GUIDELINES FOR PROCESS SAFETY METRICS

Center for Chemical Process Safety
New York, New York

An AIChE Technology Alliance
Center for Chemical Process Safety

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ITEMS ON THE CD ACCOMPANYING THIS BOOK

• A. Hopkins, Thinking About Process Safety Indicators (reprinted from Safety Science 47 (2009) 460-65 with permission from Elsevier)
• F. Henselwood, Use of Pareto Shape Parameter as a Leading Indicator of Process Safety Performance, Process Safety Progress, February 26, 2009 (reprinted with permission of John Wiley & Sons, Inc.)
• Examples of Safety Metrics Dashboards
• Full Listing of Potential Process Safety Metrics to Consider (Based on Risk Based Process Safety Elements)
ACRONYMS AND ABBREVIATIONS

ACC  American Chemistry Council
AIChE  American Institute of Chemical Engineers
ANI  American Nuclear Insurers
API  American Petroleum Institute
CAPP  Chemical Accident Prevention Program
CCPS  Center for Chemical Process Safety
CFR  Code of Federal Regulations
COMAH  Control of Major Accident Hazards (U.K. HSE Regulation)
CSB  U.S. Chemical Safety and Hazard Investigation Board
EPA  U.S. Environmental Protection Agency
EFCE  European Federation of Chemical Engineering
EU  European Union
FMEA  Failure Modes and Effects Analysis
GEMI  Global Environmental Management Initiative
HIRA  Hazard Identification and Risk Analysis
HSE  Health and Safety Executive (U.K.)
ILO  International Labour Organization
INPO  Institute of Nuclear Power Operations
MI  Mechanical Integrity
MOC  Management of Change
NEP  National Emphasis Program
NGO  Non-Governmental Organization
OECD  Organization for Economic Cooperation and Development
OII  Occupational Injury and Illness
OSHA  U.S. Occupational Safety and Health Administration
P&ID  Piping and Instrumentation Diagram
PHA  Process Hazard Analysis
PSI  Process Safety Incident
PSIC  Process Safety Incidents Count
PSISR  Process Safety Incident Severity Rate
PSM  Process Safety Management (U.S. OSHA Regulation)
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>RAGAGEP</td>
<td>Recognized and Generally Accepted Good Engineering Practice</td>
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<tr>
<td>RBPS</td>
<td>Risk-Based Process Safety</td>
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<tr>
<td>RMP</td>
<td>Risk Management Program; Risk Management Plan</td>
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<tr>
<td>ROP</td>
<td>Reactor Oversight Program (U.S. Nuclear Regulatory Commission)</td>
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<tr>
<td>SAICM</td>
<td>Strategic Approach to International Chemicals Management</td>
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<tr>
<td>SAT</td>
<td>Systematic Approach to Training</td>
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<tr>
<td>TCPA</td>
<td>Toxic Catastrophe and Prevention Act</td>
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<tr>
<td>TQ</td>
<td>Threshold Quantity</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<tr>
<td>VPP</td>
<td>Voluntary Protection Programs (U.S. Occupational Safety and Health Administration)</td>
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<tr>
<td>Term</td>
<td>Definition</td>
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<td>-----------------------------</td>
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<tr>
<td>Asset Integrity</td>
<td>Work activities that help ensure that equipment is properly designed, is installed in accordance with specifications, and remains fit for purpose over its life cycle.</td>
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<tr>
<td>Audit</td>
<td>A systematic, independent review to verify conformance with prescribed standards of care using a well-defined review process to ensure consistency and to allow the auditor to reach defensible findings.</td>
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<tr>
<td>Controls</td>
<td>Engineered mechanisms and administrative policies/procedures implemented to prevent or mitigate incidents.</td>
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<td>Element</td>
<td>Basic division in a process safety management system that correlates to the type of work that must be done (e.g., management of change [MOC]).</td>
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<tr>
<td>Facility</td>
<td>The physical location or site where the management system activity is performed.</td>
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<tr>
<td>Hazard</td>
<td>Chemical or physical conditions that have the potential for causing harm to people, property, or the environment.</td>
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<tr>
<td>Hazard Identification and</td>
<td>A collective term that encompasses all activities involved in identifying hazards and evaluating risk at facilities, throughout their life cycle, to make certain that risks to employees, the public, or the environment are consistently controlled within the organization’s risk tolerance.</td>
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<tr>
<td>Risk Analysis (HIRA)</td>
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<tr>
<td>Incident</td>
<td>An unusual or unexpected event that either resulted in, or had the potential to result in, serious injury to personnel, significant damage to property, adverse environmental impact, or a major interruption of process operations.</td>
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<tr>
<td>Incident Investigation</td>
<td>A systematic approach for determining the causes of an incident and developing recommendations that address the causes to help prevent or mitigate future incidents.</td>
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<tr>
<td>Knowledge (or Process Safety Knowledge)</td>
<td>Knowledge is related to information, which is often associated with policies, and other rule-based facts. It includes work activities to gather, organize, maintain, and provide information to other process safety elements. Process safety knowledge primarily consists of written documents such as hazard information, process technology information, and equipment-specific information.</td>
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<tr>
<td>Lagging Metric</td>
<td>A retrospective set of metrics based on incidents that meet an established threshold of severity.</td>
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<tr>
<td>Leading Metric</td>
<td>A forward-looking set of metrics that indicate the performance of the key work processes, operating discipline, or layers of protection that prevent incidents.</td>
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<tr>
<td>Life Cycle</td>
<td>The stages that a physical process or a management system goes through as it proceeds from birth to death. These stages include conception, design, deployment, acquisition, operation, maintenance, decommissioning, and disposal.</td>
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<tr>
<td>Management of Change (MOC)</td>
<td>A system to identify, review, and approve all modifications to equipment, procedures, raw materials, and processing conditions, other than &quot;replacement in kind,&quot; prior to implementation.</td>
</tr>
<tr>
<td>Management System</td>
<td>A formally established set of activities designed to produce specific results in a consistent manner on a sustainable basis.</td>
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<tr>
<td>Mechanical Integrity</td>
<td>A program that helps ensure that equipment is properly designed, installed in accordance with specifications, and remains fit for purpose over its life cycle. Also, asset integrity.</td>
</tr>
<tr>
<td>Near-Miss Incident</td>
<td>The description of less severe incidents (i.e., below the threshold for inclusion in a lagging metric), or unsafe conditions that activated one or more layers of protection. Although these events are actual events (i.e., a &quot;lagging&quot; metric), they are generally considered to be a good indicator of conditions that could ultimately lead to a severe incident.</td>
</tr>
<tr>
<td>OSHA Process Safety Management (OSHA PSM)</td>
<td>A U.S. regulatory standard that requires use of a 14-element management system to help prevent or mitigate the effects of catastrophic releases of chemicals or energy from processes covered by the regulations (49 C.F.R. §1910.119).</td>
</tr>
<tr>
<td>Procedures</td>
<td>Written step-by-step instructions and associated information (cautions, notes, warnings) that describe how to safely perform a task.</td>
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<td>Term</td>
<td>Definition</td>
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<tr>
<td>Process</td>
<td>A broad term that includes the equipment and technology needed for petrochemical production, including reactors, tanks, piping, boilers, cooling towers, refrigeration systems, etc.</td>
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<tr>
<td>Process Safety</td>
<td>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.</td>
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<tr>
<td>Process Safety Culture</td>
<td>The combination of group values and behaviors that determines the manner in which process safety is managed. A sound process safety culture refers to attitudes and behaviors that support the goal of safer process operations.</td>
</tr>
<tr>
<td>Process Safety Management</td>
<td>The application of management systems to the identification, understanding, and control of process hazards to prevent process-related injuries and incidents; it 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.</td>
</tr>
<tr>
<td>Process Safety Metric</td>
<td>A standard of measurement or indicator of process safety management efficiency or performance.</td>
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<tr>
<td>Reliability</td>
<td>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.</td>
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<tr>
<td>Reliability Analysis</td>
<td>The determination of reliability of a process, system, or equipment.</td>
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<tr>
<td>Risk-Based Process Safety</td>
<td>The CCPS'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.</td>
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<tr>
<td>Safe Operating Limits</td>
<td>Limits established for critical process parameters, such as temperature, pressure, level, flow, or concentration, based on a combination of equipment design limits and the dynamics of the process.</td>
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<td>Safeguard</td>
<td>See Controls.</td>
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<td><strong>Safety Instrumented System</strong></td>
<td>The instrumentation, controls, and interlocks provided for safe operation of the process.</td>
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<td><strong>Six Sigma</strong></td>
<td>A metric for measuring defects and improving quality. Also, a robust business improvement methodology that focuses an organization on customer requirements, process alignment, analytical rigor, and timely execution.</td>
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<td><strong>Stakeholder</strong></td>
<td>Individuals or organizations that can (or believe they can) be affected by the facility’s operations, or that are involved with assisting or monitoring facility operations.</td>
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<tr>
<td><strong>Sustainability</strong></td>
<td>Meeting the needs of the present without compromising the ability of future generations to meet their own needs.</td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td>Practical instruction in job and task requirements and methods. Training may be provided in a classroom or at the workplace, and its objective is to enable workers to meet some minimum initial performance standards, to maintain their proficiency, or to qualify for promotion to a more demanding position.</td>
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<tr>
<td><strong>Transparency</strong></td>
<td>Openness of an organization with regard to sharing information about how it operates.</td>
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<tr>
<td><strong>Triple Bottom Line</strong></td>
<td>Expanding the traditional business-reporting framework to take into account environmental and social performance in addition to financial performance.</td>
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ACKNOWLEDGMENTS

The American Institute of Chemical Engineers (AIChE) and the Center for Chemical Process Safety (CCPS) express their appreciation and gratitude to all members of the Process Safety Metrics Subcommittee and their CCPS member companies for their generous support and technical contributions in the preparation of these Guidelines. The AIChE and CCPS also express their gratitude to the team of authors from AcuTech Consulting Group.

PROCESS SAFETY METRICS SUBCOMMITTEE MEMBERS:

Tim Overton, Chair The Dow Chemical Company
Michael Broadribb BP
Cho Nai Cheung Contra Costa County Health Services Department
Elroy Christie Honeywell
Susie Cowher INEOS
Eric Freiburger NOVA Chemical
Harry Glidden DuPont
Kent Goddard Solutia
Rick Griffin Chevron Phillips Chemical Company
Karen Haase American Petroleum Institute
Kenneth Harrington Chevron Phillips Chemical Company
Steven Hedrick Bayer Material Science
Shakeel Kadri Air Products and Chemicals
Lisa Long U.S. Occupational Safety and Health Administration
Jack McCavit CCPS Emeritus
Mark Miner Nalco
Jeff Philiph Monsanto
Cathy Pincus ExxonMobil
William Ralph BP
Isador (Irv) Rosenthal The Wharton School, University of Pennsylvania
Randall Sawyer Contra Costa County Health Services Department
S. L. Sreedhar Santos Ltd.
Tomaysa Sterling American Chemistry Council