FEATURE

MANAGING MAJOR ACCIDENT HAZARDS THROUGH SCE MANAGEMENT PROCESS

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Most operating plants are classified as hazardous installations due to the handling of large quantities of flammable, explosive and toxic substances on site. The quantities are estimated to be above specified threshold values as according to the Occupational Safety & Health Act 1994, Control of Industrial Major Accident Hazards (CIMAH) Regulations, 1996.

The safety report shall demonstrate to the Department of Occupational Safety & Health (DOSH) that, as an operator of all hazardous facilities, operating units apply strict measures to manage major accident hazards.

Process safety incident and other major accident hazard (MAH) prevention and mitigation require both management and engineering approaches, right from design to operations and maintenance throughout the plant life-cycle. The two keys are managing soft and hard barriers. Soft barriers are managing process safety information, engineering changes, permit to work and safe operating while hard barriers are safety critical elements (SCEs). Here, we will discuss hard barrier or SCEs management process.

The initial processes are identification and establishment of hazard via a Hazard Identification Study (HAZID) and Hazard & Operability Study (HAZOP). SCEs are identified by analysing the hazards, and constitute the means required to manage the associated risks.

The SCE management process has four main stages:

1. Identification of major accident hazards.
2. Identification of safety critical elements involved in managing major accident hazards.
3. Identification of performance standards and assurance processes that ensure the continued suitability of the safety critical elements.
4. Verification that all stages have been undertaken, non-conformances have been identified, controlled and closed-out and hence, major accident hazards are being controlled.

Through the diligent application of these stages, it is possible to meet the requirements for MAH and SCE management process, offering a better way to control risk.

MAJOR ACCIDENT HAZARD

Major Accident Hazard (MAH) is a typical hazard that can lead to a low probability and high consequence event which requires a different approach from the occupational, or personal, safety management processes/programme. The basic reason for this is that while single failures can cause dangerous occurrences, major accidents do not generally happen as a result of failure of one piece of equipment or one wrong action by an individual. Instead, they are epitomised by a series of failures of plant, personnel functions & processes as well as procedures.

The key safety plant, systems and equipment required to manage MAH are known collectively as SCEs. The concept of SCEs is perhaps easier to understand if they are considered as barriers between the hazard and the consequence of the incident.

METHODS

MAHs are established from a Hazard Identification Study as well as Hazard and Operability Study (HAZOP). SCEs are identified by analysing these hazards and constitute the means required to manage the associated risks. The concept of Safety Critical Elements is perhaps made easier to understand if they are hard barriers between the hazard and the consequence of the incident.

In a major accident hazard, each barrier type is represented by one or more SCEs and is designed to stop and minimise the effects of a hazard. The concept of barriers is widely recognised and applied for the MAH and SCE management process. The barrier types to be used are as follows:

- Structural integrity
- Process containment
- Ignition control
- Protection systems
- Detection systems
- Shutdown systems
- Emergency response
- Life saving

Asset shall use these barrier types to indicate and group together the SCEs identified for that particular asset.

For example, in the event of a hydrocarbon gas release (i.e. process containment barrier failing), the ignition control barrier should work to prevent a major accident. Even the

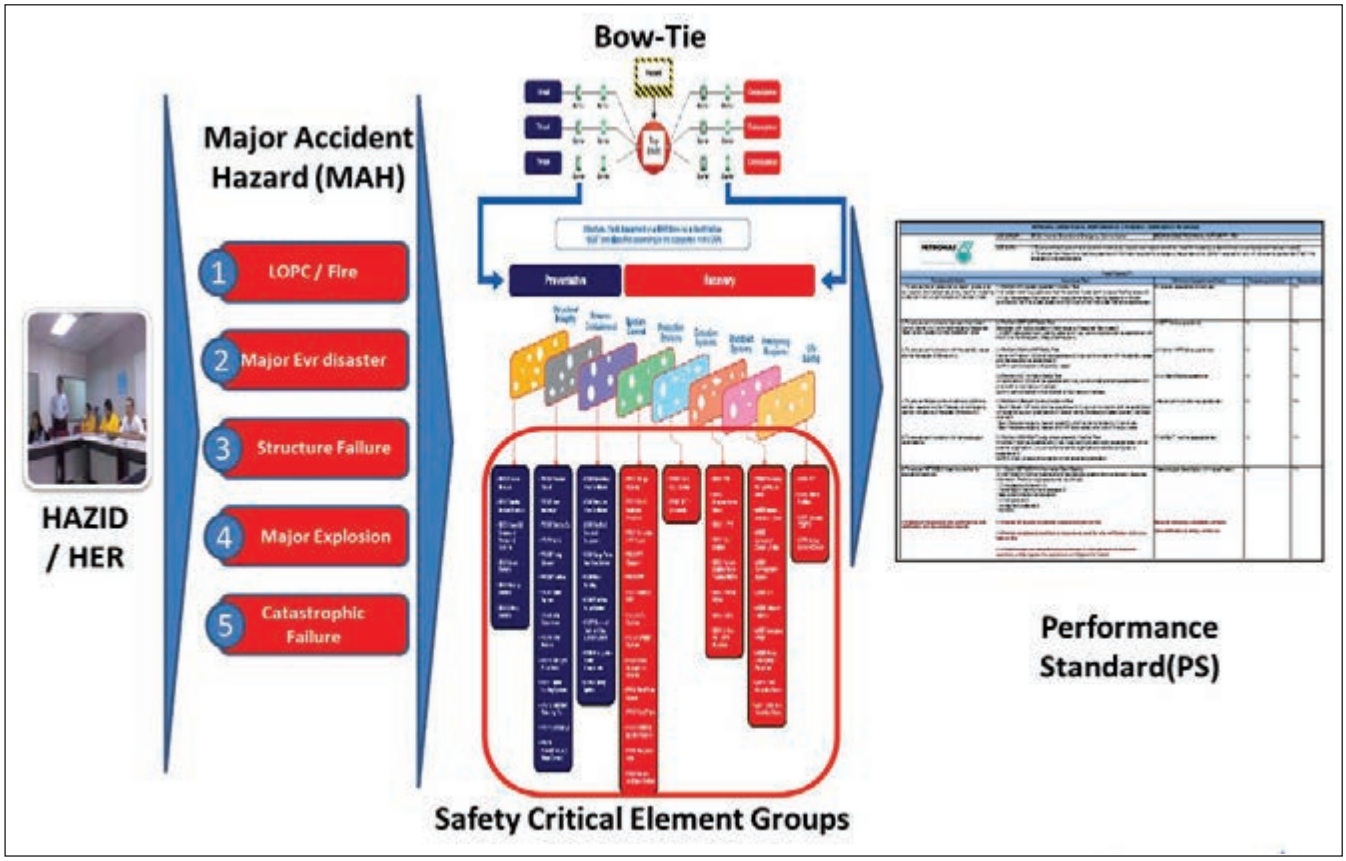

Figure 1: General overview of major accident hazard and safety critical element groups

occurrence of multiple barrier failures, such as process containment and detection systems, will not necessarily lead to a major accident if subsequent barriers such as mitigation (e.g. protection systems and shutdown systems) do not fail. However, a loss of process containment involving toxic gas can lead to a major accident event without other barrier fails should it is manned at that particular time.

Good barrier performance can be achieved through the adoption of well-written performance standards as well as assurance & verification procedures. These procedures must be adhered to by personnel who are competent in their defined roles in maintaining and assuring the performance of SCEs for a specific asset.

MAH IDENTIFICATION

This requirement for explicit identification of the MAH and SCEs as a separate sub-set of the asset risks is a characteristic of the MAH and SCEs management process, as it deals specifically with the management of low frequency but high consequence hazards.

Taking the framework of the safety case developed, the MAH (and subsequently, SCEs) are listed in the dedicated subsection for an asset, called Hazard Effect Register. In both cases, this dedicated subsection is required to identify and quantify the MAH and the means of managing these hazards through the subsequent utilisation of SCEs.

The severity of accidents is given in HSE Risk Ranking Matrix (RRM) as shown in Figure 3. Major accidents are defined as any incident with a severity level of 5 as well as scenarios considered to be more likely, but with a severity level 3 or 4, i.e. E4, D4 and E3 (see Figure 2, Typical Risk Matrix).

The above definition of MAH deliberately excludes occupational hazards. MAH is identified through the use of systematic identification processes, such as HAZID studies and quantified through techniques such as Quantitative Risk Assessment (QRA). To follow best established industry practice, it is necessary to both identify and quantify MAH. The MAH should be identified in a specific subsection of the safety case together with the means used to prevent, detect, control, mitigate, rescue or help recover from a major accident (which effectively become the SCEs).

IDENTIFICATION OF SCE FOR GIVEN MAH

Once the potential SCEs have been identified, the procedure starts at the top left-hand corner of the flowchart (Figure 3). The flow process shown in the diagram relates to both process as well as non-process systems.

The rationale for excluding any SCE shall be properly documented and approved at the appropriate level. All SCEs are to be registered in the asset register system and shall be periodically reviewed to ensure completeness and adequacy.

The petrochemical industry has had its fair share of disasters. As a result, most countries require some form of safety management for their plants. The Bow-Tie Model or

IMPACT		Severity	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
		People	Slight Injury	Minor Injury	Major Injury	Single Fatality	Multiple Fatalities
		Asset	Slight Damage	Minor Damage	Local Damage	Major Damage	Extensive Damage
		Environment	Slight Impact	Minor Impact	Localised Impact	Major Impact	Massive Impact
		Reputation	Slight Impact	Limited Impact	Considerable Impact	Major National Impact	Major International Impact
LIKELIHOOD	**E Almost Certain**	Happens several times per year at location	**E1**	**E2**	**E3**	**E4**	**E5**
	D Likely	Happens several times per year in company	**D1**	**D2**	**D3**	**D4**	**D5**
	C Possible	Incident has occurred in our company	**C1**	**C2**	**C3**	**C4**	**C5**
	B Unlikely	Heard of incident in industry	**B1**	**B2**	**B3**	**B4**	**B5**
	A Remotely likely to happen	Never heard of in industry	**A1**	**A2**	**A3**	**A4**	**A5**

Figure 2: Typical Risk Ranking Matrix

Bow-Tie Analysis is considered as the most comprehensive way for identification of SCEs associated with a given hazard.

THE BOW-TIE MODEL

The Bow-Tie Analysis or method is simply a pictorial representation of how the management of a hazard and its effects go towards minimising the consequence(s) arising from a hazardous event. The Bow-Tie model (see Figure 4) was developed to meet the requirements for risk assessment while integrating the understanding of how accidents happen, based on the Swiss cheese model.

Using the Bow-Tie methodology to identify barriers, essentially enables one to identify specific roles and functions of each barrier and to understand the possible consequence of the failure of a barrier.

LIMITATION OF BOW-TIES

Bow-Ties are not the panacea for all risk management problems. If one wants to quantify the level of risk in absolute terms, then the Bow-Tie method will not help directly. To model complex inter-relationships between risk controls, there are better ways than using Bow-Ties. To identify individual safeguards for every line of every section of every unit in a process facility, a HAZOP study is the solution. But to remove the mystique of risk management and to obtain insights into risk controls that are easy to understand and communicate and, at the same time to realise some efficiency gains, there is no better method than the Bow-Tie.

PERFORMANCE STANDARD FOR SCES

The Performance Standard shall include acceptance criteria that the SCEs must be developed in detail to enable the practical verification that all barriers are in place and effective. They are initiated during the asset's define phase and finalised with specific performance requirements and assurance tasks during the execution phase as part of the detailed design.

These are the SCE performance standards to be used and maintained during the operation phase. The performance standards should not be confused with either the design specifications required to establish technical integrity or the preventive maintenance strategy required for the maintenance of equipment, e.g. lubrication. They specifically cover only the specific required to validate that SCEs perform the function necessary for the barrier to be effective.

The development of Performance Standards is an essential stage in the MAH and SCE Management Process. This is because it is necessary to gain confidence that SCEs will fulfil their intended purpose when required. This will be achieved by assessing SCEs against the relevant PS criteria, through assurance and verification activities. All information related to a specific SCE (goal, functionality and specific acceptance criteria) are found in the PS and must be captured by the asset-specific PMMS/SAP system.

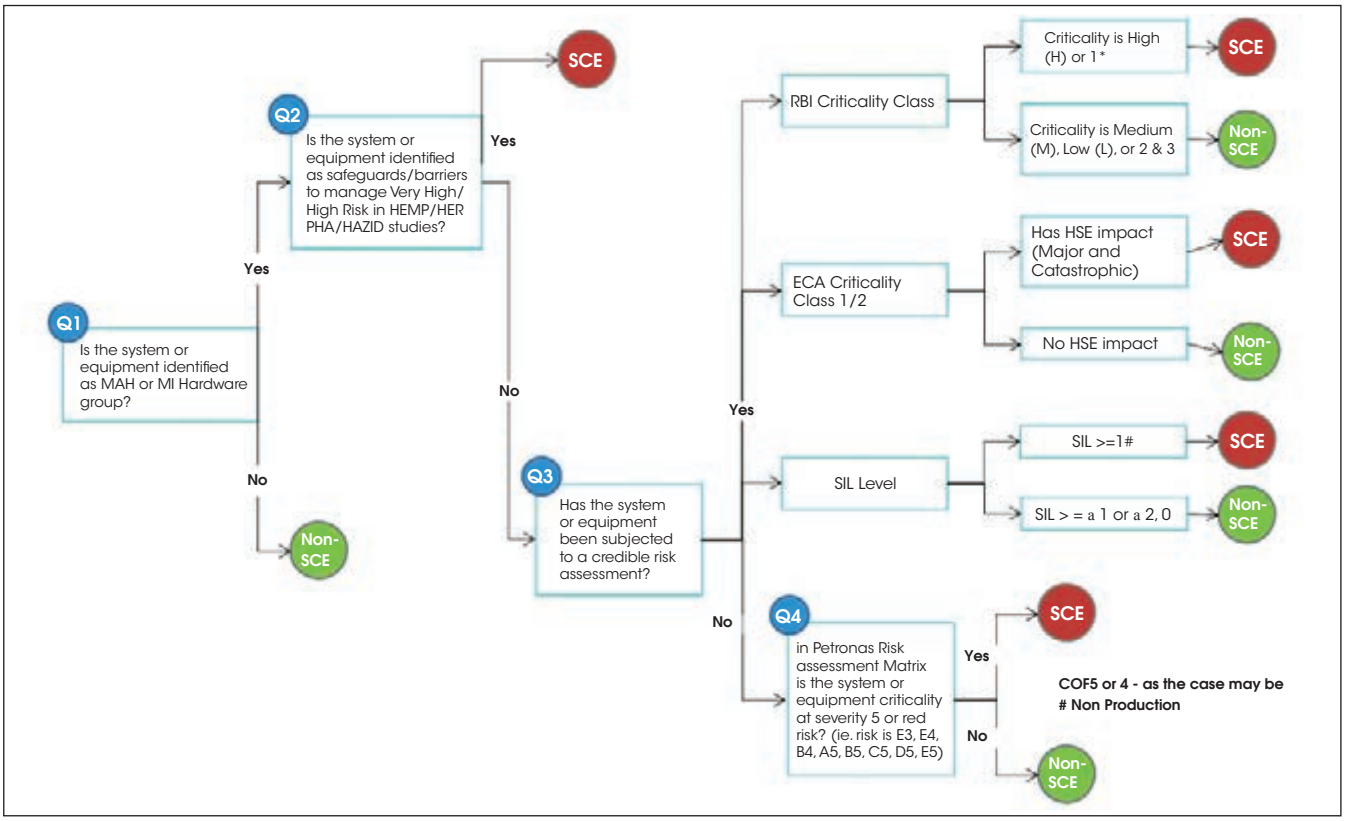

Figure 3: Flowchart for Identifying SCEs

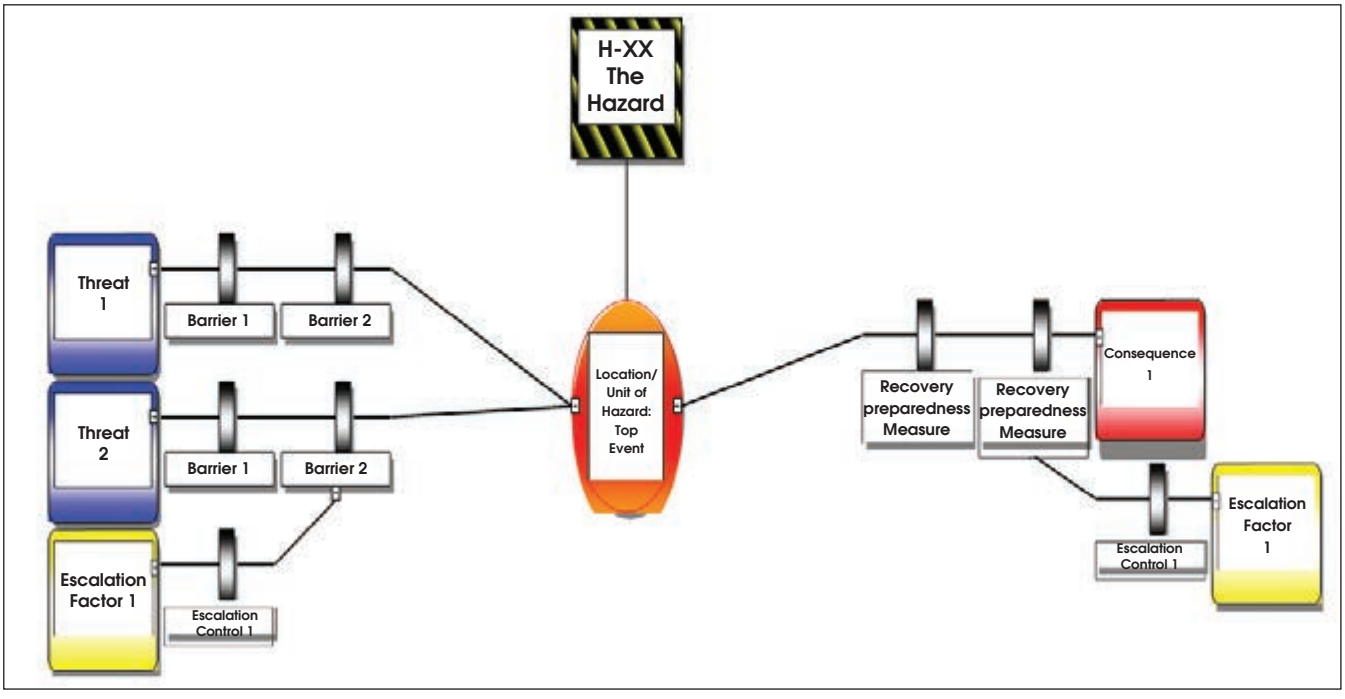

Figure 4: Bow-Tie Diagram

SUMMARY

It is important to note that the MAHs vary in severity and probability throughout the life-cycle of the asset. This means that SCEs might change accordingly. To this end, the MAH and SCEs management processes require a full periodic review. ■

Author's Biodata

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