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HIPPS
High Integrity Pressure Protection System

L&T Valves

L&T Valves is a wholly owned subsidiary of Larsen & Toubro. Backed by a heritage of excellence that exceeds five decades, the company manufactures engineered flow-control solutions for key sectors of the economy.

Product Range:

- Gate, Globe & Check Valves
- Valves for Power
- Pipeline & Process Ball Valves
- Triple-offset Butterfly Valves
- Flanged & Wafer-type Butterfly Valves
- Double Block and Bleed Plug Valves
- Control Valves
- Customized Solutions including HIPPS

The valves are designed using state-of-the-art 3D design, simulation and analysis software. Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD) are used to fine-tune product performance.

The Quality Management System of L&T Valves is certified to comply with ISO 9001 and API Spec Q1. The company is licensed to offer products monogrammed API 600, API 6D and API 609 as well as valves with CE Marking (Pressure Equipment Directive 97/23/EC) and ATEX certification (Council Directive 94/9/EC). Ball and Butterfly Valves with SIL 3 certification (IEC 61508) are also offered.

Valve manufacturing at L&T Valves leverages the best in technology and skill, and all manufacturing operations are guided by international safety, health and environment standards.

L&T Valves distribution network spans the globe, partnering key valve distribution companies in all major industrial centres.

High Integrity Pressure Protection System

L&T Valves offers a range of customised SIL 3 capable High Integrity Pressure Protection Systems (HIPPS) for over-pressure protection that leverages our expertise of over five decades in flow-control and system integration.

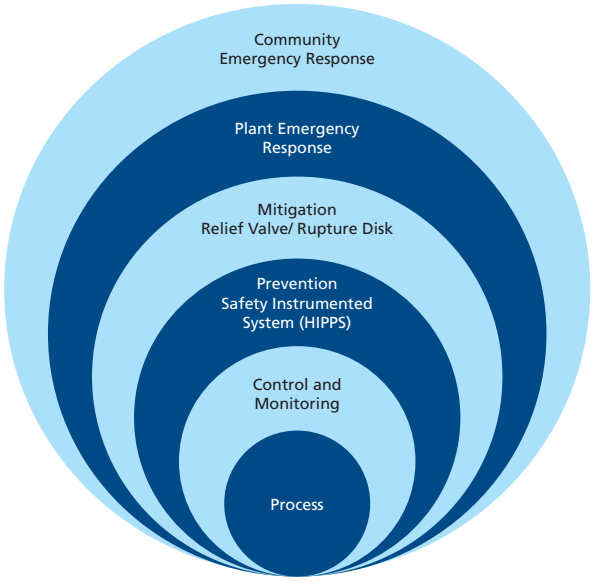
In industrial plants, flammable gases released by pressure relief valves during unplanned over-pressurization is primarily flared. Flaring and venting pose health and safety hazards and constitute a significant source of greenhouse gas emissions.

High Integrity Pressure Protection System (HIPPS) is a Safety Instrumented System (SIS), which by definition is a distinct, reliable system used to safeguard a process to prevent a catastrophic release of toxic, flammable, or explosive chemicals.

HIPPS can be employed to prevent over-pressurization of a plant by shutting-off the source of the high pressure gas rather than by releasing it to the atmosphere. This system closes the source of over-pressure within seconds and has at least the same reliability as a safety relief valve or flare system.

As per ASME Section VIII, UG-140, which covers 'Over-pressure Protection by System Design', HIPPS can be used for the following applications:

- Chemical reactions so fast the pressure propagation rate could result in loss of containment prior to the relief device opening
- Chemical reactions so fast the lowest possible relieving rate yields impractically large vent areas
- Exothermic reactions occurring at uncontrollable rates
- Plugging, polymerization, or deposition formed during normal operation
- Reactive process chemicals relieved into lateral headers with polymerization and thus plugging, rendering the relief device useless
- Multi-phase venting, where actual vent rate is difficult to predict



Codes & Standards

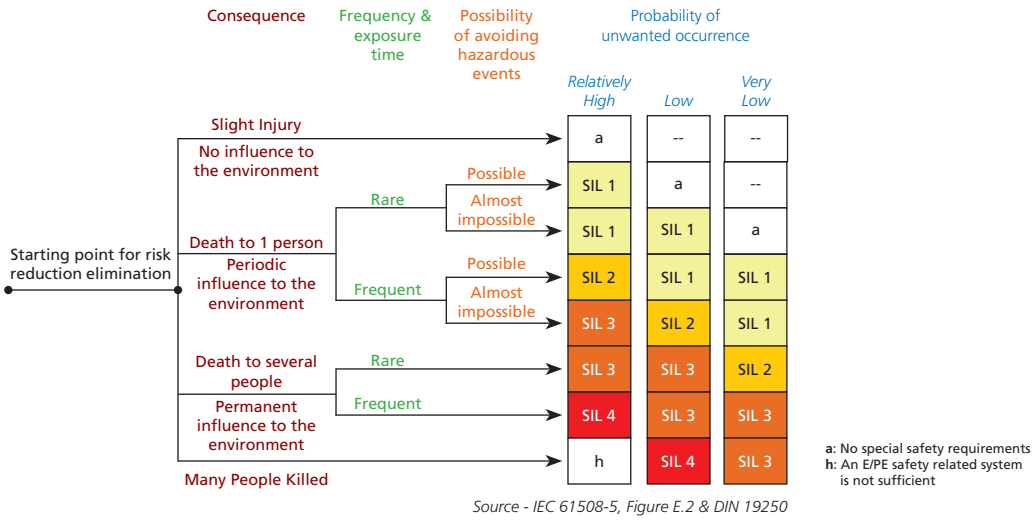
API 521 and ASME code case 2211 spell out the conditions when a SIS can be used as an alternative to a pressure relief device. HIPPS must provide an installation that is as safe as or safer than the pressure relief device that it replaces.

In addition, the SIS design must comply with international standards IEC 61511 and IEC 61508. IEC 61508 is a standard for functional safety of electrical, electronic and programmable electronic equipment and included mechanical components that are necessary to execute the safety function. IEC 61511 was developed for integrators, SIS designers and users as it deals with process sector implementation of the IEC 61508 standard. IEC 61511 has been adopted in the US as ANSI/ ISA S84.00.01.

Implementing HIPPS as an SIS would result in risk reduction of the plant facility by prevention rather than mitigation. The recommended safety integrity levels for HIPPS would be either SIL 3 or SIL 4. The Risk reduction factor RRF and Average probability of failure on demand ($PFD_{avg.}$) listed in IEC 61508 are:

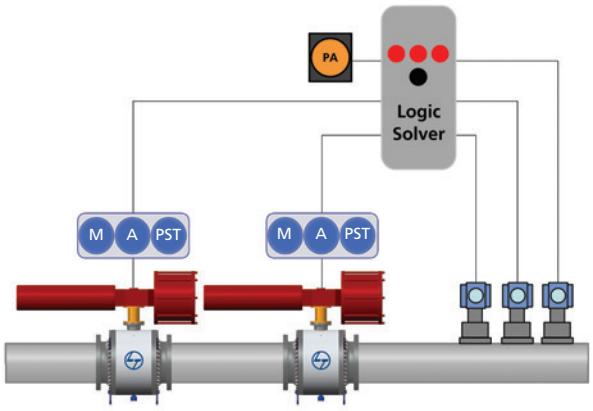
Safety Integrity Level	Risk Reduction Factor (RRF)	PFD (Avg. Probability of Dangerous Failure on Low Demand Mode)	PFH (Avg. Frequency of Dangerous Failure on High Demand Mode)
SIL 4	100,000 to 10,000	$\geq 10^{-5}$ to $<10^{-4}$	$\geq 10^{-9}$ to $<10^{-8}$
SIL 3	10,000 to 1000	$\geq 10^{-4}$ to $<10^{-3}$	$\geq 10^{-8}$ to $<10^{-7}$
SIL 2	1000 to 100	$\geq 10^{-3}$ to $<10^{-2}$	$\geq 10^{-7}$ to $<10^{-6}$
SIL 1	100 to 10	$\geq 10^{-2}$ to $<10^{-1}$	$\geq 10^{-6}$ to $<10^{-5}$

IEC 61508 lists possible methods to determine applicable Safety Integrity Levels, such as Risk Graph Method given below.



Source - IEC 61508-5, Figure E.2 & DIN 19250

Components of a HIPPS system



A typical HIPPS system comprises the following:

- Three pressure sensors (2oo3 voting) that detect the over pressure in the line
- A logic solver which receives and processes the input signal from the sensors and transmits the output to the Solenoid Valve in the final element.
- A final element (Actuated Valve) which perform the emergency closure action via a Solenoid Operated Valve (SOV) to bring the process to a safe state. Typically, 3 SOVs are used - a manual-reset SOV (M), an auto-reset SOV (A) and one for Partial Stroke Testing (PST).

The above schematic is a typical HIPPS architecture and the components in the loop can vary according to the application. L&T Valves can also offer ready-to-fit skids designed to meet customer specifications.

Pressure Transmitters

The pressure transmitters detect the high pressure in the system and the safety loop may include a minimum of three transmitters, which operate in a 2oo3 voting logic, to achieve the SIL 3 requirement. Thus failure of one transmitter channel to respond will not affect safety integrity. If a fault develops on one transmitter channel this would be revealed by an alarm and can be intervened without causing HIPPS activation.

- Transmitters used in a voting arrangement are diverse, that is, of different manufacturers or technologies, to reduce the likelihood of common mode failures.
- Common pressure transmitters used employ capacitance, piezo-resistive or Silicon resonant technology.
- Based on the requirement, the three pressure transmitters can either be directly connected to the main line with double block and bleed valve arrangement or alternatively a High Integrity Manifold Block (HIMB) shall be used to connect Gauge Pressure Transmitters with process.
- When provided, HIMB shall have integrated block and bleed facility for three transmitters & shall be mechanically interlocked with tamper-proof facility in such a way that only one pressure transmitter can be isolated or vented at any one time.

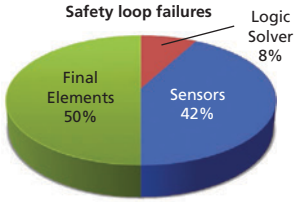
Logic Solver

Control systems from L&T Electrical and Automation

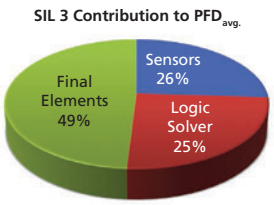
The Logic Solver processes signals from the sensors and closes the final element by de-energising the SOV. The logic solver hardware must be designed to meet the SIL 3 performance requirements, as a minimum, in accordance with IEC 61508. The logic solver can be either solid state, or programmable electronic systems (PE). Programmable electronic systems are provided with additional self-diagnostics and fault tolerance.

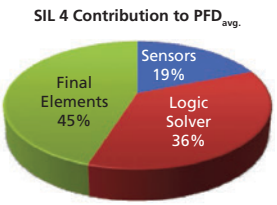
Final Element

Final elements (Actuated Valves) are accorded the highest priority in a HIPPS loop as studies suggest that they account for 50% of safety loop failures historically and calculations suggest that their contribution to $PFD_{avg.}$ is the highest when compared with the sensors and logic solver. Thus selection and design of valves and actuator is of paramount importance in a safety loop.



Source: Oreda (Analysis of Safety Loop Failures)





Source: Exida

Shutdown Valves

Selection of valves for HIPPS systems depends on reliability of the valve failure stroke, seat tightness, and impact of process conditions on valve drive train and seat design. A 1oo2 voting logic is normally specified for the HIPPS shutdown valves (in accordance with IEC 61511).

Trunnion-mounted Ball Valves (TMBV) are preferred for HIPPS applications as they provide the best flow performance for shut down applications.

Soft and metal seats can be offered.

Triple-offset Butterfly Valves (TOBV), can be used in clean tight shutoff applications such as LNG where pressure drop is not a concern.

The disc seat could either be a laminar seat or a solid seat based on the application.

Product Range and Options

Valve Types	Trunnion-mounted Ball Valve	Triple-offset Butterfly Valve
Sizes	2" to 56"	3" to 100"
Pressure Rating	Class 150 to 2500	Class 150 to 1500
Temperature Range	-196°C to 350°C	-196°C to 538°C
Seat Options	Soft Seat, Metal Seat	Metal-Graphite Laminated Seat, Solid Metal Seat
Body Materials	Carbon Steel, Stainless Steel, Duplex & Super Duplex Steels, Special Alloys, Carbon Steel with Stainless Steel/ Inconel Overlay	
Actuation Options	Pneumatic and hydraulic. Fail safe position provided by spring return.	

Features of Final Element:

- **Certified to SIL 3**
  L&T Actuated TMBV and TOBV are certified to SIL 3 by an independent third party


Certificate / Certificat
Zertifikat / 合格証
L&T 1004017 C001
Ball Valves
L&T VALVES LIMITED
Tamil Nadu- India
IEC 61508 : 2010 Parts 1-7
Systematic Capability: SC 3 (SIL 3 Capable)
Random Capability: Type A, Route 2H Device
Evaluating Assessor
Certifying Assessor


Certificate / Certificat
Zertifikat / 合格証
L&T 1004017 C002
Butterfly Valves
L&T VALVES LIMITED
Tamil Nadu- India
IEC 61508 : 2010 Parts 1-7
Systematic Capability: SC 3 (SIL 3 Capable)
Random Capability: Type A, Route 2H Device
Evaluating Assessor
Certifying Assessor

- **Partial Stroke Testing (PST)**
  Partial stroke testing capability is built into each HIPPS shutdown valve, for testing (closure limited to 30%) and real time diagnostics. The PST data could be recorded with remote status indication in SCADA or an equivalent protocol.
- **Fast Acting**
  HIPPS valves designed to go from full open to full close in ≤ 2 seconds
- **Tight Shut-off**
  Leakage requirements as per Class V or VI of ANSI/ FCI 70-2
- **Fugitive Emission**
  Meets ISO 15848-1 requirements
- **Fire Safe**
  Valves fire safe tested to API 607 or API 6FA

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