



Guidelines for

**Integrating
Management
Systems
and Metrics
to Improve
Process Safety
Performance**

GUIDELINES FOR INTEGRATING MANAGEMENT SYSTEMS AND METRICS TO IMPROVE PROCESS SAFETY PERFORMANCE

Center for Chemical Process Safety
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GUIDELINES FOR INTEGRATING MANAGEMENT SYSTEMS AND METRICS TO IMPROVE PROCESS SAFETY PERFORMANCE

This book is one in a series of process safety guidelines and concept books published by the Center for Chemical Process Safety (CCPS). Please go to www.wiley.com/go/ccps for a full list of titles in this series.

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ACRONYMS AND ABBREVIATIONS

ACC	American Chemistry Council
AFPM	American Fuel & Petroleum Manufacturers
AIChE	American Institute of Chemical Engineers
ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
BPCS	Basic Process Control System
CCPS	Center for Chemical Process Safety
CFR	Code of Federal Regulations
COMAH	UK HSE Control of Major Accident Hazards
CPI	Chemical Process Industries
CSB	U.S. Chemical Safety Board
EPA	U.S. Environmental Protection Agency
EU	European Union
ISO	International Organization for Standardization
OD	Operational Discipline
OECD	Organisation for Economic Co-operation and Development
OSHA	U.S. Occupational Safety and Health Administration
PSM	Process Safety Management
RAGAGEP	Recognized and Generally Accepted Good Engineering Practices
RBPS	Risk Based Process Safety
RC	Responsible Care®
RMP	Risk Management Program
SHEQ&S	Safety (process safety), Health (occupational safety and health), Environmental, Quality, and Security
UK	United Kingdom
UK HSE	UK Health and Safety Executive
U.S.	United States

GLOSSARY

This Glossary is current at the time of publication. Please access the CCPS website for the latest Glossary.

Accident Prevention Pillar	A group of mutually supporting RBPS elements. The RBPS management system is composed of four accident prevention pillars: (1) commit to process safety, (2) understand hazards and risk, (3) manage risk, and (4) learn from experience.
Administrative Control	Procedures that will hold human and/or equipment performance within established limits.
Barrier	Anything used to control, prevent, or impede energy flows. Includes engineering (physical, equipment design) and administrative (procedures and work processes). See also Layer of Protection.
Basic Process Control System (BPCS)	A system that responds to input signals from the process and its associated equipment, other programmable systems, and/or from an operator, and generates output signals causing the process and its associated equipment to operate in the desired manner and within normal production limits.
Bow Tie	A diagram for visualizing the types of preventive and mitigative barriers which can be used to manage risk. These barriers are drawn with the threats on the left, the unwanted event at the center, and the consequences on the right, representing the flow of the hazardous materials or energies through its barriers to its destination. The hazards or threats can be proactively addressed on the left with specific barriers (safeguards, layers of protection) to help prevent a hazardous event from occurring; barriers reacting to the event to help reduce the event's consequences are shown on the right.

Consequence	The direct, undesirable result of an accident sequence usually involving a fire, explosion, or release of toxic material. Consequence descriptions may be qualitative or quantitative estimates of the effects of an accident.
Consequence Analysis	The analysis of the expected effects of incident outcome cases, independent of frequency or probability.
Containment	A system condition in which under no condition reactants or products are exchanged between the chemical system and its environment.
Engineered Control	A specific hardware or software system designed to maintain a process within safe operating limits, to safely shut it down in the event of a process upset, or to reduce human exposure to the effects of an upset.
Environmental Group	In context of this guideline, the environmental group manages the air, water and land permits, including hazardous waste storage and disposal.
Equipment	A piece of hardware which can be defined in terms of mechanical, electrical or instrumentation components contained within its boundaries.
Equipment Reliability	The probability that, when operating under stated environment conditions, process equipment will perform its intended function adequately for a specified exposure period.
Event	An occurrence involving a process that is caused by equipment performance or human action or by an occurrence external to the process.
Explosion	A release of energy that causes a pressure discontinuity or blast wave.
Explosive	A chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature. (OSHA 1994)
Facility	The physical location where the management system activity is performed. In early life-cycle stages, a facility may be the company's central research laboratory or the engineering offices of a technology vendor. In later stages, the facility may be a typical chemical plant, storage terminal, distribution center, or corporate office. Site is used synonymously with facility when describing RMP audit criteria.
Failure	An unacceptable difference between expected and observed performance.
Fire	A combustion reaction accompanied by the evolution of heat, light and flame.

Fire Protection	Methods of providing for fire control or fire extinguishment. (NFPA 850)
Flammable	A gas that can burn with a flame if mixed with a gaseous oxidizer such as air or chlorine and then ignited. The term “flammable gas” includes vapors from flammable or combustible liquids above their flash points.
Frequency	Number of occurrences of an event per unit time (e.g., 1 event in 1000 yrs. = 1×10^{-3} events/yr.).
Hazard	An inherent chemical or physical characteristic that has the potential for causing damage to people, property, or the environment. In this document it is the combination of a hazardous material, an operating environment, and certain unplanned events that could result in an accident.
Hazard Analysis	The identification of undesired events that lead to the materialization of a hazard, the analysis of the mechanisms by which these undesired events could occur, and usually the estimation of the consequences.
Hazard Evaluation	Identification of individual hazards of a system, determination of the mechanisms by which they could give rise to undesired events, and evaluation of the consequences of these events on health (including public health), environment, and property. Uses qualitative techniques to pinpoint weaknesses in the design and operation of facilities that could lead to incidents.
Hazardous Material	In a broad sense, any substance or mixture of substances having properties capable of producing adverse effects to the health or safety of human beings or the environment. Material presenting dangers beyond the fire problems relating to flash point and boiling point. These dangers may arise from, but are not limited to, toxicity, reactivity, instability, or corrosivity.
Health Group	In context of this guideline, the group administering the Occupational Safety and Health programs.
Incident	An event, or series of events, resulting in one or more undesirable consequences, such as harm to people, damage to the environment, or asset/business losses. Such events include fires, explosions, releases of toxic or otherwise harmful substances, and so forth.
Independent Protection Layer (IPL)	A device, system, or action that is capable of preventing a postulated accident sequence from proceeding to a defined, undesirable endpoint. An IPL is independent of the event that initiated the accident sequence and independent of any other IPLs. IPLs are normally identified during layer of protection analyses.

Layer of Protection	A device, system, or action, supported by a management system that is capable of preventing an initiating event from propagating to a specific loss event or impact.
Layer of Protection Analysis (LOPA)	An approach that analyzes one incident scenario (cause-consequence pair) at a time, using predefined values for the initiating event frequency, independent protection layer failure probabilities, and consequence severity, in order to compare a scenario risk estimate to risk criteria for determining where additional risk reduction or more detailed analysis is needed. Scenarios are identified elsewhere, typically using a scenario-based hazard evaluation procedure such as a HAZOP Study.
Likelihood	A measure of the expected probability or frequency of occurrence of an event. This may be expressed as an event frequency (e.g., events per year), a probability of occurrence during a time interval (e.g., annual probability) or a conditional probability (e.g., probability of occurrence, given that a precursor event has occurred).
Mitigation	Lessening the risk of an accident event sequence by acting on the source in a preventive way by reducing the likelihood of occurrence of the event, or in a protective way by reducing the magnitude of the event and/or the exposure of local persons or property.
Normal Process	Any process operations intended to be performed between startup and shutdown to support continued operations within the safe upper and lower operating limits.
Occupational Safety and Health	In context of this guideline, the discipline that focuses on the prevention and mitigation of adverse health effects on people working with hazardous materials and energies, such as industrial hygiene and personal protective equipment. This discipline also addresses safe work practices, such as confined space entry, electrical energy isolation, line breaks and fall protection. (Compare to the process safety discipline).
Quality Group	In context of this guideline, the group in an organization that monitors the quality of the product, including such management systems as ISO 9000, and ensuring customer relations.
Pillar	See Accident Prevention Pillar
Prevention	The process of eliminating or preventing the hazards or risks associated with a particular activity. Prevention is sometimes used to describe actions taken in advance to reduce the likelihood of an undesired event.

Process Safety	A disciplined framework for managing the integrity of operating systems and processes handling hazardous substances by applying good design principles, engineering, and operating practices. It deals with the prevention and control of incidents that have the potential to release hazardous materials or energy. Such incidents can cause toxic effects, fire, or explosion and could ultimately result in serious injuries, property damage, lost production, and environmental impact.
Process Safety System (PSS)	A process safety system comprises the design, procedures, and hardware intended to operate and maintain the process safely.
Process Safety Management (PSM)	A management system that is focused on prevention of, preparedness for, mitigation of, response to, and restoration from catastrophic releases of chemicals or energy from a process associated with a facility.
Program	A series of actions proposed in order to achieve a certain result.
Reliability	The probability that an item is able to perform a required function under stated conditions for a stated period of time or for a stated demand.
Risk	A measure of human injury, environmental damage, or economic loss in terms of both the incident likelihood and the magnitude of the loss or injury. A simplified version of this relationship expresses risk as the product of the likelihood and the consequences of an incident. (i.e., $\text{Risk} = \text{Consequence} \times \text{Likelihood}$)
Risk Based Process Safety (RBPS)	The Center for Chemical Process Safety's process safety management system approach that uses risk-based strategies and implementation tactics that are commensurate with the risk-based need for process safety activities, availability of resources, and existing process safety culture to design, correct, and improve process safety management activities.
Runaway Reaction	A thermally unstable reaction system which exhibits an uncontrolled accelerating rate of reaction leading to rapid increases in temperature and pressure.
Safeguards or Protective Features	Design features, equipment, procedures, etc. in place to decrease the probability or mitigate the severity of a cause-consequence scenario.
Safety Group	In context of this guideline, the safety group is divided between the process safety and the occupational safety and health disciplines.

Safety Layer	A system or subsystem that is considered adequate to protect against a specific hazard. The safety layer cannot be compromised by the failure of another safety layer, it is totally independent of any other protective layers, may be a non-control alternative (e.g., chemical, mechanical), may be an administrative procedure, may require diverse hardware and software packages, must be approved according to company policy and procedures, must have acceptable reliability, and must meet proper equipment classification.
Safety System	Equipment and/or procedures designed to limit or terminate an incident sequence, thus avoiding a loss event or mitigating its consequences.
Security Group	In context of this guideline, the security group manages and controls access to the facility.
Shutdown	A process by which operations are brought to a safe and non-operating condition.
System	A collection of people, equipment and methods organized to accomplish a set of specific functions.
Toller	A contracted company that manufactures, stores, uses, handles, or transports chemical components of a facility's final products. Sometimes called third party service provider, toll processor, supplier of outside services, external contract manufacturer, contract processor, contract manufacturer, custom chemical manufacturer.
Toxic Hazard	In the context of these guidelines, a measure of the danger posed to living organisms by a toxic agent, determined not only by the toxicity of the agent itself, but also by the means by which it may be introduced into the subject organisms under prevailing conditions.
Toxic Material	A material that, when exposed to living organisms at a specified dose, has the potential to cause injury or death (it is poisonous).
Unstable Material	A material that, in the pure state or as commercially produced, will vigorously polymerize, decompose or condense, become self-reactive, or otherwise undergo a violent chemical change under conditions of shock, pressure, or temperature. (NFPA 704, 2001 edition)

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