

Practical Approach to Vendor Package HAZOP Studies and Preparing the Package Vendor

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Abstract

During the design phase of a project, vendor packages (e.g., compressors, water desalination) are typically treated as a "black box" with a very specific function, and the typical perspective of the buyer/owner/operator is that safety issues have been thoroughly addressed, based on the package vendor having designed and built a large number of similar units. Although in many cases, this is true, in other cases, low-probability/high-consequence events just haven't yet occurred on the systems that have been installed or the system operator may have made retrofits that have addressed potential safety issues. Regardless, the thorough evaluation of vendor packages, prior to acceptance/installation, as part of a holistic safety review is critical.

When structuring a HAZOP Study that will properly challenge the design, a key issue is the knowledge, background, and state of preparedness of the vendors that participate in your HAZOP Study. Many individuals may be very familiar with the normal functioning of the system, but not so much the dynamic response of the system to upsets or things that might challenge safety limits. In other cases, the individual sent to participate in the HAZOP Study may not have been exposed to and knowledgeable of the types of the design limits that are pursued during the HAZOP Study. Another key issue that is often not investigated is the potential interactions between the vendor package and the process system. The HAZOP Study must also thoroughly review the vendor-provided information to ensure that turnover packages include all of the key process safety information that may be required for company requirements and regulatory programs.

The key objective of this paper is to provide practical tips on key issues that should be evaluated as part of the HAZOP Study, and to provide checklists and timelines that can help the vendor representatives that are attending your HAZOP Study prepare. The tables of key information that the vendor should be prepared to discuss and the charts containing timelines for preparing the vendor for the HAZOP Study that will be provided in the paper will provide definitive guidelines and tips for ensuring that the vendor is properly prepared to support the HAZOP Study. The following key topics are addressed:

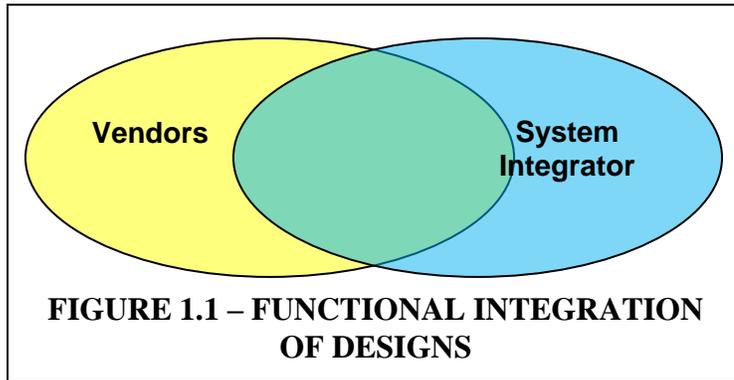
- Background, Evolution of the Use of Packaged Units, and Vendor Package Integration into HAZOP
- Evolution of the use of packaged units in the design process and the importance of thorough evaluation, BEFORE YOU TAKE OWNERSHIP
- Importance and benefits of challenging the Vendor and thoroughly evaluating (via HAZOP) the vendor packages
- Examples from one project of safety issues that had not been addressed in the vendor-provided design details
- How to help your vendor get prepared for the HAZOP Study, including a master checklist of issues not always considered by the vendor, to avoid “design formulation” instead of HAZOP
- Timelines for preparation for a HAZOP Study that includes a vendor package
- Characteristics to look for in the individuals from the vendor company that are participating in your HAZOP Study

1. Background, Evolution of the Use of Packaged Units, and Vendor Package Integration into HAZOP

Over the past decades, especially in the oil & gas industries, standardization of key design elements have progressed hand-in-hand with the vast proliferation of applications, especially with projects associated with oil & gas exploration & production. The use of standardized design elements have allowed vendors (companies specializing in “packaged units”) to make relatively minor alterations to their basic design packages to rapidly customize their design to meet the system design requirements. This, of course, results in decreased cost of production (and increased profit to the vendor), and **if** the package is well suited to application, the “Open Arts” Engineering Firm (i.e., the System Integrator) that is assembling the whole process can use this modularized approach to expedite production schedules and the creation of a safe and highly-operable system. Definition of main stakeholders:

- Vendor/Package Designer & Constructor – These are experts at the design and construction of modules designed to achieve a very specific function. Vendor packages can range from large critical units like compressor packages and turbine drives to smaller packages like nitrogen and instrument air supplies. Tailoring the analysis approach to match the safety-criticality of the package being evaluated is discussed in this paper.

- System Integrator (often referred to as the System Designer or the EC – Engineering Contractor) – This is the main Engineering Company that has the responsibility of overall system functionality and piecing together the various (vendor) packages to achieve overall system safety and operability. On the System Integrator Team may be Process Engineers, Package Managers, and Control/Protection Systems Engineers.



It is also important to define:

- System – overall process containing various modules including vendor packages that comprise the plant facility
- Module – specific vendor package including any accessories that can be source of potential hazards (e.g., chemical storage and handling provided by the vendor)

Theoretically, with a clear specification of the functional requirements of the vendor module by the System Integrator and an understanding of the inputs/outputs from the specific modules, a cohesive design can be created (see Figure 1.1). However, the key challenges in closing the modular-design gap (See Table 1.1), create several factors that make this situation non-ideal:

TABLE 1.1 KEY CHALLENGES IN CLOSING THE MODULAR-DESIGN GAP	
VENDOR – Fixed-Price Units may not allow for:	
<ul style="list-style-type: none"> • Significant tailoring to the system requirements • Time to investigate the system requirements • Creation of custom design information to suit client requirements 	
SYSTEM INTEGRATION – Resource Limitations may not allow for:	
<ul style="list-style-type: none"> • Creating design information for the Vendor • Independent verification of key safety or 	

- Challenges to the vendor in integrating the project specific requirements which are conveyed as a part of the purchase order and/or during the HAZOP
- Limited understanding of the vendor in how the package integrates with the overall process
- Limited design information (and late) for the vendor package

- Lack of development of the overall process and hence not enough information on the boundary conditions at the time where vendor package selection must be made
- Drive to get the vendor package frozen early in the design to avoid additional scope changes, cost, and schedule impacts
- Design gaps that are identified during the HAZOP or later when the overall design progresses
- No time allocation for system integration

This is a classic interface/management issue that manifests itself with challenges during design, installation, and operation. A mechanism for addressing this is the HAZOP Study, which by nature, has to pull together all of these various elements and examine them in a cohesive and comprehensive manner.

The focus of this paper will be the preparation of the vendor for the HAZOP Study and the effective utilization of the team's energies to align the vendor design and vet the design. This process will enable flushing out key design issues at the earliest phase possible and result in a design that is easier to implement and addresses all relevant operational and safety issues.

2. Importance and Benefits of Challenging the Vendor for a Thorough Evaluation of Package Units

While the vendors are quite specialized in the area of their work, they may not be aware of the specific requirements of the company (company/project-specific standards) and the specific standards that are obligatory in the country. For example, Australian Standards take precedence over the international standard to which the vendor may have complied. Also, some of the vendor packages may have been specified for different industry (e.g., water treatment standards for the mining industry may be more complex than the standards required of water agencies).

Vendor packages are typically robust, due to their broad application. In addition, vendor packages are typically associated with "low risk" systems. However, this very broad application is actually at the core of what often causes challenges in their evaluation during a HAZOP Study, i.e., there are so many applications of the same system, vendors may not have recently asked probing questions of the kind that materialize during a HAZOP Study. In addition, these same characteristics are reflected in vendor P&IDs having less detail than what may be more common for complex chemical processes.

These forcing functions are at the core of the importance of a thorough challenging of the design, possibly via the application of a HAZOP Study. Properly applied, the interaction involved in a HAZOP Study should be able to address some key challenges that can exist in package designs:

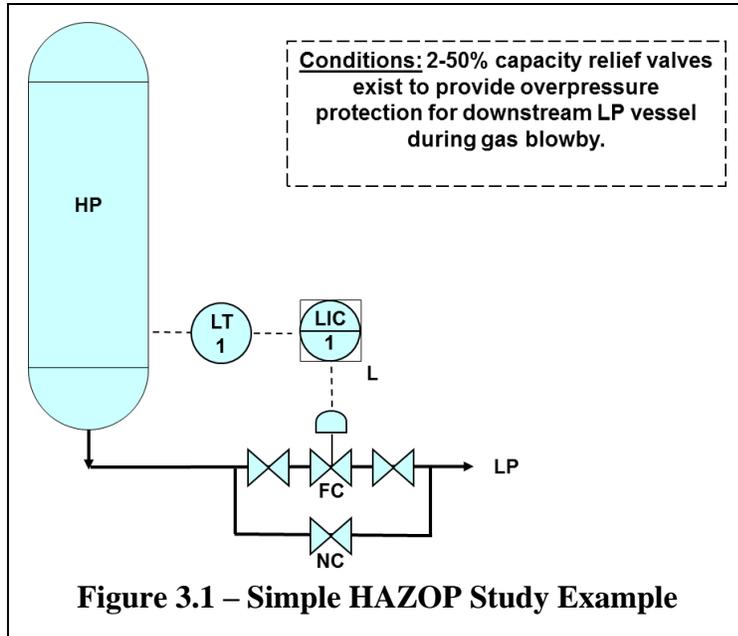
- Mismatches with the rest of the process, possibly due to the use of a standardized package without verifying that specific design needs are addressed
- Incompatibilities with design requirements or incomplete verification of the design

- Design weaknesses
- Vendors not receiving a basis-of-design document that addresses all of the needs of the entire system
- Lack of communications and interface with the System Integrator can result in de-prioritization of schedule or quality
- Design information that is not complete or consistent with project standards
- Human nature is to focus attention on areas that under the highest scrutiny – System Integrators that aren't scrutinizing the vendor process may not get the same level of attention/quality.
- Potential for key people who are part of the design process being reassigned before all of the efforts are completed
- Waiting too late in the vendor package design can limit the ability to implement helpful options
- Vendors are keen to get their off the shelf product with minimum design changes to the customer as this will be maximize their profits, however it must be emphasized that unless they are specifically confronted with the need to get their package working for the present application there will be a lot of rework at the end.
- Once the package is in the possession of the operating company, there may be a decreased ability for the vendor to effect changes possibly due to unavailability of key equipment, technical resources, or geographical location
- Once the project is done, the vendor staff may be quickly demobilized, and the HAZOP Study may be one of the best mechanisms to leverage a high-quality, trouble-free, and safe design.

Section 3 provides some background on the HAZOP Study method to provide a framework for what the depth of preparation needed by the vendor, and Section 4 discusses those preparation activities.

3. What is a HAZOP Study and How Does This Help

The Hazard and Operability (HAZOP) Study was originally crafted as a brainstorming mechanism for thoroughly identifying potential hazard and operability problems for an operating or completely-designed facility.



HAZOP is a tool designed to utilize basic design functional information (example in Figure 3.1) to feed into a brainstorming process that pivots on the use of a “deviation matrix” (Table 3.2) that is designed to help the team focus on general process issues. A cyclic approach (Figure 3.2) is designed to add further structure to the activity for the development of scenarios that reflect important things that can go wrong. These scenarios are often documented in a tabular form to summarize critical ways that a system can fail. It is this

transformation from a “how does the system function” perspective to a “how can it fail perspective” that makes the HAZOP approach valuable for identifying potential weakness in design or operations. It is this same strategy that makes the concept useful throughout the design process. It is important that the D-HAZOP approach is applied such that it should not dilute its objectivity in evaluating potential hazard and operability issues.

When considering the use of HAZOP to identify hazard or operability vulnerabilities to resolve issues during the design process, one should really not ask “Is it a good idea?” but “Why would anyone not want to infuse a mechanism to resolve problems into the design process?”.

TABLE 3.1 – TIPS
HAZOP is a <u>Decision-Making</u> and Technical <u>Problem-Solving</u> Tool
Use HAZOP as a Decision-Making Platform throughout the Design Process

DESIGN/ OPERATIONS PARAMETER	GUIDE WORDS					
	No/Low	More/ High	Misdirected	Reverse	As Well As	Other Than
Flow	No/Low Flow	More Flow	Misdirected Flow	Back Flow	Contam- inants	Wrong Material
Temperature	Lower Temp.	Higher Temp.				
Pressure	Lower Pressure	Higher Pressure				
Level	No/Lower Level	Higher Level				
Other/ General	Composition, Maintenance, Start-up/Shutdown, Heat Tracing, Piping Specifications, Phase, Viscosity, Density, Reaction, Corrosion, Erosion/Fatigue, Sampling, Service Loss, Duration, Sequence, Human Factors, Safety/Health, Instrumentation, Agitation, Speed					

Table 3.2 – HAZOP Study Deviation Matrix

Since it is intended to resolve hazard and operability issues and provide a framework for making difficult decisions, the concept is very well-suited to the design process. The same fundamental strategies can be used throughout the design formulation and detailed design process as a decision-making and technical problem solving tool, with creative adjustments on its use.

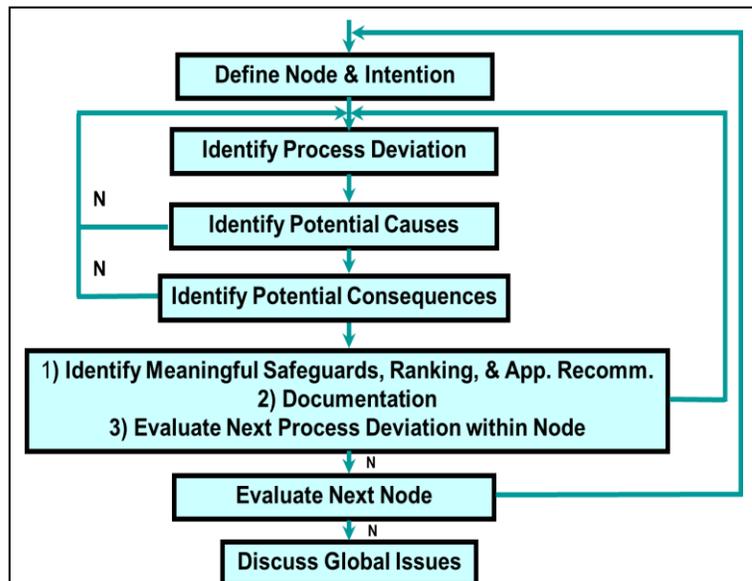


Figure 3.2 – General HAZOP Flow Chart

4. Preparation of the Vendor for the HAZOP Study

4.1 General Preparation Needs

The broader application of the HAZOP technique that began in the 1990s precipitated from tragedies that occurred in the 1980s, through recognition that establishment of a high level of process safety was a technical management issue^[2,3]. The application of HAZOP was also driven by United States regulatory requirements (Process Safety Management (PSM)^[4] and Risk Management Programs (RMPs)^[5]), as well as Safety Cases^[6], which had broader application outside the United States. Without the design information that provides a basis for the evaluation, and without an understanding of the hazards and operability issues that need to be controlled, the foundation for these Safety Management Systems (SMS) would crumble.

Thus, if the Vendor Package is a critical element for maintaining the safety of a process that is encompassed by these regulatory requirements, the level of detail of key Process Safety Information (PSI) and application of a Process Hazard Analysis (PHA) tool like HAZOP must be applied commensurate to the level of potential risk, in the same manner as the main portion of the process. Although there is a lot of flexibility of application, if not required by regulation, application of a thorough HAZOP to a Vendor Package may be useful for:

- Optimizing process and personnel safety
- Optimizing package operational issues
- Maintaining project progress
- Technical problem-solving and decision-making
- Providing a framework for ensuring that the “turnover design information package” is complete and high quality

TABLE 4.1 – GENERAL INFORMATION REQUIREMENTS FOR A HAZOP STUDY

- **Process Flow Diagrams**
- **Piping & Instrumentation Diagrams (with changes identifiable from any previous HAZOP Studies)**
- **Cause & Effect Diagrams**
- **Alarm & PSV Setpoints**
- **Site Layout / Platform Location Drawings**
- **Accident/Incident History & Reports**
- **Management of Change (MOC) & Pre-Startup Safety Review (PSSR) Documentation**
- **Previous HA/PHA Recommendation Status**
- Equipment Data Books
- Operating & Emergency Procedures
- Maintenance Records
- System Descriptions
- Previous HA/PHA Reports
- Toxic, Chemical, and Physical Properties
- Prevention Program Compliance Audits

Bold items in the list above are generally more important.

Vendor involvement and preparation is critical to achieving these objectives.

Table 4.1 illustrates the general information requirements for the performance of a HAZOP Study. A thorough review of a vendor package is an overall part of this approach, and Section 4.3 provides additional regarding specific information needed for a review of a vendor package.

Although HAZOP Studies have been in use since the 1970s, there are many “styles” of application, and many vendors have not been exposed to a HAZOP Study that thoroughly challenges key elements of the design, that is important for achieving the level of safety and operability that you wish for your facility. Thus, providing clear expectations, possibly through the use of examples, and helping the vendor prepare for the HAZOP Study is critical.

It is important recognize that the vendor may resist changes to their standard design, in some cases due to a perception that the change may upset the delivery schedule which may have been promised to get the job. However, in many cases the vendor can benefit from the ideas and operational experiences that can be offered by the HAZOP Study Team. Resistance to change can also be a result of not understanding potentially stringent requirements of the industry (e.g., desalination plant vendors supplying a package for associated water treatment, where there is a need to consider hazardous area locations, etc.). Note that if changes are necessary, it may be relatively easy for the System Integrator to flex their muscle to make the vendor make some changes which have been received quite late in the project.

4.2 Preparation Timing to Support Achieving Your Objectives

Section 4.1 stressed the importance of vendor preparation before the HAZOP Study. If the vendor documentation is poor and/or the vendor is poorly prepared to support a challenging HAZOP Study, it can result in an unfortunate waste of time and critical resources that can result in a huge negative impact on a project. In addition to frequent and quality communications, a key part of preparing your vendor includes:

- Not assuming that their concept of accuracy, completeness, and detail is consistent with your needs
- Not assuming that the depth-of-challenge that you are planning for the HAZOP Study is consistent with what they may have been exposed to previously
- Not assuming that they will pace their preparation activities accordingly

Thus, if a meaningful HAZOP Study of the same detail as would be performed for the main process system is required (not always the case), the preparation steps identified in Table 4.2 are likely helpful (please note that this pre-supposes that the Process Engineer has worked with the vendor to provide functional specifications and that the basic design has been verified to meet these functional specifications, possibly via a joint design review by the stakeholders):

Our experience is that if P&IDs don't contain complete information and the Vendor is not prepped (i.e., pre-warned) regarding the types of questions that materialize during the HAZOP Study, the HAZOP Study Team will struggle (i.e., more time and increased session costs, associated with poorly focused resources) to identify and evaluate HAZOP Study scenarios.

TABLE 4.2
SCHEDULE FOR EFFECTIVE HAZOP STUDY PREPARATION

- **3 Weeks Before HAZOP Session**
 - Process Engineer – Review complete Vendor Drawing Package (Process Flow Diagram (PFD), Material Balance, Process Description, Piping & Instrumentation Diagram (P&ID), and Cause & Effect (C&E) Diagram) to ensure that they have a clear understanding of the process.
 - Process Engineer – Verify with the vendor that any special requirements such as chemical handling and spill management have been addressed.
 - Process Engineer - Transmit to the vendor any "Probing Questions" based on any perceived design information gaps (note that other background information may have been provided as part of the design package beyond the P&IDs).
 - Package Manager – Verify with the vendor that any deviations from the basis-of-design have been agreed to and approved by the concerned disciplines.
 - Package Manager – Verify with vendor that they have incorporated any of the required codes and standard to which the package must comply.
 - Control/Protection Systems Engineer – Verify with the vendor that their design integrates with the rest of the plant and that common functions such as the Emergency Shutdown (ESD), Fire and Gas Detection System, and Power & Other Utilities have been addressed.

- **2 Weeks Before HAZOP Session**
 - Process Engineer – Communicate with vendor and ask a few questions to "Spot Check" that the vendor understood and is addressing any gaps.
 - Process Engineer – Ensure that the vendor has provided all the missing information regarding the process, utility consumption figures, etc.

- **1 Week Before HAZOP Session**
 - Vendor – Provide updated drawings (and other design information, in a form suitable for reproduction).
 - Process Engineer – Having the ultimate responsibility for the design, verify that gaps have been addressed and the drawings are complete and accurate. In general, Process Engineers are the only ones capable of taking on the role of ensuring that the design and control philosophy addresses the system functional requirements.

- **2 Days Before HAZOP Session**
 - Process Engineer – Ensure that copies of pertinent information are reproduced for the HAZOP Study Team Members (typically 11x17" (A3) printouts of the P&IDs are adequate).

4.3 Types of Information

Important general design information requirements were specified in Section 4.1. Any information provided should be in a form that is consistent with project specifications, up-to-date, legible, and consistent. Section 4.2 provides a schedule to working with the vendor to ensure that key preparation activities are performed. Table 4.3 and Table 4.4 provide examples of common information gaps in vendor design information packages, and key HAZOP-related issues that the vendor should be prepared to address. This is a critical part of vendor preparation for a HAZOP Study.

TABLE 4.3 – COMMON DESIGN INFORMATION GAPS

General P&ID Information Content:

- Key Equipment Design Information Blocks (either top or bottom of P&ID) – Include at least design pressures (e.g., vessels, pumps, filters, strainers, and heat exchangers), design temperatures, material specifications.
- Project-Specific Equipment Tag Numbers
- Some Indication of Piping Specifications (e.g., size, material, design pressure)
- Piping specifications conform to the project or are approved for design by the main Engineering Contractor.

Control Valves:

- Valve Failure Positions (e.g., loss of air, loss of power, loss of hydraulic pressure, thermostatic control)
- Actuator Types
- Size
- Setpoints

Relief Valves:

- Setpoints
- Size/Sizing Basis

Pumps:

- Blocked-in Discharge Pressure
- If Stopped, is Flow Reversal possible?
- AutoStart Function - Flow/pressure/electrical fault? Setpoint?

Block Valves:

- “Normal” Position (unless clear from context)
- Electrical Issues
- Hazardous Area Drainings, as required

TABLE 4.4 – ADDITIONAL QUESTIONS/INFORMATION DETAILS THAT THE VENDOR SHOULD BE PREPARED TO ADDRESS

Heat Exchangers/Coolers:

- Impact of Loss of Heating/Cooling Medium Flow?
- Impact of Changes in Heating/Cooling Medium Temperature?
- Impact of Loss of Power (total or partial) to Cooler Fans?
- Impact of Fin-Fan Cooler Louver Malfunction Open/Closed (also, what is the “failure position”)?

General Process Condition Changes:

- Consequences of loss of flow, excess flow?
- Consequences of temperature excursions high/low?
- Do these consequences violate a) safety limits resulting in near-term damage, b) safety limits resulting in long-term damage or equipment degradation, or c) compromising warrantee or stable operation?

Instrumentation:

- Protection System Setpoints?
- Protection System Actions? If complex, a C&E may be necessary.
- Alarm Setpoints?
- Alarm Annunciation Locations (i.e., local, DCS, remote center)?
- Alarm Effect (i.e., panel indicator, audible alarm, flashing lights)?
- Communication with the DCS and partitioning of instrumentation and control between the local panel and from the DCS?

Electric Immersion Heaters:

- Damaged if Uncovered (without activation of protection features)?
- Will Control/Protection Temperature Transmitters function as-intended, if uncovered?

Other (primarily applicable for lube oil systems):

- For three-way valves, is total isolation possible? Can flow go down both paths if the valve is mispositioned?
- Sensitivity to lube oil composition?

Tanks:

- Vent locations and potential hazards?
- Provisions for tank maintenance, e.g., draining?
- Accessibility / procedures for filling?
- Materials of construction?
- Secondary containment and draining requirements?

5. Key Vendor Representatives

It is important to recognize that in addition to it being an independent safety evaluation, a HAZOP Study is a technical problem-solving and decision-making exercise that is fundamental to making progress on the engineering project. Another critical element in making progress is the quality of the resources (i.e., design/safety information and personnel) available to the HAZOP Study. Since unlimited attendance is not practical, it is important to understand the technical resources needed for technical problem-solving and decision-making. Table 5.1 identifies the key disciplines useful for any HAZOP Team. A Vendor Package HAZOP Study is no different, and the key technical disciplines must be properly supported.

The investment in resources aligned to a HAZOP Team is significant. Channeling these resources and energies can yield significant benefits, and rapid feedback can result in being able to utilize these insights much more quickly. The best applications use this feedback loop to resolve issues more quickly and avoid “11th hour” surprises that could occur if the HAZOP is finished after all of the detailed engineering work is done and can result in significant scheduler and budgetary impacts. By focusing the HAZOP as a problem-solving process, the team can:

- use their capabilities to have more useful input into the design
- avoid last-minute complications
- have a much greater feeling that they are actively contributing to facility safety

Having a platform to interactively resolve critical issues during the design phase of a project is supportive of maintaining schedule and budget. The Vendor Package HAZOP Study is an important platform to validate that the package has been integrated into the overall engineering design, e.g.:

- Flowrates
- Design pressures/temperatures
- Materials of construction
- Process chemistry
- Piping sizes
- Power supplies
- Process control/protection system communications
- Contingency (emergency) response

Table 5.1
Key Disciplines Useful for a
HAZOP Team

- Facilitation/Leadership
- Process Engineering
- Control/Protection
Systems Engineering
- HSE Engineering
- Rotating Equipment
Specialists
- Operations

Thus, it is essential that the right people participate in the HAZOP Study, and they are motivated to objectively evaluate the design and to openly participate in technical problem-solving. I.e., personnel must:

- Be knowledgeable in the design of the package
- Be knowledgeable in the dynamics of system response
- Have critically considered the response of their package to upset conditions

6. Vendor HAZOP Study Implementation Tips

In the past, vendor packages were limited to small skids in a process unit, and it may have been more acceptable to get by with limited design information and by applying a simplified PHA tool such as a What-If/Checklist. However, with larger, more complex, and higher hazard vendor packages that represent a larger part of the key plant performance, and which may be more prone to integration challenges, a full HAZOP approach is often recommended.

There will be cases where a HAZOP approach will not be compatible with the vendor's familiarity with your industry or with the available design information. In these cases, other approaches must be used to perform an evaluation that addresses the reality of the situation and does justice to flushing out potential hazard and operability vulnerabilities.

Table 6.1 provides a list of other general tips associated with properly preparing the vendor. In addition, another frequently encountered situation is working with a vendor who is not familiar with the industry or has little or no experience in providing documents to the detail required by the client. Often a two-step approach works well if there is no reasonable expectation that the vendor can be properly prepared with the level-of-detail of information needed:

- 1) Focus on Critical Vendor Design Information – Often, especially for relatively simple systems that are often not scrutinized by HAZOP, design information lacks key documentation of basic safety elements such as design pressures, relief valve set pressures, relief valve sizing bases, etc. A thorough design review, involving a small team of process engineers and operations representatives can produce a list of focused questions that the vendor will have an easier time responding to. These responses can then be checked by a subset of the team and entered into the design basis information documentation.
- 2) What-If/Checklist Follow-up – In addition to securing and reviewing the information that is a result of a team in Step #1 focusing the vendor's attention on key safety information, a What-If/Checklist of potentially key hazards can be applied by the same team to ensure that there aren't any critical hazard or operability vulnerabilities.

TABLE 6.1 – OTHER TIPS

- Having some availability of a knowledgeable vendor representative (at least by phone and during pre-scheduled periods) during the HAZOP Study Session is very helpful. If affordable, video link or direct presence is even better, although rarely necessary. It is important to communicate with any representatives that are planning to attend to ensure that they can properly support the HAZOP Study. Having the right person available by phone is likely many times better than having the wrong person physically present at the HAZOP Study. In addition, if someone is attending by video/teleconference, they may have access to technical resources (i.e., documentation and people) that they might otherwise not have.
- Reviewing available vendor package drawings and sending a list of the HAZOP Study pre-loaded causes to the Vendor could facilitate the vendor being better prepared with thoughtful insights to the potential consequences and system dynamics associated with the vendor package event in question.

7. Conclusion

Although there can be a number of challenges in the performance of HAZOP Studies for package units, not evaluating the package (rationalizing it with “low risk” or “the vendor has been doing it for decades”) can result in potential hazards or operability challenges during start-up/commissioning or plant operation. Furthermore, not scrutinizing these units if they are part of regulated, hazardous processes may be difficult to justify. If the Vendor Package is a critical element for maintaining the safety of a process that is encompassed by these regulatory requirements, the level of detail of key Process Safety Information (PSI) and application of a Process Hazard Analysis (PHA) tool like HAZOP must be applied commensurate to the level of potential risk, in the same manner as the main portion of the process.

This paper has provided a number of tips for vendor preparation, needed design information, critical resources (documentation and people) to have at the HAZOP Study, and performance of the HAZOP Study itself to make the exercise as productive as possible, and to provide tangible benefits. Although there is a lot of flexibility of application, even if not required by regulation, application of a thorough HAZOP to a vendor package is likely useful for:

- Optimizing process and personnel safety
- Optimizing package operational issues
- Maintaining project progress
- Minimizing commissioning and start-up problems
- Technical problem-solving and decision-making

- Providing a framework for ensuring that the “turnover design information package” is complete and high quality

Properly applied, the interaction involved in a HAZOP Study will be able to precipitate distinct advantages that are supportive of maintaining capital project momentum, quality, budget, and schedule:

- Facilitating compatibility with the rest of the facility design – Rectifying design incompatibilities or customization that is requested early in the design process can often be accommodated without an impact on schedule or budget
- Ensuring that design deficiencies or safety/operability vulnerabilities are uncovered as early as possible during the design process so that changes can be made easily and the project schedule is not compromised, with a minimal impact on budget
- Making the design more robust
- Ensuring that packages are provided in a timeframe, state of design-readiness, and quality that supports the overall project schedule
- Creating more complete and higher quality design information (“turnover”) packages
- Scrutinizing the vendor package can result in a higher quality product – equipment and documentation – being delivered
- Avoiding re-work to correct potential design deficiencies or misapplication
- Once the project is done, the vendor staff may be quickly demobilized, and the HAZOP Study may be one of the best mechanisms to leverage a high-quality, trouble-free, and safe design.

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