IChemE

IChemE Safety Centre Guidance

Lead Process Safety Metrics

Supplementary guide – risk-based audit programme

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Preface

This document is a supplement to the ISC guidance document *Lead Process Safety Metrics – selecting tracking and learning,* 2015. This guidance note is intended to provide context for the lead metric 'number of process safety related audits to plan' and 'number of non-conformances found in process safety audits' under the element of assurance and expand on those metrics. This should be used to help identify and establish suitable performance metrics for your system. It is intended to complement existing publications on the areas of metrics and auditing by, for the first time, providing guidance to enable a company to measure the effectiveness of its audit programme. This document is not intended to repeat the basics of how to set up metrics or auditing systems. Examples of these referenced publications include:

Guidelines for Auditing Process Safety Management Systems, CCPS, 2011 [1]
Process Safety Metrics Guide for Leading and Lagging Indicators, CCPS, 2021 [2]

This is the fourth in a series of supplementary guidance documents that will focus on providing more clarity on the type of failures/events to be included in your metrics and will also aid in the goal of capturing similar data across companies and across industries.

This is intended to supplement but not supersede regulatory requirements that may apply. Application of this guide may support demonstration of requirements, but in no way guarantees compliance.

Acknowledgements

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Disclaimer

The information provided in this document is provided in good faith but without liability on the part of IChemE or the IChemE Safety Centre.

Definitions and terminology

Terminology used throughout the document are defined below:

Asset

A discrete element of a business that has a monetary value. Assets include physical plant and equipment. Examples are a refinery or chemical plant, production platform, retail network or project.

Audit

A series of related activities with a beginning and an end to give a considered and referenced opinion on the levels of assurance management can rely upon; alert management on weaknesses identified and advise on area for improvement in an implement process safety management system. It complements management reviews, metrics, asset integrity and conduct of operations.

Audit programme

Arrangements for a set of one or more audits planned for a specific time frame and directed towards a specific purpose.

HIRA

Hazard identification and risk assessment.

How to use this guidance

This guidance helps to identify suitable performance metrics relating to assurance programmes for an organisation.

The benefit of using the right metrics to monitor a company's audit programme is that it may be a more effective process to manage the risks on their facilities than a non-risk-based approach. This is because a risk-based approach has the potential to uncover higher risk levels by focusing on identifying risks associated with the ageing of a facility and its inherent hazards. However, the facility should first confirm suitability of this process within the regulations and laws which affect the operating unit. Any decision on which approach or metrics to use to define the scope and health of an audit programme should be considered carefully to ensure that you can achieve the desired output.

These metrics have been tested and used in different industries and have been found to provide value and input into decision-making.

Recommended steps on how to implement this guidance:

- **determine the scope for implementation**
  - are the metrics to be applied across an entire organisation or an individual facility?

- **map your current leading metrics to the list in** Table 1
  - you may find you are already recording some of these metrics, or very similar ones

- **determine any gaps between your current metrics and the metrics outlined in** Table 1

- **where gaps are identified, determine if you have other metrics to cover them**
  - where you have metrics covering the gaps, and they are useful, continue to record them
  - if the metrics covering the gaps are not useful, consider adopting the metrics in this guidance
  - ensure that you have a comprehensive picture of the health of your barriers with the metrics that you are recording

- **develop an action plan to address the gaps identified**
  - review the implementation section of each metric to see how challenges can be overcome

Note: barriers refer to those controls that are put in place to prevent or mitigate a major incident.

Scope of the document

The scope of the document is to suggest lead process safety metrics associated with audits that can be implemented to help monitor and improve the audit programme in place. The document can also assist in developing an audit programme, considering the metrics proposed.

For the application of the guidance document, it is assumed that a process safety management framework is in place (eg there is something to audit). The scope of process safety is defined by the company in the context of its risk appetite and operations.

Activities undertaken in development of this publication were:

- **develop guidance for organisations to achieve consistency of the quality of risk-based audit programmes to ensure that measurement in different companies is consistent;**

- **the goal is to standardise measurement to address the following:**
  – define what makes an audit programme effective in providing assurance. Explore how do we know that audits are uncovering issues and that those issues are being resolved. It covers all metrics as well as how audits are done;
  – demonstrate how to get assurance from the audit process;
  – to align the underlying processes and performance standards.

To achieve these activities the working group considered the following levels of audits, which may be varied across industries:

- **1st level – monitoring – site level assurance;**

- **2nd level – internal audit – group level audit/head office;**

- **3rd level – external/independent audit – for example higher level audit such as insurance audits, third party (regulatory) audits, head office audits/corporate, audits from other asset owners.**

Note:

- **monitoring is an important aspect of the audit programme even though it is not traditionally called audit, but a daily log completed by a supervisor;**

- **regulatory inspections are not within the scope of the guidance document; therefore, those are excluded.**

Purpose of an audit programme

This section provides the background underpinning the suggested metrics in Table 1.

The purpose of an audit programme is to undertake a series of related activities with a beginning and an end at a point in time to give a considered and referenced opinion on the level of assurance management can rely upon; alert management on weaknesses identified and advise on areas for improvement in meeting the process safety management system requirements. It complements management reviews, metrics, asset integrity and conduct of operations.

To assist in defining your audit objectives, it is useful to use questions to scope the audit:

- where are the key risks?

- do we do what we say/declare we do?

- do we do what we should do?

- do we know which controls are implemented and how effective they are?

- outcome of the audit programme – can we capture it?
  eg is it just compliance – in other words do we do what we say we do? Cost-related issues or if it is an improvement audit in other words do we do what we should do – needs to set aside budget to deal with that gap.

Audits can be carried out for several reasons:

- to meet external requirements (eg Occupational Safety and Health Administration Process Safety Management (OSHA PSM);

- to meet requirements mandated by internal standards and procedures (eg demonstration of As Low As Reasonably Practicable (ALARP);

- to meet local business needs for assurance on specific risks (eg theme audit on competence).

When developing an audit programme consider developing an integrated plan that includes the various levels of audit and the sources of input that will be used to help inform the audit plan (eg key risks, incident trends, input from the safety discipline).

In addition, when developing an audit programme, consider the value of the different audits and how to use the information they provide; understand the findings and how to prioritise and close the resulting actions which are appropriate to the risk and the control required.

The fundamental questions concerning audits are:

- why do we audit? Who should do the audit and are they competent?

- results – how do we use that information?

- how do we prioritise closing the actions (eg impact on major accident hazards, elimination of hazards, reduction in frequency of events or improving business resilience)? How long does it take to close actions?

- try to understand the findings – to improve and how to magnify the improvement.

Phases of an audit programme

This section discusses the different audit phases typically applied worldwide. It is provided as background underpinning the suggested metrics in Table 1.

Prior to undertaking an audit, the facility should already understand its major risks and how the operation is controlled. This is done via conducting appropriate Hazard Identification and Risk Assessment (HIRA) processes. Once these are understood, the facility should already have the metrics in place which evaluate the health of the identified critical control measures and systems. Once these processes are in place then an audit can take place, to ensure that the major risks are understood and controlled. If these elements have not yet been undertaken adequately then an audit is unlikely to be as effective at managing major risks. These relationships are shown diagrammatically in Figure 1.
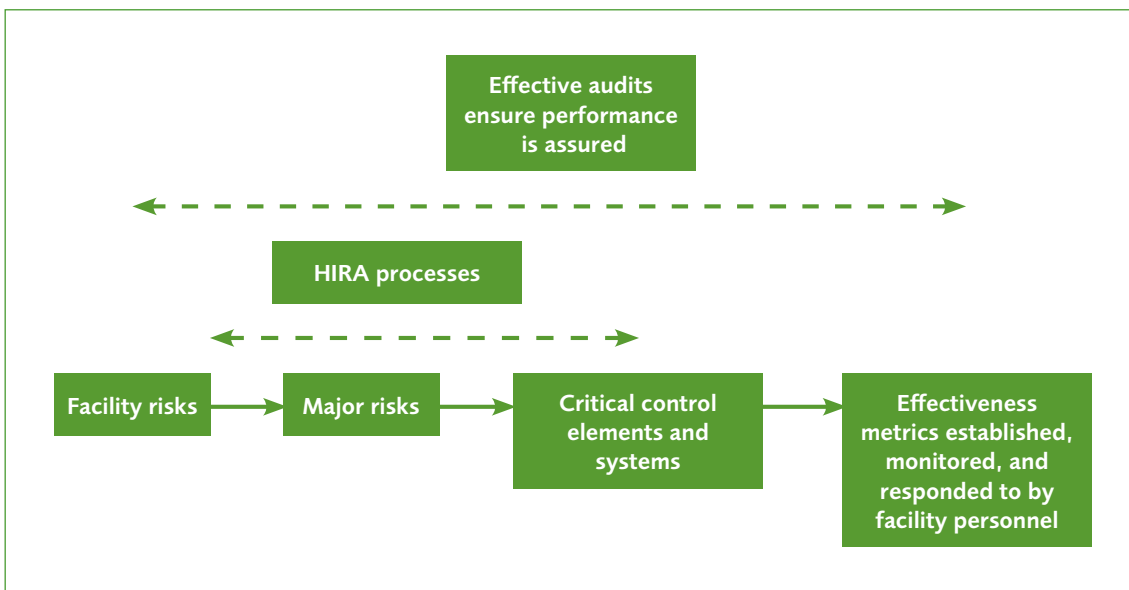
Figure 1: Relationship of effective audits to understanding of major risks at an asset.

The typical phases of the audit programme considered for the purposes of this guidance document are the following:

- ■ audit planning and preparation;
- ■ Hazard Identification and Risk Assessment (HIRA);
- ■ execution;
- ■ verify – compliance audits.

Table 1 will provide the metrics associated with these phases.

Appendix shows elements of an audit programme.

Purpose of the suggested metrics

Metrics are performance indicators designed to show progress toward an intended result. Leading metrics are a form of active monitoring focused on a few critical risk control systems to ensure their continued effectiveness. They require a routine systematic check that key actions or activities are undertaken as intended. Metrics can be considered as measures of process or inputs essential to delivering the desired safety outcome.

Note: it can often be found that key performance indicators commonly used in the industry are really checklists for auditing the quality of the audit as opposed to checking the effectiveness of the audit programme.

For example:

- **audit** – the structured process of collecting independent information on how well the safety management system is performing;

- **measurement, monitoring, and checks** – the collection of information about implementation and effectiveness of plans and standards.

Metrics should also be used to look for trends in data over both long and short time periods and to compare year on year data. They should be reviewed by management at regular intervals.

Although audits adopt a sampling approach, there should be a consistency in findings between all levels of audit. It is also important to have competent auditors at all levels. If there are inconsistencies, then these shall be reviewed. This may highlight that a particular level of audit not focusing on the facility's current major risks. This could present an opportunity to refocus the various audit levels, to managing the risk most effectively and consistently.

From a process safety viewpoint (catastrophic incidents), confidence requires that checks (audits) are being done on the critical controls identified, that issues identified are being addressed, that there is a longer-term review process in place that looks at trends across multiple audits to seek information about weaknesses in the system.

Table 1 – Suggested metrics

Elements of the audit programme	Purpose	Critical aspects/challenges	Relevant metrics
Audit planning and preparation	Ensure appropriate risks are subject to audit	Limited time and resources mean you cannot audit everything Board and senior management want targeted information	% of critical risks are audited to the required frequency
	Ensure appropriate controls are subject to audit	Limited time and resources mean you cannot audit everything Board and senior management want targeted information	% of critical controls (safety critical equipment, critical procedure documents) audited to the required frequency
	Ensure stakeholders are given sufficient time and notice to complete the preparation	Whilst 'snap' audits have their place, audits are more efficient if sufficient time is allowed for data request and review prior to field work	Stakeholders are given sufficient time and notice to complete the preparation
	Ensure availability of key staff to participate in an audit	Identify key personnel that will be interviewed or asked to respond to auditors' enquiries to ensure they are available	% of key pre-identified staff attending the audit
	Audit completion on time	Audits are effective if the report is accepted by management in a timely manner. Drawn out audit acceptance can be a sign of poor audit (eg it was not factually correct or is not properly written) or poor culture of accepting adverse findings	% of audit reports accepted by management in the required time frame
	Ensure process safety auditor competency	Less than competent process safety auditor would result in failure to achieve a successful audit	Sufficient number of competent process safety auditors versus total number of process safety auditors (Number of process safety audit roles assessed as competent refers to a formal assessment process against predefined competency requirement which will involve knowledge on unit/facility, training, certification, prior auditing experience, etc) Note: an auditor without prior auditing experience is sometimes included in the audit team as a member and to develop competency in the auditing process
	Ensure setting audit frequency based on facility major hazard profile and process safety performance (incidents, near misses and KPIs)	Auditing at a less frequency or delaying of audit would impact on audit ineffectiveness Conversely, frequent auditing would result in greater audit load and operational challenges as key operating personnel may remain busy in auditing process and lose site supervision	% of compliance on number of process safety audits executed versus number of audits planned in a given duration Target conformance (towards 100%) This indicates senior management commitment to the audit process

Hazard identification and risk assessment (HIRA)	Ensure major accident hazards and safety barriers (plant, process and people) are covered in the audit process – subset of *Ensure appropriate controls are subject to audit*	Difference in methodologies Quality of assessment Is the technique/methodology suitable? Competency of facilitator End user competency Does the process have added value? Weakness in a safety barrier could potentially result in a catastrophic hazardous scenario. Hence safety barrier effectiveness is key to hazard control	Number of HIRAs that are overdue % of revalidations that require the study to be redone Number of qualified facilitators Number of recommendations per study per year Number of recommendations unresolved and/or extended beyond original execution date % of repeat recommendations Suitable techniques/methodologies used
Execution	Elements such as paperwork, talking to people, interviews, check the bigger systems eg management of change, go through incident investigations, check measurements etc	Does the audit include learning from process safety incident or near-miss reported in other units in a facility or in a different facility belonging to the same owner or any other similar units/facilities elsewhere in the world? Note: there may be higher number of near misses or incidents reported in a particular unit or facility compared to other similar unit/facility which is dependent on unit/site safety performance Though near misses or process safety incidents are lagging indicators for the facility where the incident took place, it could be a leading indicator for other similar units/facilities	Absolute number of repeated barrier/critical controls failures resulting in near misses/incidents reported at a given site and % of such items covered in the audit process Absolute number of multiple occurrences eg repeated observations of non-compliances flagged out in various audits (target conformance towards 100%)
Verify – compliance audits	To give a considered and referenced opinion on the level of assurance management/ leadership can rely upon; alert management/leadership on weaknesses identified and advise on area for improvement in an implemented process safety management system	Criticality based on the risk profile of the asset	% of near misses and incident investigations that identified management system weaknesses that could have been detected by prior audits but were not % of audits completed on schedule % of audits having few significant findings Number of previous audits conducted by each audit team member Number of days overdue for open findings % of unresolved audit findings with no meaningful action assigned % of repeat audit findings Trends in the number of significant findings % of recommendations that are implemented/appropriately resolved

References

1. *Guidelines for Auditing Process Safety Management Systems*, CCPS, 2011

2. *Process Safety Metrics Guide for Leading and Lagging Indicators*, CCPS, 2021

3. *Guidelines for Auditing Management Systems*, ISO 19011, 2018

4. IChemE Safety Centre, *Lead Process Safety Metrics – selecting, tracking and learning*, ISC, 2015

5. IChemE Safety Centre, *Safety Lore No 13 Learning from major incidents related to audits*, ISC, 2021

6. *Guidelines for Risk Based Process Safety*, CCPS, 2007
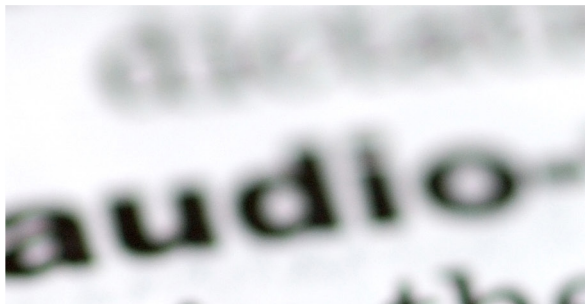
Appendix

Elements of an audit programme to be considered

Process safety risks for a given asset are identified through various risk assessment methods, which can be qualitative such as HAZOP, HAZID, HIRA, etc or quantitative such as QRA, FERA, etc. This is based on the underlying concept of risk which is a function of severity and probability. Capture prioritisation – from high risks to lower ones and that would correlate with the metrics identified/proposed.

Various critical aspects of process safety which are relevant through the entire asset lifecycle are indicated below:

■ **availability and quality of key practices and engineering documents**

Adequate process safety management is based on clear instructions and procedures. They should be based on reliable and up to date technical information. Availability of basis of design, P&IDs, cause/effect diagrams, safe operating limits, etc, allow auditors to verify that the staff have adequate information to manage risk controls and help effectively in the decision-making process.

■ **effectiveness of safety barriers/safety critical element**

Safety studies are executed during the site design and development stage and accordingly, necessary preventive and mitigative barriers are incorporated in the design to bring the risk down to tolerable (ALARP) or acceptable. Maintenance of safety barriers to deliver the desired performance is as important as designing them. Often, it is noted that these safety barriers although designed and installed are not maintained properly, resulting in failure upon demand. Examples could be failure of a safety instrumented function upon demand or failure of a pressure safety valve upon demand.

Eg Bhopal incident (release of toxic MIC) 1984, Buncefield, 2005.

■ **effective management of change (MoC)**

Changes to the original plant design is suggested from reliability, maintainability and/or operability point of view. These changes, if not assessed through a proper hazard/risk assessment under MoC procedure, could potentially result in a major hazard scenario.

■ **procedural controls (start-up/shutdown/permit to work system)**

Start-up/shutdown are the critical phases of a plant. Unless managed properly, this may result in a potential hazardous scenario such as the Texas City isomerisation unit fire and explosion, 2005.

Also, strict adherence to permit to work system is a must to manage the hazard effectively. Eg Piper Alpha, 1988.

■ **human factors (communication, training, fatigue management)**

Human factor related issues are dominating contributing factors to hazardous scenarios. Non-experienced staff, operator fatigue, communication gaps between day and night shift operators and supervisors and operators etc are some of the bad examples which are causes for various incidents.

Eg Texas City refinery incident, 2005
    Piper Alpha disaster, 1988
    Bayer Corp science explosion, 2008

The above list is not exhaustive. There could be several other causes which contribute to a major incident.

In order to render the process safety audit effective, audit scope/Terms of Reference should cover all the elements. At times audit is targeted towards one particular aspect, which is generally triggered from a safety incident that happened at the site under consideration. However, as it becomes obvious from various incident investigation reports, there can be several root causes to a particular incident. Similarly, audit should bring in a multi-dimensional approach. Therefore, it is absolutely essential that the audit scope is developed keeping in view of hazard from facility, process operation, previous incident histories at the site and select the targeted area of audit accordingly to provide the desired outcome. Best practices from similar process industries could be used as benchmarking.

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