High-Integrity Pressure Protection System (HIPPS)

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Top 25 Interview Questions & Answers

Part 1: Fundamental HIPPS Concepts

1. What is a HIPPS?

A **HIPPS**, or **High-Integrity Pressure Protection System**, is a specialized type of Safety Instrumented System (SIS). Its purpose is to provide a highly reliable, last line of defense to prevent a pipeline or vessel from being over-pressurized. It acts as a "safety barrier" that automatically shuts off the source of the high pressure before the design pressure of the downstream system is exceeded.

2. What is the primary purpose of a HIPPS?

The primary purpose of a HIPPS is to **prevent catastrophic failure due to overpressure**. It is designed to be a faster and more reliable alternative to traditional mechanical relief systems like pressure relief valves (PRVs) or rupture discs, especially in high-pressure or high-flow applications.

3. When is a HIPPS typically used?

A HIPPS is used in situations where traditional relief systems are impractical or undesirable. Common scenarios include:

High-Pressure/High-Volume Sources: Such as upstream of gas processing plants where flaring a large volume of gas is environmentally or economically unacceptable.

Protecting Downstream Pipelines: Preventing a high-pressure production line from rupturing a lower-pressure downstream flowline.

Toxic or Hazardous Fluids: When releasing the process fluid to the atmosphere via a relief valve would be extremely dangerous.

Subsea Applications: Where installing a conventional flare system is physically impossible.

4. How does a HIPPS differ from a standard Safety Instrumented System (SIS)?

A HIPPS is a *type* of SIS, but it is one with the **highest level of integrity and performance**. The key differences are:

High SIL Rating: HIPPS are almost always rated for **SIL 3 or SIL 4**, representing the highest levels of reliability. A standard SIS might be SIL 1 or SIL 2.

Extremely Fast Response Time: A HIPPS must detect the overpressure and close its final elements very quickly (often within 2-3 seconds) to prevent the pressure from exceeding the design limit.

Focus on Prevention: Its sole job is to stop the flow and *prevent* the overpressure event, whereas a relief system *mitigates* the event after it has already occurred.

5. Is a HIPPS a preventative or mitigative safeguard?

A HIPPS is a **preventative** safeguard. It acts to prevent the hazardous overpressure scenario from ever reaching its ultimate consequence (vessel rupture). A pressure relief valve, which opens to relieve pressure *after* it has already exceeded the setpoint, is a **mitigative** safeguard.

Part 2: Architecture & Components

6. What are the three main components of a HIPPS?

Just like any SIF (Safety Instrumented Function), a HIPPS consists of three core parts:

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Sensors (Initiators): High-integrity pressure transmitters that detect the rise in pressure.

Logic Solver: A certified safety PLC or solid-state logic solver that processes the inputs from the sensors and decides when to trip.

Final Elements: High-speed, fail-safe shutdown valves and their actuators that physically stop the flow.

7. What is "voting logic" and why is it used in a HIPPS?

Voting logic is the arrangement of sensors and final elements to achieve high levels of both **safety** and **availability**. The most common architectures are:

2oo3 (two-out-of-three) for sensors: The system uses three pressure transmitters. A trip is initiated only if **at least two** of the three sensors detect a high-pressure condition. This architecture is highly secure against spurious (false) trips.

1oo2 (one-out-of-two) for final elements: The system uses two shutdown valves in series. A trip signal will close **both** valves. This architecture is highly reliable in shutting down the flow, as either valve closing will achieve the safe state.

8. Why are pressure transmitters the preferred sensors for a HIPPS?

Pressure transmitters are used instead of simple pressure switches because they are "smart" devices that provide continuous, live measurement. This allows for advanced diagnostics, such as:

Self-Monitoring: They can detect internal faults and signal a failure to the logic solver.

Rate of Change Detection: The logic solver can be programmed to trip based on a very rapid rate of pressure increase, even before the setpoint is reached.

Drift Detection: In a 2oo3 system, the logic solver can detect if one sensor's reading is drifting away from the other two.

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9. What are the key requirements for the final element (valves and actuators) in a HIPPS?

Extremely Fast Stroking Speed: Must be able to go from fully open to fully closed in seconds (e.g., a 2-second stroking time is common).

High Reliability: Must have a very low Probability of Failure on Demand (PFD). This often requires high-performance actuators and certified valve bodies.

Fail-Safe Design: The valve/actuator assembly must be designed to automatically go to the safe (closed) position upon loss of power or signal (e.g., using a spring-return actuator).

Certified: The entire valve and actuator assembly must be certified for use in the required SIL level.

10. What is the role of the logic solver in a HIPPS?

The logic solver is the "brain" of the system. Its role is to:

Continuously read the pressure values from the sensors.

Execute the voting logic (e.g., 2oo3).

Compare the validated pressure to the trip setpoint.

Send a trip signal to the final elements if the setpoint is exceeded.

Perform continuous diagnostics on itself, the sensors, and the final elements.

11. What is a "dedicated" logic solver?

This means the logic solver used for the HIPPS must be completely **separate and independent** from the plant's Basic Process Control System (BPCS). This independence is a fundamental requirement for any SIS to ensure that a failure in the BPCS cannot compromise the safety function.

Part 3: Performance & SIL

12. What does SIL stand for and what does it mean for a HIPPS?

SIL stands for **Safety Integrity Level**. It is a measure of the reliability and performance of a safety system. For a HIPPS, which is almost always **SIL 3**, it means the system must have a Probability of Failure on Demand (PFD) between 10−4 and 10−3. In simple terms, it must be designed to work successfully at least 99.9% of the time it is needed.

13. What is PFD?

PFD stands for **Probability of Failure on Demand**. It is the probability that a safety system will fail to perform its function when a demand is placed upon it. A lower PFD means a more reliable system.

14. How is the overall PFD of a HIPPS calculated?

The total PFD for the HIPPS is the **sum** of the PFDs of its three subsystems:

$$PFD_{HIPPS} = PFD_{Sensors} + PFD_{LogicSolver} + PFD_{FinalElements}$$

To achieve a SIL 3 target, each of these subsystems must be designed with extremely low failure rates, often through the use of redundancy (voting).

15. What is "spurious trip rate" and why is it important for a HIPPS?

A **spurious trip** is an unnecessary shutdown caused by a failure within the safety system itself (e.g., a single sensor failing in a 1oo1 system). While a HIPPS must be extremely safe (it must work when needed), it must also be highly available (it must not cause false

shutdowns). Architectures like 2oo3 voting are used specifically to minimize the spurious trip rate, which is a major economic concern.

16. What is the typical response time for a HIPPS?

The total response time, from the pressure exceeding the setpoint to the final elements being fully closed, is typically **2 to 3 seconds**. For some very high-pressure gas systems, it can be even faster.

17. Why is such a fast response time necessary?

In many high-pressure scenarios, once the pressure starts to rise, it can do so extremely quickly (a phenomenon known as "line packing"). The HIPPS must shut off the source faster than the pressure can build up to a level that would rupture the downstream pipe or vessel.

Part 4: Testing, Standards & Maintenance

18. What is "proof testing"?

Proof testing is a scheduled, periodic test performed on a safety system to reveal any undetected ("dormant") failures that would otherwise only be found during a real demand. It is a critical part of maintaining the SIL rating of the HIPPS over its lifetime.

19. How is a HIPPS proof tested?

A full "stroke" test is performed on the entire system:

The process is typically bypassed or taken offline.

A calibrated pressure source is used to simulate a high-pressure condition at the sensors.

The logic solver's trip functionality is verified.

The final element valves are commanded to close, and their ability to fully close within the required time (**stroking time**) is measured and documented.

20. What is "Partial Stroke Testing" (PST)?

PST is a technique used to test the final element valves while the plant is still online. The valve is commanded to move a small amount (e.g., 10-20% of its travel) and then return to its fully open position. This test is not a full proof test, but it can detect a large percentage of potential valve failures (like being "stuck") without requiring a full shutdown. It is often used to extend the interval between full proof tests.

21. What are the main international standards that govern HIPPS?

HIPPS design and management are governed by the primary functional safety standards:

IEC 61508: The fundamental standard for the functional safety of electrical, electronic, and programmable electronic safety-related systems.

IEC 61511: The process industry-specific implementation of IEC 61508, covering the entire safety lifecycle for SIS, including HIPPS.

22. Can you bypass a HIPPS?

Bypassing a HIPPS is an extremely critical operation that must be managed under a strict permit-to-work system. Because it is often the *only* thing preventing a catastrophic failure,

bypassing it for maintenance requires alternative safety measures to be put in place, such as continuous monitoring by an operator or reducing the system pressure.

23. What documentation is critical for a HIPPS?

Safety Requirement Specification (SRS): The "bible" for the HIPPS, which defines exactly what it is supposed to do, its required SIL, response time, and all other performance criteria.

LOPA Report: The Layer of Protection Analysis report that justifies the need for the HIPPS and determines the required SIL.

Proof Test Procedures and Records: Detailed procedures for how to test the HIPPS and historical records of all tests performed.

SIL Calculation Reports: Detailed calculations showing that the chosen components and architecture meet the required PFD target.

24. What is meant by "prior use" justification?

"Prior use" or "proven in use" is a concept where a component can be justified for use in a safety system based on extensive and documented historical operating evidence from a similar application. This can demonstrate that the component has a very low failure rate in the real world, even if it doesn't have a formal SIL certificate from the manufacturer.

25. Why is a HIPPS considered a "last line of defense"?

It is considered a last line of defense because it is designed to act only when all other preceding layers of protection have failed. In a typical system, the Basic Process Control System (BPCS) and operator alarms are the first lines of defense. The HIPPS is the final, high-integrity barrier that activates just before a catastrophic failure would occur. 🛡️

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