

GENERAL SPECIFICATION

TECHNOLOGY

GS EP TEC 260

HIPS Design, Implementation and Life cycle

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General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 2 of 54

Contents

1. Scope	5
2. Reference documents	5
3. Terminology and Definitions	7
3.1 Abbreviations	7
4. HIPS Supply	8
5. General Requirements	9
5.1 HIPS Safety Requirement Specification (SRS).....	9
5.2 Avoidance of Common Mode Failures	12
5.3 HIPS dossier	13
6. HIPS General Design & Construction Requirements	13
6.1 HIPS Scope of Work and Engineering Deliverables	13
6.2 HIPS Instrument Design.....	13
6.3 HIPS Instrument Earthing	14
6.4 HIPS Instrument Cables.....	14
6.5 HIPS Instrument Installation.....	14
6.6 HIPS Instrument Trouble Shooting Loop Diagrams.....	14
6.7 HIPS Functional Logic Diagrams	14
7. HIPS Sensors.....	15
7.1 General.....	15
7.2 Pressure Sensors Selection	16
7.3 Flow Sensors Selection.....	16
7.4 Level Sensors Selection.....	17
7.5 HIPS Sensors Installation and Isolation.....	18
8. HIPS Logic Solver	22
8.1 HIPS Logic Solver Cabinet.....	22
8.2 HIPS Logic Solver General Requirements	22
8.3 HIPS Logic Solver Hardware Arrangement and Fault Tolerance.....	23
8.4 HIPS Logic Solver SIL Requirements.....	24

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 3 of 54

8.5	HIPS Logic Solver Voting Arrangement.....	24
8.6	HIPS Shutdown Valve Interlock Logic.....	24
8.7	HIPS Reset and Black-start.....	25
8.8	HIPS Bypass Functions	25
8.9	HIPS Periodic Proof Test Facilities.....	25
8.10	Cyber Security	26
8.11	Operator Interface.....	26
8.12	HIPS Sequence of Events.....	27
8.13	Spare Capacity	28
9.	HIPS Final Elements.....	28
9.1	HIPS Valves.....	29
9.2	HIPS Actuators and Valve Control Panels.....	30
9.3	HIPS Valve and Actuator Lifting Facilities Requirements	33
9.4	HIPS Valve and Actuator Painting.....	33
9.5	HIPS Electrical Final Elements / Switchgear	34
10.	Verification and Reliability	34
10.1	HIPS Third Party Verification.....	34
10.2	HIPS Reliability (SIL) Study.....	36
11.	HIPS Testing Requirements	36
11.1	Testing Methodology.....	36
11.2	Design Validation Test (DVT).....	37
11.3	Factory Acceptance Tests (FAT).....	37
11.4	HIPS Integrated Factory Acceptance Test (IFAT)	42
11.5	HIPS Pre-commissioning and Commissioning, Yard & Site Acceptance Tests (SAT) ...	42
11.6	HIPS Operational Test Procedure (OTP)	43
11.7	Wet HIPS Performance Tests	43
12.	HIPS Preservation, Storage and Handling Requirements	44
13.	HIPS Operational Phase Periodic Proof Testing	44
14.	Safety Life-Cycle for HIPS	46
14.1	HIPS Obsolescence Management	47
14.2	HIPS Maintenance	47



General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 4 of 54

14.3	HIPS Spare Parts.....	48
14.4	Operational Reporting	48
Appendix 1	Typical 5-step Reliability Methodology.....	50
Appendix 2	Typical HIPS Engineering Deliverables	51

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 5 of 54

1. Scope

Where the provision of a High Integrity Protection System (HIPS) has been justified in accordance with **GS EP SAF 260**, this General Specification then describes the minimum requirements for the design, implementation and life-cycle of all instrumented parts of the HIPS, comprising sensors, logic solver, final elements and interface with other systems.

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

For subsea HIPS, sections 5, 10, 13 and 14 are applicable. This is in addition to the requirements of **GS EP SPS 002**.

This General Specification applies to all types of HIPS including pressure, temperature, level, flow or other parameter driven.

This General Specification in conjunction with **GS EP SAF 260** applies in all project phases as well as during operation and maintenance. The specified requirements complement the governing national and international standards relevant for the application of such safety instrumented systems.

This General Specification will be complemented by a project particular specification providing project specific details.

2. Reference documents

The equipment shall satisfy the requirements of the country of installation and specific standards referred to in this specification.

Where national regulations exist, their provisions and those of standards and codes they refer shall apply, supplementing or amending the provisions of this General specification.

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

Reference	Title
IEC 61508 (All parts)	Functional safety of electrical/electronic/programmable electronic safety-related systems – All parts
IEC 61511 (All parts)	Functional safety - Safety instrumented systems for the process industry sector – All parts
ISO 4406	Hydraulic fluid power - Fluids - Method for coding the level of contamination by solid particles

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 6 of 54

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published.

Reference	Title
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 351	External protection of structures and equipment by painting. Floating structures
GS EP COR 354	External protection of onshore structures and equipment by painting
GS EP ECP 103	Process sizing criteria
GS EP EXP 105	Pre-commissioning Execution
GS EP EXP 107	Commissioning Execution
GS EP EXP 405	Standard reliability data report
GS EP EXP 407	Identification of Safety Critical Elements
GS EP INS 101	Instrumentation Design
GS EP INS 106	Instrument Installation
GS EP INS 109	Instrument cabinets
GS EP INS 115	Instrument Earthing
GS EP INS 116	Instrument Cables
GS EP INS 118	Instrument Troubleshooting Loop Diagrams (TSLDs)
GS EP INS 135	Cybersecurity Requirements for Industrial Information Systems (SII)
GS EP INS 137	On/Off Valve Control Panels and Actuators
GS EP PVV 142	Valves
GS EP PVV 154	Ball valves
GS EP SAF 260	Design of High Integrity Protection Systems (HIPS)
GS EP SAF 261	Emergency Shutdown and Emergency Depressurisation (ESD & EDP)
GS EP SAF 337	Passive Fire Protection: basis of design
GS EP SAF 361	SIL assignment
GS EP SPS 002	Design of Subsea Stations
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 7 of 54

3. Terminology and Definitions

There are five types of statements in this specification, the “shall”, “should”, “may”, “can” and “must” statements. They are to be understood as follows:

Shall	Is to be understood as mandatory. Deviating from a “shall” statement requires derogation approved by Company.
Should	Is to be understood as strongly recommended to comply with the requirements of the specification. Alternatives shall provide a similar level of protection and this shall be documented.
May	Is to be understood as permission.
Can	Is to be understood as a physical possibility.
Must	Expresses a regulatory obligation.
Company	TOTAL E&P or any TOTAL E&P subsidiary.
Contractor	Any Party that has signed a Contract with Company for the Engineering, Procurement, Construction, and Installation in part(s) or in full 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

3.1 Abbreviations

The following terms and abbreviations are used in this document:

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
ESD	Emergency Shut-Down
FAT	Factory Acceptance Test
HART	Highway Addressable Remote Transducer protocol
HFT	Hardware Fault Tolerance
HIPS	High Integrity Protection System
HMI	Human-Machine Interface
HVAC	Heating Ventilation and Air Conditioning
I/O	Input/Output
ICSS	Integrated Control and Safety System

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 8 of 54

IFAT	Integrated Factory Acceptance Test	
IMS	Instrument Maintenance System	
ITP	Inspection & Test Plan	
MTTR	Mean Time To Repair	
NPS	Nominal Pipe Section	
NPT	Nominal Pipe Thread	
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	
SRS	Safety Requirements Specification	
SVTS	Smart Valve Testing System	
SOE	Sequence Of Event	
UCP	Unit Control Panel	

4. HIPS Supply

A Company approved HIPS integrator shall be designated for the design and supply of the complete HIPS package.

HIPS sensors (including associated isolation valves/manifold and mechanical interlocks) and HIPS logic solver shall be procured directly by the HIPS Integrator.

HIPS final elements shall be either procured directly by the HIPS Integrator or free-issued by Contractor to HIPS Integrator. The HIPS Integrator shall ensure that the overall HIPS design including the HIPS sensors, HIPS logic solver and HIPS final elements meet the HIPS Safety Requirements Specification.

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 9 of 54

HIPS Third Party verification shall cover the complete HIPS including HIPS sensors, HIPS logic solver and HIPS final elements as described in section 10.

5. General Requirements

5.1 HIPS Safety Requirement Specification (SRS)

HIPS requirements shall be defined in a project particular HIPS Safety Requirements Specification (SRS). This shall consider the complete HIPS instrumented system comprising sensing elements, logic solver and final elements.

The HIPS SRS shall be developed following the requirements of [IEC 61511-1](#) clause 10 and in addition, the mandatory requirements as described in the present General Specification shall be specified and adhered to.

5.1.1 HIPS SRS General

The safety instrumented function (SIF) to be achieved by the HIPS shall be clearly defined.

The credible scenarios and sources of HIPS demand, assumptions regarding how quickly they will cause that demand, the demand frequency, associated process conditions, and other layers of protection and associated set-points assumed in the design of the HIPS shall be specified. Any changes to such shall not occur without due consideration for the potential impact upon HIPS function.

The HIPS shall be autonomous with dedicated sensors, logic solver and final elements, 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).

The HIPS shall be interfaced with the facility ICSS for monitoring and alignment of shutdown actions and interlock actions (if any) ensuring orderly shutdown and restart. Shutdown alignment actions typically performed by the PSS/ESD will include:

- Setting the PSS/ESD command on the HIPS valve to “close” and de-energising the PSS/ESD solenoids, this will ensure that the operator systematically reopens the valve from the CCR.
- Secondary shutdown actions such as upstream / subsea well shut-in necessary to avoid riser packing and prevent increased HIPS demand.

Any communications with HIPS shall not be able to impede or override safety functions.

HIPS shall be designed according to fail-safe principles. HIPS components including sensors, signals, logic solvers 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 move to the safe state.

It shall not be possible to disable the HIPS.

The HIPS shall be designed to accommodate periodic proof testing without disabling the HIPS safety function.

Safe, simple and robust shall remain key objectives when specifying and selecting any HIPS component. Complex designs shall be avoided as far as possible.

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 10 of 54

5.1.2 HIPS SRS Service Conditions

The required performance of the HIPS will be determined based on clearly identified service conditions such that the HIPS can be readily assessed or re-validated against changing assumptions or conditions during the plant life-cycle.

The HIPS SRS shall clearly identify and describe all credible process and environmental service conditions, such as:

- Process fluid compositions (all possible production scenarios)
- Possibility of slug flow
- Fluids with plugging potential (e.g. wax, hydrates)
- 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
- Hazardous area classification

For all of the conditions, it shall be clearly defined when they occur, as well as the impact on each condition of the various operational situations, e.g. shut-in, cool-down, start-up, normal production.

These identified service conditions will be used in defining the material requirements of sensors and final elements, and in defining any needs for heating and winterisation of HIPS components.

The HIPS shall be suitable for any given operational situation / service condition regardless its duration, including temporary conditions such as methanol injection, or cool-down.

5.1.3 HIPS SRS Reliability Criteria and Data

The required SIL level for the HIPS safety instrumented function (SIF) shall be determined following the criteria defined in [GS EP SAF 260](#) and the specific requirements for HIPS defined in [GS EP SAF 361](#), the resulting integrity target shall be specified in the HIPS SRS.

HIPS components or subsystems shall be specified such that the overall SIL target of the HIPS SIF is achieved, and in addition, the minimum SIL level required by this General Specification for HIPS components shall also be met (even when a lower component SIL level would permit reaching the required SIL level of the overall HIPS SIF).

During selection, where HIPS devices are assessed as being suitable through prior-use for use in a HIPS, in accordance with [IEC 61511](#), the HIPS Integrator shall document this assessment of HIPS prior-use demonstrating that the devices can meet the required functional and safety integrity requirements based on previous operating experience in similar environments. Prototype devices shall not be used in a HIPS safety instrumented function.

HIPS probability of failure calculations shall be performed as defined in **GS EP SAF 260** and shall include a sensitivity analysis to test the robustness of the calculated HIPS SIL level against variation in reliability data (e.g. failure rate $\pm 20\%$), proof test period, component MTTR, and β factor for two identical items not less than 10%.

Reliability data used in the HIPS SIL calculations shall adhere to the data source rules defined in **GS EP EXP 405**. All parameters to be used for the calculations (λ , β , MTTR, test frequency) shall be defined.

The HIPS SRS shall specify the type and interval for HIPS periodic proof testing to be performed during the HIPS operational phase to maintain the HIPS functional safety at its required SIL level. This shall be subject to sensitivity analysis during the reliability (SIL) study (refer to section 10) to optimise / maximise the proof test interval and shall respect the requirements for realistic test intervals (refer to section 13).

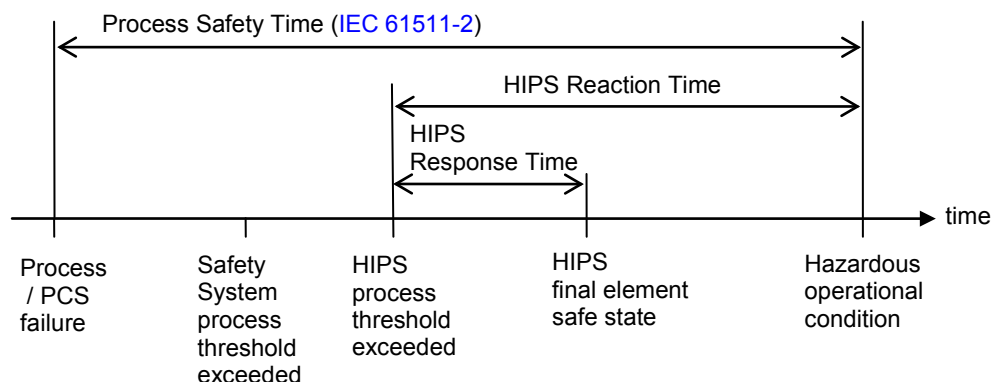
5.1.4 HIPS SRS Availability Criteria

Process availability is not a safety related criteria, however the HIPS design shall take into account the process availability target, allowing for testing and maintenance activities (with or without disturbing the process, e.g. partial stroking testing requirement) and the predicted / allowable frequency of spurious trips. This shall be assessed and reflected within the HIPS SRS.

5.1.5 HIPS SRS Reaction and Response Times

The HIPS reaction time and HIPS response time shall be defined in the HIPS SRS.

Figure 1 - HIPS Reaction and Response Time Typical Depiction



The HIPS response time shall not exceed one third of the required HIPS reaction time.

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 validation by Company's HIPS Committee prior to any implementation.

The "hazardous operational condition" is deemed to occur when the maximum allowable incidental condition of the equipment is reached, as defined by the applicable design codes.

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

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 12 of 54

The HIPS response time is the summation of the following:

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

and which are further defined in the following sections.

5.1.5.1 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
- Lag time of the sensing element
- Processing (cycle) time of electronic instrument/transmitter
- Signal conditioning, e.g. dampening or filtering.

5.1.5.2 Logic solver Response Time

The HIPS logic solver response time shall be 300 msec or less.

The logic solver response time comprises the summation of the following parts:

- Worst (longest) processing (cycle) time of any input card, multiplied by 2
- Processing time of the logic part and output, multiplied by 2.

The requirement to multiply processing time by 2 is because if a process threshold value occurs just after a cycle has started, it will only be processed during the next cycle.

5.1.5.3 Final Element Response Time

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

Actuated valves:

- The response time of 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.

5.2 Avoidance of Common Mode Failures

The HIPS shall be designed to minimise common mode failure.

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 13 of 54

This shall be managed in accordance with **GS EP SAF 260**, **IEC 61511-1** clause 9.4 as well as the requirements defined in the present General Specification, notably:

- Sensor positioning
- Sensor and final element selection
- Logic solver selection
- Maintenance and human interventions
- Utility failure.

The design of the HIPS and other protection layers shall be assessed to ensure that the likelihood of common cause, common mode and dependent failures between protection layers and between protection layers and the PCS are sufficiently low in comparison to the overall safety integrity requirements of the protection layers.

5.3 HIPS dossier

A HIPS dossier shall be prepared in accordance with **GS EP SAF 260**.

The HIPS SRS will be included in the HIPS dossier.

6. HIPS General Design & Construction Requirements

6.1 HIPS Scope of Work and Engineering Deliverables

Typical HIPS engineering deliverables (non-exhaustive) and scope of work split between Contractor and HIPS Integrator is listed in Appendix 2.

Native files for reliability calculations and process dynamic simulations shall be handed-over to Company to ensure that the safety-lifecycle requirements for future modification / revalidation can be achieved.

6.2 HIPS Instrument Design

Instrument design shall adhere to the requirements of **GS EP INS 101** with the additional restrictions as specified in the present general specification.

6.2.1 Hazardous Area Protection

Intrinsically safe instruments shall only be used in the HIPS if other hazardous area protection means are not available. Intrinsically safe barriers shall also meet the HIPS SIL target and be certified accordingly.

6.2.2 Instrument Standardisation

The requirement for standardisation shall be balanced with the requirements to minimise common mode failure between redundant inputs and between protection layers through diversity. Different vendors for redundant sensors forming part of the HIPS SIF are preferred.

Instruments shall only be from approved vendors.

The brand and sizing system (i.e. metric or imperial) for instrument tubing and fittings shall be standardised with that of the main facility, notably for HIPS valve control panels.

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 14 of 54

6.2.3 Signal Segregation

All HIPS field devices shall be hard-wired directly into the HIPS cabinet via individual cables without intermediate junction boxes or cabinets. 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 local junction box, but individual cables to the HIPS system cabinet shall be run. This exception is not applicable to process measuring instruments, e.g. pressure transmitters.

6.3 HIPS Instrument Earthing

HIPS instrument earthing design shall adhere to the requirements of **GS EP INS 115**.

HIPS 24VDC power supply 0V shall be referenced to earth.

6.4 HIPS Instrument Cables

HIPS instrument cables shall adhere to the requirements of **GS EP INS 116**, as defined for cables used for safety and protective functions.

6.5 HIPS Instrument Installation

All HIPS instruments shall adhere to the requirements of **GS EP INS 106** with the additional restrictions as specified in the present general specification.

All HIPS elements including sensors, sensor isolation valves, final elements, control panels, etc. are considered as permanent work locations and shall be directly accessible from grade or fixed platform. Moveable ladders shall not be used.

6.6 HIPS Instrument Trouble Shooting Loop Diagrams

The HIPS Integrator shall provide a dedicated set of HIPS trouble shooting loop diagrams covering all HIPS related loops. These shall adhere to the requirements of **GS EP INS 118**. The HIPS trouble shooting loop diagrams shall also include the connection and component details between marshalling field terminal rail at the rear of the HIPS cabinet and the HIPS logic solver I/O cards.

6.7 HIPS Functional Logic Diagrams

The HIPS Integrator shall provide fully detailed functional logic diagrams (FLD), representing the safety logic design in block diagram format. These diagrams typically show the signal path from the logic solver's inputs to outputs in a format close to how a solid state system is physically built.

These drawings shall be very complete in terms of module identification, tag numbers and description of sensors/final elements/alarm/trips/etc. and a clear identification and location of status lights, push buttons, etc. The logic shall be clearly annotated throughout showing corresponding logic 1 and logic 0 equivalent state e.g. closed=1, open=0, reset=1, tripped=0, isolated=0, solenoid in test=0, etc.

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 15 of 54

7. HIPS Sensors

7.1 General

HIPS sensors shall be designed in accordance with **GS EP INS 101** with the additional restrictions as specified in the present general specification.

All HIPS sensors shall be certified in compliance with **IEC 61508** as SIL-2 for single sensor/transmitter use and SIL-3 for dual sensor/transmitter use. This does not relieve the mandatory requirement for third party SIL demonstration for the complete HIPS SIF (refer to section 10), 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 process monitoring or alarm; dedicated ICSS sensors shall be installed instead.

Pressure, level, flow, and temperature sensors shall be analogue 4-20 mA with HART protocol, however complex diagnostic options should be avoided.

Each measurement (input) part of the HIPS SIF shall use triple sensors installed in a 2oo3 voting configuration. The same type of sensor technology shall be used for a given process measurement with identical measurement range and elevation, avoiding spurious trips due to different sensor characteristics and/or different sensor responses and/or different process conditions.

The following sensors do not usually require triplication:

- Final element / on-off valve position detectors providing only simple status indication (i.e. not part of the HIPS SIF or executive logic)
- The position detection of process sensor isolation valves
- Pressure switches for detecting a solenoid valve test.

The potential alteration of sensor configuration via the superposed HART signal is not permitted on safety instrumented functions. Therefore, all SMART sensors shall be equipped with a hardware write protection 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, except for SVTS if any.

Upon detection of transmitter fault/failure, the transmitter output signal of analogue transmitters shall be driven to the extremity which would initiate a trip, typically HIGH for pressure transmitters.

HIPS Sensor Dampening and Filtering settings shall be clearly stated on the instrument datasheets and duly verified during FAT as most Manufacturers activate a certain dampening / filter time by default. Any dampening or filtering in the HIPS sensor will affect the HIPS response time. For pressure and temperature applications, this should be completely disabled unless

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 16 of 54

measurement noise is anticipated. For flow and level applications, measurement noise can occur due to turbulent flow or vessel liquid surface movement and a small amount of dampening may be specified. In this case the resulting response time impact shall be duly accounted for in the HIPS response time calculation.

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 / Filtering Value (usually DISABLED for Pressure and Temperature)
- Hardware write protection
- Square-root output (for dP flow sensors only)
- Trip threshold value in process value and in sensor mA output value.

The instrument hook-up diagrams shall show all details from the process pipe/vessel flange to the HIPS sensor.

7.2 Pressure Sensors Selection

HIPS pressure sensors shall be designed in accordance with **GS EP INS 101** with the additional restrictions as specified in the present general specification.

Pressure sensors shall be direct mounted to a process isolation valve/manifold assembly (refer to section 7.5).

The final selection of pressure sensor type and implementation shall be subject to validation 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.

7.3 Flow Sensors Selection

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 difficult 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 7.5.

The required turn-down ratio (i.e. the minimum/maximum flow ratio) for orifice and venturi tube flow meters shall not greater 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.

General Specification		GS EP TEC 260
HIPS Design, Implementation and Life cycle		
Rev.: 02	Effective date: 12/2016	Page: 17 of 54

Pressure & temperature compensation computing is not possible with solid state logic systems, therefore the HIPS trip setpoint shall take into account the maximum possible measurement error due to this lack of P&T compensation.

For dP based flow sensors, the square root extraction shall be performed in the transmitter. The HIPS Integrator shall provide a graph showing flow versus transmitter mA output signal. It shall also show the flow trip threshold value and the corresponding mA (required to set the logic solver input card trip threshold). This graph and flow trip threshold value versus mA shall be validated during the flow calibration tests.

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 subject to validation 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.

7.4 Level Sensors Selection

HIPS level sensors shall be designed in accordance with **GS EP INS 101** with the additional restrictions as specified in the present general specification.

dP type level sensors shall either be membrane type flange or thread mounted on an integral interlocking manifold (refer to section 7.5).

The location and elevation of the vessel tapplings is deemed critical and shall be represented on the level sketch.

Level sensors top-mounted on the vessel may only be used if they can be isolated and calibrated during production, they shall have a stilling well inside the vessel.

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 selection criteria for HIPS level instruments shall follow the criteria given in **GS EP INS 101** with the following additional restrictions; Differential pressure (dP) type sensors is the preferred solution on pressurised vessels, however, measurement error due to variation in fluid density (typically observed for liquid density from multi-reservoir developments and gas density for vessels with high operating pressure), shall be carefully assessed. The liquid and gas densities used to calculate calibration range and corresponding trip threshold shall ensure that the HIPS function is guaranteed under all expected density variations.