



Exploration & Production

GENERAL SPECIFICATION

TECHNOLOGY

GS EP TEC 260

HIPS Design, Implementation and Life Cycle

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Contents

1. Scope	5
2. Reference documents.....	5
3. Definitions.....	7
3.1 Parties	7
3.2 Abbreviations	8
4. Obsolescence and lifetime cycle management	9
5. Cyber security	10
6. Service conditions	10
7. General design & construction requirements	10
7.1 Hazardous area classification and EMC certification	10
7.2 Materials of construction	11
7.3 Standardisation	11
7.4 Electrical links	11
7.5 Earthing	12
8. Performance requirements.....	12
8.1 HIPS reliability criteria.....	12
8.2 HIPS availability criteria	13
8.3 HIPS reaction and response times.....	13
9. HIPS sensors	14
9.1 General.....	14
9.2 Pressure sensors	16
9.3 Flow sensors.....	16
9.4 Level sensors.....	17
9.5 Sensor isolation valves and interlocking arrangements	19
9.6 Heat tracing and winterisation requirements	21
9.7 Sensor protection enclosures.....	22
9.8 Sensor engineering documents.....	23



10. HIPS logic solvers	24
10.1 General.....	24
10.2 Logic solver reliability	25
10.3 Logic solver availability	25
10.4 Cyber security	26
10.5 I/O modules and logic modules	26
10.6 Discrepancy monitoring.....	27
10.7 Voting arrangements and downgraded modes.....	27
10.8 Operator interface	27
10.9 Reset and black-start	29
10.10 Inhibit and override functions	29
10.11 Testing facilities	30
10.12 Sequence of event	30
10.13 Interfaces with other systems.....	31
10.14 Functional logic and troubleshooting loop diagrams.....	32
10.15 Spare capacity	33
10.16 HIPS cabinet.....	33
11. HIPS final elements	34
11.1 HIPS valves	34
11.2 HIPS Actuators and valve control panels	36
11.3 Valve and actuator installation and handling requirements.....	40
11.4 Valve and actuator painting.....	40
11.5 Electrical switchgear for HIPS functions	41
12. Testing requirements.....	41
12.1 Testing methodology.....	41
12.2 Test procedures	42
12.3 Test preparation.....	42
12.4 Test witnessing	42
12.5 Test recording and corrections follow-up.....	43
12.6 Design Validation Test (DVT).....	43
12.7 Factory Acceptance Tests (FAT).....	44
12.8 Integrated Factory Acceptance Test (IFAT).....	51
12.9 Yard & On-Site Acceptance Tests (SAT).....	52



12.10	Operational Test Procedure (OTP).....	53
12.11	Wet HIPS performance tests.....	54
13.	HIPS design validation.....	54
14.	Preservation, storage and installation requirements.....	56
	Bibliography.....	58
Appendix 1	Typical logic solver power supply and earthing diagram	59
Appendix 2	Example of a typical integral HIPS mimic panel.....	60
Appendix 3	Typical 5-step reliability methodology	61



1. Scope

This General Specification describes the minimum requirements for the design, implementation and life-cycle of all parts of a High Integrity Protection System (HIPS), comprising:

- Sensors
- Logic solver
- Final elements
- Interfaces with other systems

and associated project execution and SIL demonstration requirements.

This General Specification applies to surface oil & gas processing and transport facilities.

This General Specification shall be applied in conjunction with **GS EP SAF 260**, which serves as the governing specification defining the basic configuration of any HIPS.

A HIPS is a complex system involving multiple technical and safety engineering disciplines. This General Specification represents the consensus of multiple corporate technical and safety departments and shall be strictly adhered to. Eventual Derogation Requests must be fully motivated and provide fully worked-out detailed solutions which do not reduce the reliability and availability of the HIPS, and which shall be subject to review and approval by Company's HIPS Committee and/or corporate engineering discipline manager(s).

This General Specification shall be complemented with a project specification providing the project specific details, without altering the requirements defined in this specification.

This General Specification also serves as a Safety Requirement Specification, required by [IEC 61508/IEC 61511](#) for safety instrumented systems for the process industry. In case of conflict or discrepancy between [IEC 61508/IEC 61511](#) and this specification, then the most stringent requirement to Company's judgement shall be applied.

HIPS shall be a complete autonomous Safety Instrumented System (SIS), being a fully stand-alone system with dedicated sensors, logic solver and final elements, and which shall not rely or depend on other control/safety systems present (other systems may also actuate HIPS final elements, but the final elements remain part of the HIPS).

As such, a HIPS cannot be broken into individual components processed by different parties; nor can it be integrated inside another safety system.

The HIPS shall be single supply by a Company approved HIPS Integrator.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.



Standards

Reference	Title
ASME B16.34	Valves - Flanged, Threaded, and Welding End
EN 10204	Metallic Products - Type of Inspection Documents
IEC 60331	Fire resisting Characteristics of Electric Cables
IEC 60529	Degrees of Protection Provided by Enclosures (IP code)
IEC 60617-12	Graphical Symbols for Diagrams - Part 12: Symbols for Binary Logic, Analogue and Hybrid Elements
IEC 61508	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems
IEC 61511	Functional Safety - Safety Instrumented Systems for the Process Industry Sector
IECEX	IEC System for Certification to Standards relating to Equipment for use in Explosive Atmospheres (IECEX System)
ISO 4406	Hydraulic Fluid Power - Fluids - Method for Coding the Level of Contamination by Solid Particles
ISO 10497	Testing of Valves - Fire Type-Testing Requirements

Professional Documents

Reference	Title
API 607	Fire Test for Quarter-turn Valves and Valves Equipped with Non-Metallic Seats

Regulations

Reference	Title
European Directive 94/9/EC dated 23 March 1994	Directive of the European Parliament and of the Council on the approximation of the Laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres (ATEX)
European Directive 2004/108/EC dated 15 December 2004	Directive of the European Parliament and of the Council on the approximation of the Laws of Member States relating to electro-magnetic compatibility (EMC)



Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
OREDA	Offshore Reliability Database

Total General Specifications

Reference	Title
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 354	External protection of onshore structures and equipment by painting
GS EP ELE 161	Electrical cables
GS EP EXP 405	Standard reliability data report
GS EP INS 101	Instrumentation engineering, supply and construction general requirements
GS EP INS 107	Design and installation of instrumentation links
GS EP INS 137	On/off valve control panels and actuators functional and construction requirements
GS EP PVV 142	Valves
GS EP SAF 361	SIL assignment
GS EP SAF 260	Design of High Integrity Protection Systems (HIPS)
GS EP SAF 261	Emergency Shutdown and Emergency De-Pressurisation (ESD & EDP)
GS EP SAF 337	Passive fire protection: Basis of design
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

3. Definitions

3.1 Parties

Company	TOTAL E&P or any TOTAL E&P subsidiary.
Contractor	Any company TOTAL E&P has signed a contract with for the Engineering, Procurement, Construction and Installation of a part of a project.



Manufacturer	Any company being the original manufacturer of a HIPS component, not necessarily being the supplier of the component(s).
HIPS Integrator	The designated company having received a Purchase Order by Contractor or by Company for the design and supply of a complete HIPS package.

3.2 Abbreviations

AISI	American Iron and Steel Institute
ASME	American Society of Mechanical Engineers
CCR	Central Control Room
DB&B	Double Block & Bleed
DVT	Design Validation Test
EMC	Electro-Magnetic Compatibility
ENP	Electroless Nickel Plating
ESD	Emergency Shut-Down system
FAT	Factory Acceptance Test
HART	Highway Addressable Remote Transducer protocol
HIPS	High Integrity Protection System
HMI	Human-Machine Interface
HVAC	Heating Ventilation and Air Conditioning system
I/O	Input/Output
ICSS	Integrated Control and Safety System
IFAT	Integrated Factory Acceptance Test
IMS	Instrument Maintenance System
IP	Ingress Protection
IT	Information Technologies
ITP	Inspection & Test Plan
LOPA	Layers Of Protection Analysis
MCC	Motor Control Centre
MTTR	Mean Time To Repair
MUX	Multi-Plexer
NPS	Nominal Pipe Section
NPT	Nominal Pipe Thread
OPC	OLE for Process Control protocol
OREDA	Offshore RELiability DATa organisation

OTP	Operational Test Procedure	
PC	Personal Computer	
PCS	Process Control System	
PDS	Process Data Server	
PFD	Probability of Failure on Demand	(IEC 61508, IEC 61511)
PFH	Probability of dangerous Failure per Hour	
PFP	Passive Fire Protection	
PSS	Process Safety System	
SAT	Site Acceptance Test	
SB&B	Single Block & Bleed	
SIF	Safety Instrumented Function	(IEC 61508, IEC 61511)
SIL	Safety Integrity Level	(IEC 61508, IEC 61511)
SIS	Safety Instrumented System	(IEC 61508, IEC 61511)
SMART	Self Monitoring And Reporting Technology	
SVTS	Smart Valve Testing System	
SOE	Sequence Of Event	
TCP/IP	Transmission Control Protocol/Internet Protocol	
UPS	Uninterruptible Power Supply	
VCP	Valve Control Panel	
VDU	Video Display Unit	
VSD	Variable Speed Drive	

4. Obsolescence and lifetime cycle management

A dedicated obsolescence and lifetime cycle management plan shall be established for the HIPS package in accordance with **GS EP TEC 007**, starting at Basic Engineering, meeting the specified HIPS lifetime including future migration (revamp) and decommissioning stages.

As per **GS EP TEC 007**, Contractor and HIPS Integrator have both separate tasks and deliverables to fulfil in the Obsolescence Plan, Dossier and Strategy Development. Therefore, the HIPS Integrator shall establish and issue his own dedicated obsolescence and lifetime cycle management philosophy and associated data for the complete HIPS package.

Besides technology, the support and commitment of any component Manufacturer, knowledge transfer and knowledge management are key issues to be addressed in the obsolescence and lifetime cycle management philosophy for the HIPS package, and shall as well define the selection of individual package components.

A number of specific design requirements for HIPS components, as defined here-after in various sections, are also driven by low-obsolescence requirements, such as solid state technology, 4~20 mA sensors, hard-wired/ModBus links and interdiction of IT-based equipment/links.

5. Cyber security

One of the key design objectives for the HIPS package shall be that the integrity (i.e. availability and reliability) cannot be affected by software alterations or via software interfaces with other systems, as the consequences of a failure on demand are potentially catastrophic and/or may cause significant production loss/stop.

Despite the use of solid state technology, cyber threats can still pose a direct or indirect threat to the integrity of a HIPS package, and a number of important HIPS design topics are related to cyber security as further detailed in section 10.4.

6. Service conditions

The HIPS dossier, HIPS design specifications and HIPS equipment data sheets by Company, Contractor and HIPS Integrator shall clearly identify and describe all possible process and ambient service conditions, such as (but not limited to):

- Process fluid compositions (all possible production scenarios)
- Possibility of slugging flow
- Rate of change in process pressure, temperatures, flows
- Presence & worst case concentrations of H₂S, CO₂, solids, sand, paraffin, etc.
- High & low extreme process pressure, temperatures, flows
- Change of process fluid composition & properties over the facility's lifetime
- Presence & worst case concentrations of injected chemical products
- High & low extreme ambient outdoor and indoor conditions.

For any of the conditions, it shall be clearly defined when they occur and what their impact is during the various operational situations, e.g. shut-in, cool-down, start-up, normal production.

This will also be required to define the needs for heating and winterisation of HIPS components.

The fact that some conditions only occur temporarily (such as methanol injection, or cool-down) does not relieve the design of the HIPS to be able to deal with these temporarily situations: the HIPS shall be suitable for any given situation/condition regardless its duration.

The presence of injected chemicals (notably methanol) and fluid elements such as H₂S is important as it has a direct impact on the selection of non-metallic components of sensors and final elements. Therefore, they must be clearly defined in the HIPS project specification.

7. General design & construction requirements

All the General Specifications as listed in section 2 apply if full, being complemented with the more restricted requirements as per following sections.

7.1 Hazardous area classification and EMC certification

All outdoor electronic/electrical equipment shall be certified, regardless of the area:

Ex d / e / de / ia, II-2G, IIB, T4

to **ATEX** (mandatory for European facilities) or to **IECEx** standards by a Notified Body, approved by Company, unless defined differently by the project specification. Certification to product

category '3G' or gas group 'IIA' is not permitted. Additional certifications, such as GOST, may apply as per project specifications.

Intrinsic safe instruments shall only be used if other protection methods are not available.

Local field junction boxes shall be Ex 'e'.

All electrical equipment shall be CE labelled for compliance with the [European ATEX](#) and [EMC Directives](#). [ATEX/IECEX](#) and [EMC](#) certificates for each HIPS component shall be included in the final vendor documentation.

7.2 Materials of construction

All outdoor HIPS sensors and control elements, including process isolation valves/manifolds, associated mounting accessories and protection equipment, shall be fully made of AISI 316 stainless steel, or better for process wetted parts as per applicable piping class.

Position detection switches may be made of non-metallic material if they are installed inside a protective enclosure, but first preference shall be metallic material.

For the process wetted parts of sensors and process isolation valves/manifolds, a material traceability certificate 3.1 as per [EN 10204](#) shall be provided.

Local field junction boxes, internal and external supports, earth bosses, shall all be AISI 316.

7.3 Standardisation

The HIPS system cabinets will preferably have identical colour and size as the ICSS system cabinets. Double-width cabinets shall not be used.

The brand and sizing system (i.e. metric or imperial) for instrument tubing and fittings shall be standardised throughout the whole facility.

It is the responsibility of the Contractor to specify these standardisation details to the HIPS Integrator, valve supplier, etc.

7.4 Electrical links

All HIPS field devices shall be hard-wired directly into the HIPS cabinet via individual armoured fire-resistant instrument cables as per [IEC 60331](#), without intermediate junction boxes or intermediate marshalling facilities. This rule also applies for cables towards MCC switchgear.

Exception to the direct-cable rule is given to particular field devices which have by design a short length of cable encapsulated (moulded) into the device, such as limit switches or heater blocks. In those cases, multiple devices of the same type might be hooked-up to a joined local junction box, but individual cables to the HIPS system cabinet shall be run. Segregated junction boxes for power and for signals in accordance with [GS EP INS 107](#) referential shall be retained.

Cables shall be in compliance with [GS EP ELE 161](#) with armouring in compliance with [GS EP INS 107](#).

Internal cabinet wiring, as well as all other plastic cabinet components such as ducting, circuit breakers, etc., shall have low smoke and non-toxic smoke properties.

Terminals shall be spring-loaded type, DIN-rail mounted, for all indoor and outdoor junction boxes and cabinet terminals (Ex-rated where required), both for signal and power cabling. Screw type terminals are only permitted inside final field devices (e.g. sensors, solenoids), earth bars, and for the power feeders & distribution inside the HIPS system cabinet.

7.5 Earthing

As strict segregation in earthing systems (i.e. IE, IPE, ISE) as per [GS EP INS 107](#) shall be applied. All design specifications, drawings and equipment itself shall clearly indicate and use the IE, IPE, ISE terminology, including junction boxes and field cabinets/enclosures.

Particular care shall be given to yellow/green DIN-rail earth terminals in junction boxes and marshalling compartments, because they provide a direct internal connection to the DIN rail itself. As such, it might be required that the DIN rail is isolated from the chassis or enclosure, to ensure that cable screens remain isolated from the local PE network. This shall be clearly identified during design, at design drawings and be duly verified during FAT.

By default, unless the facility's instrument earthing philosophy stipulates differently, cable screens shall be earthed only on the system cabinet side (i.e. isolated on field side), while cable armouring shall be earthed on both sides, in accordance with [GS EP INS 107](#).

The HIPS project specification shall clearly define if the 0 Vdc shall be floating or earthed, in strict coherence with the facility's instrument earthing philosophy. In the absence of any specification, the 0 Vdc shall be floating (i.e. not connected to earth). In case of floating 0 Vdc, an earth leak detector shall be installed with a single-pole double throw (SPDT) volt-free alarm contact, to be grouped with other general system alarms (refer to section 10.13).

Refer to Appendix 1 for a typical cabinet earthing and power supply diagram.

8. Performance requirements

8.1 HIPS reliability criteria

Each HIPS component, signal, logic and final elements shall be designed as fail-safe, i.e. failure of any component / signal / logic / power supply / motive fluids shall cause that part of the HIPS to automatically change to safe state.

A dedicated SIL assessment in the form of a LOPA as defined by [IEC 61511](#), and in accordance with [GS EP SAF 361](#), shall be performed at the earliest stage of the HIPS design as an integral part of the HIPS Dossier.

The reliability criteria (PFD_{avg} or PFH, which ever applies according to the demand rate) of all HIPS related components or sub system shall be specified and included in the component or sub-system datasheets. All HIPS related components or sub-systems shall be specified and selected with a PFD_{avg} (or PFH) which satisfies the SIL requirements of the HIPS function (SIF).

Utility supply and distribution shall be such that it meets the availability requirements and allows maintenance without production shutdown.

This General Specification stipulates a default SIL for certain HIPS components, which shall be adhered to regardless if a lower SIL is required for the HIPS function by the SIL assessment.

Only highly reliable and proven-in-use components or sub-systems shall be used, based on Company's [GS EP EXP 405](#) and Company recognised end-user reliability databases such as [OREDA](#). Otherwise, as per [IEC 61508](#), an additional hardware fault tolerance level must be implemented for the particular component or sub-system.

Reliability of components or sub-systems shall be demonstrated through extensive use in similar service and in similar environment during their useful lifetime. Prototype or non-proven-in-use components shall not be used.

8.2 HIPS availability criteria

Design of the overall HIPS shall include fault tolerance and redundancy arrangements for sensor, logic modules, I/O modules, power supply and any other component, in order to avoid spurious trips and provide high system availability (i.e. greater than 99.99%). All active components inside the system cabinet shall be hot-swappable and self-configuring to allow for online replacement. Refer to sections 9 and 10 for more details.

Unless specified differently, the Mean Time To Repair (MTTR) shall be taken as 8 hours.

8.3 HIPS reaction and response times

The HIPS reaction time is defined as the maximum allowable time in which the HIPS shall prevent a hazardous operational condition. The required HIPS reaction time is defined by dedicated studies being part of the HIPS dossier, in accordance with **GS EP SAF 260**, subject to review and approval by Company's HIPS Committee prior to any implementation.

The HIPS response time is defined as "the time between the process threshold value occurs until the final element has reached its safe state".

By definition, the HIPS response time shall not exceed the required HIPS reaction time, i.e.:

$$T_{\text{RESPONSE}} \leq T_{\text{REACTION}}$$

The HIPS response time is the summation of the time each of the following parts requires:

- Sensor response time
- Logic solver response time, incl. input cards
- Final element response time, up to final safe state

and which are further defined in the following sections.

8.3.1 Sensor response time

The sensor response time is defined by summation of the following parts:

- Lag time of the process tapping, e.g. thermal inertia of a thermowell (note 1)
- Lag time of the sensing element
- Processing (cycle) time of electronic instrument/transmitter
- Signal conditioning, e.g. dampening or filtering (note 2).

Note 1: In case of thermowells, a dynamic simulation shall be provided to calculate the lag time caused by the thermal inertia of the thermowell.

Note 2: Dampening shall be disabled (0 msec), refer to section 9.1.

8.3.2 Logic solver response time

The logic solver response time is defined by the summation of the following parts:

- Worst (longest) processing (cycle) time of any input card
- Processing time of the logic part and output.

In general, the processing time of the logic part and output is considered negligible (0 msec) for solid state technology; all of the logic solver response time will depend on the processing (cycle)

time of the analogue input cards which contain a microprocessor for signal conversion, derive threshold values, etc.

However, the overall logic solver response time shall be multiplied by a factor 2 for the final calculation of the HIPS response time, because if a process threshold value occurs just after a cycle has started, it will only be processed during the next cycle. This also referred to as 'Safety Time' in IEC 61508.

In any design case, for solid state HIPS systems, the logic solver response time shall never be defined less than 250 msec (which includes the double cycle time) in the HIPS response time calculations.

8.3.3 Final element response time

The final element response time is defined by the summation of the following parts, split in two possible types of final elements:

Actuated valves:

- The response time off all control circuit components (e.g. solenoid valves, pilot valves, quick exhaust valves, etc.) of the motive fluid feeding the actuator
- The time required to depressurise the motive fluid before the actuator starts to move
- The inertia and mechanical slack of the moving parts in the actuator and valve (i.e. stroking time), until the valve has reached its safety position.

Electrical equipment:

- The response time off all control circuit components (e.g. interposing relay, switchgear relay, switchgear drawer, etc.)
- The inertia of the machinery, until it has fully stopped.

9. HIPS sensors

9.1 General

All HIPPS sensors shall be certified in compliance with IEC 61508 as SIL-2 for single transmitter use and SIL-3 capability for dual transmitter use. This does not relieve the mandatory requirement for SIL assessment and certification for the complete HIPS package (refer to section 13), not even when the HIPS function (SIF) requires a lower SIL.

SIL certifications for components and sub-systems shall be provided by Company recognised third party (e.g. TUV, EXIDA, SIRA). Components or sub-systems being self-certified by the Manufacturer are not permitted.

HIPS sensors shall be dedicated to the HIPS, being fully segregated from other systems, including process tappings. They shall not have a secondary function like CCR HMI monitoring; dedicated ICSS sensors shall be installed instead.

Pressure, level, flow, and temperature sensors shall be analogue 4~20 mA SMART transmitters. Position sensors on final elements and sensor isolation valves shall be inductive type proximity switches (detection = high signal), compliant with the logic solver input cards.

In any case, each measurement (input) part of the HIPS safety logic shall be triple sensors installed in a 2oo3 voting configuration. The same type of sensor technology shall be used for a

given process measurement, and with a guaranteed identical measurement location/elevation, avoiding spurious trips due to different sensor characteristics and/or different sensor responses and/or different process conditions.

Each of the three sensors is preferably from a different Manufacturer. In case three sensors from the same Manufacturer are used, then it shall be duly taken into account in the CCF factor attributed to the sensors in the SIL demonstration.

The Manufacturer and model for sensors and isolation valves/manifolds shall be approved by Company.

The following sensors do not require triplication:

- On-off valve position detectors providing only a status indication on the mimic panel
- The position detection of sensor isolation valves
- Pressure switches inside the valve control panel detecting a solenoid valve test.

Voting analogue sensors (transmitters) shall be installed on interlocking isolation valves, or integral interlocking manifolds, allowing online replacement/testing/calibration without disrupting production and without degrading the safety level of the protection loop during this maintenance operation. For this, each sensor isolation valve shall be equipped with a position detector which will initiate the voting logic to change from the 2oo3 to a 1oo2 configuration for the sensors remaining in service (refer to section 10.7).

As per [IEC 61508/IEC 61511](#), the potential alteration of sensor configuration (which is possible via the superposed HART signal) is not permitted on safety instrumented functions. Therefore, all SMART sensors shall be equipped with a hardware write protection (i.e. switch or jumper) inside the transmitter. The use of sensors with only a 'soft' write protection, such as passwords or enable/disable functions controlled from HART terminals, is not permitted.

The HART data from HIPS sensors will not be collected and transferred to the facility's IMS; the installation of HART multiplexers is not permitted.

The failure output signal of analogue SMART sensors shall be set to the extremity which would initiate a trip; typically set to HIGH (i.e. 20 mA) for pressure transmitters.

Dampening or filtering shall be completely disabled inside electronic instruments. This shall be clearly stated on the instrument datasheets and be duly verified during FAT, as most Manufacturers activate a certain dampening time by default.

All analogue electronic transmitters shall be equipped with an integral LCD display.

The data sheets for analogue sensors shall clearly indicate:

- Sensor failure output signal (HIGH or LOW)
- Dampening (DISABLED)
- Hardware write protection
- Square-root output (for dP flow sensors only)
- Trip threshold value in process value and in sensor mA output value.

9.2 Pressure sensors

The process tapplings shall be a NPS 2 inch flanged connections, having a process connection in accordance with the applicable piping class.

For gas service, the process tapping(s) and sensors shall be located in the upper plane of a horizontal pipe, or on top of a vessel, avoiding liquid to be trapped in the sensing path. For liquid service, the process tapping(s) and sensors shall be located in the lower plane of a horizontal pipe, avoiding gas and solids to be trapped in the sensing path.

Process tapplings on vertical pipes requiring horizontal piping extension shall be avoided; they shall only be used when it can be demonstrated that no other suitable solution is possible.

Pressure sensors using impulse tubing shall be avoided; they shall be direct mounted at an integral interlocking valve/manifold (refer to section 9.5).

The final selection of pressure sensor implementation shall be decided and approved by Company's HIPS Committee. Therefore, the Contractor and/or HIPS Integrator shall provide a full detailed design specification with full hook-up details for Company approval.

9.3 Flow sensors

Flow sensors shall measure the flow from the same (single) flow element (e.g. orifice, venturi tube, spool piece for ultrasonic), as it is considered impossible to achieve identical measurements from 3 different flow elements.

A HIPS based on flow sensors shall not be considered:

- In case a single flow element is not possible (for reasons of measurement principle, process conditions, or turn-down ratio)
- In case failure of the single flow element (e.g. orifice erosion) can occur, creating a common cause failure.

Although a single flow element is used, fully segregated process tapplings and sensor electronics shall be used.

The 3 sensors shall be interlocked using interlocking facilities as described in section 9.5.

The required turn-down ratio (i.e. the minimum/maximum flow ratio) for orifice and venturi tube flow meters shall not be set larger than 1:3.

All HIPS flow sensors shall be tested and calibrated under real process conditions in a calibrated flow loop as for fiscal metering, by a Company recognised third party.

Pressure & temperature compensation computing is not possible with solid state logic systems, and therefore not required.

For this reason, for dP based flow sensors, the transmitter output shall be the square root extraction of the measured differential pressure. The HIPS Integrator shall provide a carefully calculated graph representing the flow versus transmitter output signal, defining the trip threshold values in mA (required to set and test the logic solver input cards and voting blocs).

In addition, the actual flow versus transmitter output shall be accurately registered during the flow calibration tests, to define the corresponding trip threshold value in mA, otherwise the real trip threshold value is unknown and such HIPS cannot be realistic tested during lifetime.

For gas service, the process tapping(s) and sensors shall be located in the upper plane of a horizontal pipe, or on top of a vessel, avoiding liquid to be trapped in the sensing path. For liquid service, the process tapping(s) and sensors shall be located in the lower plane of a horizontal pipe, avoiding gas and solids to be trapped in the sensing path.

Process tapplings on vertical pipes shall be avoided; they shall only be used when it can be demonstrated that no other suitable solution is possible.

Permitted flow meter types are orifice, venturi and ultrasonic type flow meters. Other flow meter types such as Pitot tube, V-cone, turbine, vortex, coriolis and displacement are not permitted.

Ultrasonic flow meters can only be used if all the following requirements are applied:

- The process fluid is >99.5 % pure single phase at any time, without any contamination
- A single spool piece with intrusive type flow meter; clamp-on type is prohibited
- Sensor removal without production shut down; i.e. sonic transducers are to be used
- Accuracy shall be $\leq 2\%$; multi-path meters shall be used as required.

The final selection of flow meter type and implementation shall be decided and approved by Company's HIPS Committee. Therefore, the Contractor and/or HIPS Integrator shall provide a full detailed design specification with full hook-up details for Company approval.

9.4 Level sensors

Level sensors shall be installed in one of the two following ways:

- Direct individual sensor connection at the vessel, hence 3x dedicated vessel tapplings

or:

- A single common standpipe with 3 level sensors, hence 1x dedicated vessel tapplings.

The second solution using a standpipe is not preferred, as it may introduce a common cause failure. However, a standpipe may provide an improved (calm) environment, avoiding fluid turbulence, reducing foam, etc. Therefore, standpipes shall only be used if a direct vessel measurement would cause different measurement values or disturb the measurement itself.

Stand pipes shall not be used if there is an inherent risk of clogging, e.g. by hydrates, solids or paraffin. The use of heat tracing cannot be considered as a risk reduction factor for this.

By definition, there shall not be any valve between vessel and standpipe.

Standpipes shall be at least NPS 4 inch in diameter and have NPS 3 inch process (vessel) tapplings, for reasons of adequate liquid displacement and the fact that the weight of the standpipe and HIPS sensor assembly must be supported by the vessel.

Process tapplings for level sensor process isolation valves (at standpipe or at vessel) shall be NPS 2 inch, equipped with full-bore NPS 2 inch block & bleed, or double block & bleed as per piping specification, for non-membrane type level sensors. This shall be NPS 3 inch for membrane type dP level sensors, or NPS 4 inch in case high accuracy is required.

In case individual sensor chambers are used (e.g. for probe and displacer type sensors), then the chamber shall be at least NPS 3 inch with top flange for sensor mounting.

dP type level sensors using impulse tubing are not permitted; they shall either be membrane type or thread mounted on an integral interlocking manifold (refer to section 9.5).

The location of the vessel tappings is deemed critical:

- For gas-liquid level measurement: the lower vessel tapping shall be located at least 2 inch below the lowest trip threshold level, while the upper vessel tapping shall be located at least 4 inch above the highest liquid trip threshold level.
- For liquid-liquid interface level measurement:
 - In case of direct sensor to vessel connection:
 - . Lower tapping: min. 2 inch below the lowest interface trip threshold level
 - . Upper tapping: min. 2 inch below the weir plate elevation and min. 2 inch above the highest interface trip threshold level.
 - In case of standpipe or chamber: 3 tappings shall be used:
 - . Lower tapping: min. 2 inch below the lowest interface trip threshold level
 - . Middle tapping: min. 2 inch below the weir plate elevation and min. 2 inch above the highest interface trip threshold level
 - . Upper tapping: at least 4 inch above highest vessel liquid threshold level.
 - In any case, there must be at least 4 inch between highest interface level and the weir plate, with the vessel tapping in the middle of the 4 inch elevation.

The vessel tapping elevations of the 3 level sensors for a given HIPS measurement shall be at exactly the same elevations and not be influenced by vessel motions. Retrofitting an existing vessel with a level HIPS using a mixture of tapping elevations is not permitted.

Vessel/process tapping(s) for level instruments shall be in static process condition, i.e. level measurement tapping(s) on the vessel's incoming or outgoing piping is strictly not permitted, because the process flow creates a venturi effect and/or the measurement section(s) may become polluted by foam and solids and/or sensor erosion may occur as a result.

Stilling wells inside the vessel shall not be used if the sensor cannot be isolated during production. Top-mounted on the vessel without stilling well is not permitted.

Accurate and reliable level measurement can be difficult to achieve, notably on 3-phase production separators where foaming may occur and where fluid properties can vary over time or as a function of which wells are in operation. The following rules are to be considered as general rules: a careful assessment shall be made for each level HIPS case:

- Differential pressure (dP) type sensors shall not be used if the fluid density can vary for more than 5% (typically observed for multi-reservoir developments)
- Capacitive probe and guided radar type sensor shall not be used if foaming may occur, not even in case of very little foaming, or when build-up on the probe may occur
- Buoyancy displacer type sensors shall be considered if foaming (>1 inch) or if varying fluid density (>5%) may occur
- Parabolic radar type sensors shall only be used for gas-liquid levels without risk of foaming.

Single-point nucleonic density type sensors may be used for level HIPS; either to detect a gas-liquid level or liquid-liquid interface level. They can be a suitable solution in case of high solids content, excessive foaming, viscous fluids, or when vessel/tank tappings are impossible to

realise. However, the requirement that only one sensor out of three can be isolated (i.e. out of operation) will require a special operational procedure and hardware means, as normally no valves/manifolds are involved in such measurement. A 1oo3 interlock key at the HIPS mimic panel to disable a particular sensor shall be part of the solution.

The following types of level sensors are not permitted for HIPS applications:

- Magnetic displacer type sensors
- Nucleonic density profiler type sensors
- Any type which cannot be calibrated or tested on site.

Like any other type of analogue HIPS sensor, level sensors must be tested/calibrated under reality process conditions during FAT to verify the sensor's output (in mA) at process threshold value. Levels sensor types which cannot be tested during FAT, or during operational life, are not permitted. This may require the provision of a test vessel/standpipe during FAT.

The required provisions for periodic calibration and testing of individual level sensor (one out of three at the time) shall be studied and be a dedicated section of the HIPS project specification.

The final selection of level sensor type and implementation shall be decided and approved by Company's HIPS Committee. Therefore, the Contractor and/or HIPS Integrator shall provide a full detailed design specification with full hook-up details for Company approval.

9.5 Sensor isolation valves and interlocking arrangements

9.5.1 Process isolation principles

HIPS sensors shall be installed using only a process isolation valves/assembly, either single block & bleed (SB&B), or double block & bleed (DB&B) in accordance with the applicable piping class specification. Hence, no separate 'piping' and 'instrument' valves as for other instruments.

Pressure HIPS sensors shall have separate and dedicated process connections; hence 3 process tapings are required for a HIPS pressure measurement. The use of a single process tapping for 3 sensors is not permitted, except for very clean and stabilised single-phase fluids which have inherently zero risk of clogging under any given condition.

It is not permitted to have any piping between process connection and sensor isolation valves/manifold: it shall be mounted directly on the pipe branch or on a vessel (or standpipe).

For pressure HIPS, the inlet (process) connection of the sensor isolation valves/manifolds shall be NPS 2 inch flanged, ball or needle type, with minimum 14 mm internal diameter flow path, while the outlet connection shall be NPT threaded for direct pressure sensor mount. The passage through a needle valve seat shall be at least equivalent to a 7 mm diameter path.

For level HIPS: the inlet and the outlet connection of the sensor isolation valves/manifold shall be NPS 2 inch flanged (3 inch for membrane type dP sensors), full bore ball valves. In case DB&B valves are required as per applicable piping class specification, then an integral double full bore ball valve shall be used. In case membrane type dP sensors are used, then reduced bore valves with minimum 14 mm internal diameter flow path can be used.

Any sensor isolation valve/manifold shall be suitable for integral mounted interlock facilities, with isolation detection sensor, as per sections 9.5.2 and 9.5.3.