

HSE Design Reviews and Action Close-out

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HSE design reviews and the management and close-out of resulting actions are an important part of an engineering project's workscope and incur the expenditure of a substantial number of man-hours. HSE design reviews also have an impact on project schedule and may extend the project duration. This paper considers the different strategies in executing project HSE design reviews and the associated advantages and disadvantages. Recommendations on best practice are made from the years of experience in project execution within Amec Foster Wheeler. The pitfalls of a less than optimum approach are also identified. The close-out of actions from HSE design reviews may require changes to be made to the developed plant design (rework) or require the incorporation of additional safeguarding measures, both incurring additional project cost and potentially delay to project schedule. Approaches to managing action close-out including the use of a risk register are considered.

Introduction

In the past 12 months, an office of engineering contractor Amec Foster Wheeler has conducted more than 30 HAZOP reviews on at least 6 projects. In these reviews, it is estimated that more than 1,000 P&IDs were reviewed and 30,000 man-hours were expended in review preparation, attendance and the closing out of review actions. HAZOP reviews are only one of the different HSE design reviews conducted on projects.

HSE design reviews and the management and close-out of resulting actions are a significant part of a project's workscope and a critical item in the project schedule. Failure to adequately prepare for HSE design reviews, poor review execution and/or poor follow-up can, if not adequately controlled, result in significant disruption to a project, leading to delays in the project schedule and additional man-hour expenditure.

Background

A design project typically progresses through a number of phases: each phase developing a more detailed design. At a number of points in the project, design HSE reviews are conducted. For illustration, an overview of typical project phases and some of the associated design HSE reviews is shown in Figure 1. A summary of some of the different types of HSE design reviews is provided in Table 1.

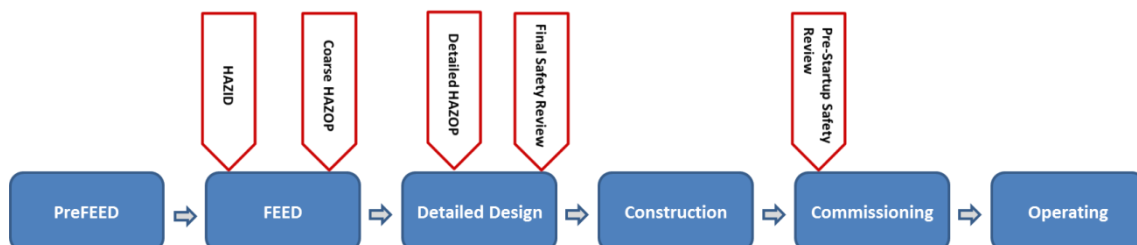


Figure 1 - Project phases and associated reviews

Table 1 - HSE Design Reviews

Project Phase	Review	Description	Documents under review
FEED	HAZID (Hazard Identification)	A review identifying significant hazards that may impact site layout or have other high level impact on plant design.	Block Flow Diagrams Process Flow Diagrams Preliminary Plot Plans
	Coarse HAZOP (Hazard and Operability)	A structured review of the process on a system-by-system basis utilising guidewords seeking to identify hazardous deviations from the design intent.	Process Flow Diagrams Process & Instrumentation Diagrams Plot Plans Design Philosophies
Detailed Design	Detailed HAZOP	A structured review of the process on a line-by-line basis utilising guidewords seeking to identify hazardous deviations from the design intent.	Process Flow Diagrams Process & Instrumentation Diagrams Plot Plans Design Philosophies Cause and Effect Charts Safeguarding Narratives
	Final Safety Review	A review to confirm that all the project design has been subjected to HSE design review, all design related actions have been closed and all design changes post review have been subjected to a management of change review.	Process & Instrumentation Diagrams Management of Change Documents Plot Plans

Project schedule

When developing the schedule for a project, decisions have to be made on the timing and duration of HSE design reviews. HSE design reviews cannot proceed outside the reality of constrained resources and schedule. Project schedule and man-hour budget limitations mean that design review duration and depth are not limitless and a balance must be found between duration and depth of review.

The timing and duration for each design review also influences the review's effectiveness: reviews that occur too late in the project schedule may leave insufficient time to close-out the review actions, limit the ability to implement actions completely and/or require expensive rework to implement.

For most projects, the HAZOP review sits on the critical path and is one of the biggest design events within the project. Duration can be reduced by executing simultaneous reviews in parallel. Amec Foster Wheeler has run up to four review teams at the same time on a single project with the corresponding reduction in overall review duration. When running multiple reviews simultaneously, it is critical that the project provides sufficient resources to support the reviews and this requirement has sometimes been found to be the limiting constraint. The following limiting factors have been found:

- Availability of review chairs
- Availability of suitable meeting rooms
- Availability of client personnel for attendance at each session.

When developing the project schedule, the timing of the design reviews is dependent on the availability of input documentation, particularly the process flow diagrams and the P&IDs. Such documentation is typically released in a series of revisions with each later revision being more developed in design. A balance must be achieved when selecting at which revision each design review will occur. The advantages and disadvantages associated with early versus late reviews are shown in Table 2.

Table 2 - Review Timing

	Advantages	Disadvantages
Early reviews	Allows incorporation of actions at an early project stage without incurring significant design rework.	The design under review may not be sufficiently developed to allow adequate review.
	Assists the development of an inherently safe design. It may still be possible to alter fundamental aspect of the design (e.g. vessel design pressures).	Significant design development may occur after the HSE design review, invalidating the review.
Late reviews	Ensures that the design under review is sufficiently developed.	Implementing review recommendations at a late stage may incur expensive rework and project delay.
	Fewer design modifications may occur after the review.	Risk reduction measures from the review more likely to be bolt-on modifications rather than inherently safe design.

An optimal approach is to conduct progressively more detailed reviews as the project progresses: early high-level reviews identify the issues with the largest risk while there is time to implement effective solutions while later detailed reviews examine the developed design for more specific problems.

Pitfalls in review execution

HSE design reviews require an effective team working together well in order to conduct a good quality review within a reasonable duration. Many different factors can influence review performance. The following are observations made by Amec Foster Wheeler Design HSE Engineers during the execution of HSE design reviews.

Use of an experienced and skilled review chair is one of the most important factors for achieving a successful review. A good review chair has the experience to foresee and prevent many problems in review execution. Some examples of lessons learnt include:

A key factor for good HAZOP review is the quality of the piping and instrumentation diagrams (P&IDs). If P&IDs are not of adequate quality or insufficiently developed then the review spends a disproportionate time correcting errors in the P&IDs resulting in more marking-up during the review than HAZOPing.

HSE design reviews are only one part of the review and assurance process within a project. However, within some project teams there is an expectation that the only forum for design concerns is the HAZOP and that the HAZOP review will detect and correct all deficiencies within the design. It should be that all design engineers have a responsibility to ensure the safe design of plant. HSE awareness sessions are recommended so that this message can be communicated to all on the project.

Information under review is more than the drawings and may include other documents such as cause and effect diagrams, design philosophies and plot plans. To utilise this ancillary information effectively, the right expertise needs to be within the review room or the review team risks misinterpreting documentation or spending excessive time trying to understand it.

The attendee list needs careful managing. It is important that a review procedure is produced before the review including a list by engineering discipline or role of the attendees required in the meeting room, and any additional people required to be 'on-call' if required to provide specialist knowledge.

The start of reviews sometimes attract large numbers of client personnel. Attendee numbers reaching almost 30 people is not unknown. Such large teams slow down the review and many of these people will contribute little or nothing to the review and their presence is a distraction. Many may drift off after the first lunch but sometimes a diplomatic request to the client is needed to reduce numbers.

HSE design reviews are often international affairs with design engineers and client personnel meeting for the first time. Some review attendees may have had no involvement with the project prior to the review. The temptation is then for the review to become a forum for design discussions and the review chair may then struggle to make progress with the review.

Some attendees bring their own agendas to the review, distracting the team from performing a balanced assessment. Reviews can also be multicultural events and some awareness of this is required for the review to be effective. For example, in some cultures it is impolite to say 'No' so instead a question may be answered in a very indirect manner and it is important that those in the review team understand these cultural differences or the meaning will be misinterpreted. The corporate hierarchy and the relationship between worker and manager varies around the world and the review chair needs to be sufficiently perceptive to detect when a review is being influenced by individuals not in the room.

The different background and roles of attendees may influence what each attendee wants from a review. For example, HAZOP reviews consider the operability of the plant under review and important input into the review comes from plant operations personnel attending the review. Operations personnel have an insight into plant operation that few design engineers can match, but some operations staff come with a shopping list of their own personal preferences that are not aligned with the project's design standards. The review team must be careful to ensure that individuals' personnel preferences do not unduly influence plant design. Few clients want a gold-plated design.

Tie-ins are difficult. When reviewing tie-ins to existing plant, it is important to assess how much of the existing plant may be impacted by a process deviation within the new plant, and vice-versa, and prepare for this by obtaining the relevant documentation beforehand and allocating enough time in the review schedule. Drawings for the existing plant may not exist or may be of such poor quality that new drawings are required.

HAZOP reviews may be conducted for continuous or batch processes. While continuous process HAZOPs seek to identify hazardous deviations from typically steady-state conditions, batch HAZOPs examine each of the multiple steps in the process sequence. Batch processes are common in certain industries (e.g. pharmaceutical manufacture) but it is important that the review team identify batch processes where they are present elsewhere (e.g. pairs of adsorbent driers within a continuous petrochemical plant). Attempting to capture the different operating phases of batch plant using continuous HAZOP methodology is likely to confuse the review team and result in inadequate review.

Pitfalls with vendor packages and licensor processes

Many projects include licensor processes and vendor packages within the workscope. The following are observations made by Amec Foster Wheeler Design HSE Engineers during the execution of HSE design reviews of vendor packages and licensor processes.

The review of processes containing vendor packages is not straightforward as vendors are typically not chosen until late in the overall project schedule. Until the vendor is known, the vendor package may be considered as a black box preventing a complete HAZOP review of the unit and associated process plant. For an effective review, an appreciation of the potential upstream and downstream process deviations associated with the 'black box' is required and in the first instance the interfaces with the package are reviewed. An engineer with knowledge of the type of vendor package is required for this review. A first HAZOP review covering the process around the black box can then be conducted. It is sometimes helpful to replace the black box with a generic unit to aid the review process. Later in the project, after selection of the package vendor, a second review should be conducted utilising the vendor's drawings and information and with the vendor engineer present.

The strategy for vendor package review and the development of review actions should consider that the ability to modify vendor package designs may be limited especially if they are 'standard'. Modifications to the package may invalidate vendors' guarantees or require recertification of a vendor package. If an HSE design review identifies that additional safeguarding is required then it may be better to install this outside the package than attempting to modify the package itself.

Not all clients want to pay for reviews of vendor packages. Some assume that the vendor design is mature and that the HSE design review will not identify any deficiencies in design. In our experience, HSE design reviews of package equipment almost always result in review actions, suggesting that not all vendors implement continuous product improvement programmes. Neglecting to conduct a vendor package review also misses another opportunity to review the interfaces between a package and the rest of the process.

Projects often also include process units whose design is owned by a technology licensor. The execution of HSE design reviews on projects containing licensor units presents a number of problems. Early reviews may be executed before the licensor has been selected. For these reviews, it is important that the attendees include engineers with knowledge of the technology. Such specialist engineers may be scarce and, unless the project plans ahead, the person may not be available for the review. Even after a licensor has been chosen, the information available to a HSE design review may be limited. The Process Design Package provided by the licensor may not have sufficient level of definition to allow good review. Attendance by the licensor engineer is critical for an effective review. Reviews need also to recognise that opportunities for modifying a licensor process are limited and that major modifications aimed at increasing inherent safety may not be possible.

Action close-out

Successfully completing a review is not enough, the review actions then need to be closed or the review will not have achieved its objectives.

Management of Actions

While some review actions can be implemented almost immediately after a review, others cannot be closed until much later in the project. Any method of tracking action close-out needs to recognise this to be effective: simply circulating lists of actions open for more than three months is not effective if some actions may not be closed for 15 months. The identification and expediting of open actions needs to be done on the basis of required close-out date.

Actions need to be auditable. The recorded response to an action should provide information on how the action was implemented, what documents and drawings were updated and when. Actions also need to be appropriate. Review actions are distributed to the relevant engineers for close-out with the interpretation of the action often left to the individual engineer, especially if he/she was not present in the review. A check is therefore needed that the action close-out is an adequate response to the action. This check may be a review by the project design safety engineer but some projects have more rigorous assurance involving review and sign-off of each action by the client and contractor. The approach should be decided early enough to ensure that adequate resources are in place at the right time.

Transfer of Actions

Typically at the end of each project phase a project passes from one contractor to another. The HSE design reviews conducted to date and the associated review actions, some closed out and some still open, are passed to the next contractor as project documentation. The previous project team and any of their knowledge which is not captured in the documentation is often not transferred. It is therefore important that actions and the description of action close-outs are clearly described so that they may be understood by other persons many months later. Difficult actions can sometimes be neglected and passed to the next project phase where there may be less understanding of the background and the action becomes even harder to close. When the next project phase is a lumpsum project, where the contractor is paid a fixed fee, it is critical that actions are explicit to avoid any opportunity for the contractor to avoid implementing the full extent of outstanding review actions.

Risk-ranking

Risk-ranking is sometimes employed within HSE design reviews and often with a risk register where identified hazards are recorded and risk-ranked (typically before and after the implementation of associated review actions). The steps of the risk-ranking process are typically:

1. Assess the severity of the hazard in terms of the potential impact to personnel safety, damage to the environment, economic cost of loss of production, economic cost of plant damage, and damage to company reputation. Assess this against a magnitude scale to produce a severity score.
2. Assess the probability of the hazardous event. Assess this against a magnitude scale to produce a probability score.
3. Utilising a defined risk matrix that relates risk against differing values of severity and probability, assess the risk ranking.

Risk-ranking and risk registers have certain uses inside and outside the design project environment. In particular, hazards identified with a review (and the effect of any actions intended to reduce risk) can be assessed to determine whether the associated risk is acceptable or if further risk reduction measures are required.

It is sometimes suggested that the close-out of HSE design review actions should be prioritised by risk-ranking. For this to be effective, actions should be assessed and prioritised by their associated project execution risk, i.e. those actions that may result in significant project rework if closed late should be assigned the highest priority. The risk associated with plant operation is less relevant to action close-out on a design project as plant start-up is normally not permitted unless all HSE design review actions are closed.

Management of change

In almost all projects, the design continues to develop after each HSE design review is completed and each design modification threatens to introduce new hazards and invalidate earlier reviews. An effective management of change process is required to safeguard the integrity of the design. Each proposed design change needs to be subjected to review before implementation and where required, a HAZOP team should be reconvened to assess the change. Reconvening the same team may be difficult.

When the project reaches the end of the design phase, a Final Safety Review is required. The purpose of the Final Safety Review is to confirm that all of the project design has been subjected to HSE design review, all design related actions have been closed and all design changes post review have been subjected to a management of change review. This review should include an audit of the project's management of change procedure for assurance that the procedure has been implemented effectively on the project. It is important that any field changes are also subject to review and they occur after a 'Final Safety Review'.

Some of the review actions may be for implementation by the operating company and fall outside the main project scope and some means of transferring these, and the responsibility for their closure, to the operating company will be needed. A record of their transfer is also needed. Even after transfer, it may be prudent to continue to monitor these actions and remind the client of the need to close all actions.

After the project moves into the construction phase, further design changes may be made by the site engineering team and therefore an effective management of change is required to the point of handover to client. If the site team does not have sufficient technical capability and knowledge of earlier project design HSE reviews then continuing support of the management of change process will be required from the original design team to ensure an adequate assessment of the impact of changes.

Finally, before plant start-up is the Pre-Startup Safety Review. It is recommended this review should include another Final Safety Review focussing on the management of change since the earlier 'Final Safety Review' and the close-out of remaining actions relating to start-up and operation.

Conclusions

HSE Design Reviews are an important part of a project and their successful execution requires much effort, skill and experience. In addition to the observation and guidance described above, the following points were identified by Amec Foster Wheeler Design HSE Engineers as fundamental to an effective review:

- The review meeting is the tip of the iceberg: do not forget that more resources are needed for the preparation beforehand, the issuing and updating of review reports and the significant effort in closing-out actions.
- Team composition is key to an effective review: for a good review the knowledge must be in the room.
- There are many different forms of design HSE review. The purpose of the review and the review methodology must be clearly communicated to all attendees.
- Do not change objectives part way through a review. Agree on the purpose and approach to the review before the review starts, and agree on the approach to action close-out.
- HSE design reviews consider the HSE aspects of the design. They are not intended to be design reviews and if they turn into design reviews the effectiveness of their intent is compromised.

Amec Foster Wheeler implements many of the good practices listed above through the development and use of its own engineering procedures. These include:

- A procedure defining the requirements for engineering reviews at each project phase.
- Procedures for each type of engineering review. For example, a procedure for HAZOP addressing requirements for attendees, team members' roles and responsibilities, methodology for batch and continuous reviews, and action close-out.
- Procedures for the management of change during the design, construction and commissioning phases, including Final Safety Review and Pre-Startup Safety Review.

The use of procedures ensures that current best practice is followed and allows for the continuous review and development of work practices. Knowledge gained can be captured, encouraging better project execution and safer plant design.