visual inspection for completed and uncompleted tasks. Checker/s, i.e. Contractor's and/or Principal's representative, shall initial and date each document.