

## Examples of Process Safety, Personal Safety and Wellness Outcome Metrics

Table 1. Process and personal safety indicators and operational excellence/quality indicators for offshore facilities in general, drilling rigs, and for service personnel

Level of Outcome	Outcome	Description	Frequency of measurement (continuous, daily, monthly)	Level of measurement (individual employee, team, facility level)	Data type (xls, other application) - how is it stored and how can it be shared?	Citation
Incident level	UH Example: Near misses	<p>Incidents in which no property is damaged, and no personal injury is sustained, but where, given a slight shift in time or position, damage or injury easily could have occurred.</p> <p>Examples:</p> <ul style="list-style-type: none"> <li>– Explosion</li> <li>– Releases from overpressure-protection devices</li> <li>– Unintended emergency shutdown</li> <li>– Operations under alarm conditions</li> <li>– Discovery of failed safety systems.</li> </ul>	Continuous, daily	Individual level, team level	Access to the near miss reporting program or recalled by employees for a certain of period	<p>M. Goldenhar, L., Williams, L. J., &amp; G. Swanson, N. (2003). Modelling relationships between job stressors and injury and near-miss outcomes for construction laborers. <i>Work &amp; Stress</i>, 17(3), 218-240.</p> <p>Prugh, R. W. (2014, September). Near-Misses as Leading Indicators for Process Safety. In <i>ASSE Professional Development Conference and Exposition</i>. American Society of Safety Engineers</p>
	UH Example: Machine downtime	<p>Unplanned downtime for a specific type of equipment.</p> <p>Example:</p> <ul style="list-style-type: none"> <li>– Structure born noise and vibrations</li> <li>– Status of the components of machines</li> </ul>	Continuous, daily; frequency of failures and duration of downtime recorded	Team level	Access to monitoring program tracking real time machine condition	Faulstich, S., Hahn, B., & Tavner, P. J. (2011). Wind turbine downtime and its importance for offshore deployment. <i>Wind energy</i> , 14(3), 327-337.
	UH Example: Maintenance , quality control	Inspection and regular maintenance of equipment or products to raise the level of safety and have a defined control of potential hazards	Continuous, regularly; number of failures recorded	Team level, facility level	Access to records	Swuste, P., Theunissen, J., Schmitz, P., Reniers, G., & Blokland, P. (2016). Process safety indicators, a review of literature. <i>Journal of Loss Prevention in the Process Industries</i> , 40, 162-173.
	UH Example: Exposure to dangerous	Number of incidents where a worker is exposed to a hazardous substance or engages in dangerous activities	Continuous, daily; measured as a percentage of	Individual level	Access to records	Seyr, Helene & Muskulus, Michael. (2016). Safety Indicators for the Marine Operations in the Installation and

	substances/activities		total number of work actions performed in a place with possible exposure			Operating Phase of an Offshore Wind Farm. <i>Energy Procedia</i> , 94, 72-81. 10.1016/j.egypro.2016.09.200.
	UH Example: Barriers quality	Physical or non-physical means planned to prevent, control, or mitigate undesired events or accidents. Example: – Physical barriers such as containment building and valves – Functional barrier systems such as a lock – Incorporeal barriers such as guidelines	Evaluated regularly for fit and function	Team level, facility level	Access to records or rated by SMEs	Reiman, T., & Pietikäinen, E. (2012). Leading indicators of system safety—monitoring and driving the organizational safety potential. <i>Safety science</i> , 50(10), 1993-2000.
	UH Example: Inherent safe installations	Reduction or elimination of hazardous materials or processes through changes in the chemistry, physics and physical design of a process.	Evaluated regularly especially at the stage of design	Team level, facility level	Access to records or rated by SMEs	Khan, F. I., & Amyotte, P. R. (2002). Inherent safety in offshore oil and gas activities: a review of the present status and future directions. <i>Journal of Loss Prevention in the Process Industries</i> , 15(4), 279-289.
	UH Example: Behavioral safety observation	Observations of employee behaviors against predetermined checklists. Example: – Correctly followed work procedures – Safety stops during enhanced risks	Daily; observed percent safe scores calculated	Individual level, team level	Access to records or rated by SMEs from the research team	Cooper, M. D., & Phillips, R. A. (2004). Exploratory analysis of the safety climate and safety behavior relationship. <i>Journal of Safety Research</i> , 35(5), 497-512.
	UH Example: Process deviations	Existence of differences between observed process and standard process.	Continuous, daily; number of deviations recorded	Individual level, team level	Access to records	Swuste, P., Theunissen, J., Schmitz, P., Reniers, G., & Blokland, P. (2016). Process safety indicators, a review of literature. <i>Journal of Loss Prevention in the Process Industries</i> , 40, 162-173.
	UH Example: Audits/Inspections	Inspections performed to check if organizational risk factors are present and if the safety management system is functioning effectively.	Continuous, daily; number performed or settled action points recorded	Team level, facility level	Access to records	Körvers, P. M. W., & Sonnemans, P. J. M. (2008). Accidents: a discrepancy between indicators and facts!. <i>Safety Science</i> , 46(7), 1067-1077.

	UH Example: Contingency plan	Plans prepared for on-site emergencies and trainings on emergencies on-site.	Regularly	Team level, facility level	Access to records or self-report recorded by research team	Reiman, T., & Pietikäinen, E. (2012). Leading indicators of system safety—monitoring and driving the organizational safety potential. <i>Safety science</i> , 50(10), 1993-2000.
	UH Example: Safety meetings	Meetings that focus on workplace safety topics. Example: – Toolbox meeting – Safety commission meeting – Human performance meeting	Regularly; frequency or settled action points recorded	Team level, facility level	Access to records	Swuste, P., Theunissen, J., Schmitz, P., Reniers, G., & Blokland, P. (2016). Process safety indicators, a review of literature. <i>Journal of Loss Prevention in the Process Industries</i> , 40, 162-173.
	UH Example: Leakage	Accidental escape of fluid and gas through a hole or cracker from a container. Example: – Non-ignited hydrocarbon leaks – Ignited hydrocarbon leaks	Continuous, daily; frequency or amount recorded	Team level	Access to database	Sneddon, A., Mearns, K., & Flin, R. (2006). Situation awareness and safety in offshore drill crews. <i>Cognition, Technology &amp; Work</i> , 8(4), 255-267.
	UH Example: Losses of containment	Escape of fluid from where it is contained.	Continuous, daily; the amount or number of loss recorded	Team level	Access to database	Webb, P. (2009). Process safety performance indicators: A contribution to the debate. <i>Safety Science</i> , 4(47), 502-507.
	UH Examples: Well kicks/loss of well control	An unexpected and unwanted influx of reservoir fluid, oil, water, or gas, into the wellbore.	Continuous, daily; kick size reported	Team level	Access to database	Skogdalen, J. E., Utne, I. B., & Vinnem, J. E. (2011). Developing safety indicators for preventing offshore oil and gas deepwater drilling blowouts. <i>Safety Science</i> , 49(8-9), 1187-1199.
Accident level	UH Example: Alarms/Safety system activation	Indicator or signals indicating danger or safety accidents. Example: – Safety critical instruments/alarms that fail during testing – Safety critical instruments/alarms that fail in use	Continuous, daily; numbers per time period recorded	Team level	Access to database	Hopkins, A. (2009). Thinking about process safety indicators. <i>Safety science</i> , 47(4), 460-465.
	UH Example: Explosion/Fire	A rapid increase in volume and release of energy in an extreme manner, usually with the combustion and the generation of high temperatures and the release of gases.	Continuous, daily; numbers and costs recorded	Team level, facility level	Access to records	Vinnem, J. E. (2010). Risk indicators for major hazards on offshore installations. <i>Safety science</i> , 48(6), 770-787.

	<p>Unexpected and unwanted physical impact among vessels and installations.</p> <p>UH Example: Collision</p> <p>Example:</p> <ul style="list-style-type: none"> <li>– Vessel collisions</li> <li>– Collision with field-related vessel/installation/ shuttle tanker</li> </ul>	Continuous, daily	Team level, facility level	Access to records	Skogdalen, J. E., Utne, I. B., & Vinnem, J. E. (2011). Developing safety indicators for preventing offshore oil and gas deepwater drilling blowouts. <i>Safety science</i> , 49(8-9), 1187-1199.
Consequence level	<p>UH Example: Personnel injury</p> <p>Injuries that arise from the normal course and scope of the employment.</p>	Regular self-report injuries over a certain period	Individual level	Access to records or recalled by employees against checklists developed by SMEs, self-report questionnaires	<p>Kao, K. Y., Thomas, C. L., Spitzmueller, C., &amp; Huang, Y. H. (2019). Being Present in Enhancing Safety: Examining the Effects of Workplace Mindfulness, Safety Behaviors, and Safety Climate on Safety Outcomes. <i>Journal of Business and Psychology</i>, 1-15.</p> <p>Mearns, K., Flin, R., Gordon, R., &amp; Fleming, M. (2001). Human and organizational factors in offshore safety. <i>Work &amp; Stress</i>, 15(2), 144-160.</p>
	<p>UH Example: Damage of property and environment</p> <p>Example:</p> <ul style="list-style-type: none"> <li>– Damage to property including platform and subsea production equipment</li> <li>– Damage to the environment</li> </ul>	Continuous, daily	Team level, facility level	Access to database	Vinnem, J. E. (2010). Risk indicators for major hazards on offshore installations. <i>Safety science</i> , 48(6), 770-787.
Root cause (personal or organizational) level	<p>UH Example: Rule-based mistake</p> <p>Situations where the use or disregard of rules results in an undesired outcome.</p> <p>Example:</p> <ul style="list-style-type: none"> <li>– Bending the rules to get the job done</li> <li>– Being under pressure by work mates to bend the rules</li> </ul>	Continuous, daily; number and type of mistakes recorded	Individual level	Access to database or recalled by employees, self-report measures collected by the research team	Ren, J., Jenkinson, I., Wang, J., Xu, D. L., & Yang, J. B. (2008). A methodology to model causal relationships on offshore safety assessment focusing on human and organizational factors. <i>Journal of Safety Research</i> , 39(1), 87-100.
	<p>Knowledge-based mistake</p> <p>Mistakes due to lack of knowledge or incorrect application of knowledge</p>				Skalle, P., Aamodt, A., & Laumann, K. (2014). Integrating human related errors with technical errors to determine causes behind offshore accidents. <i>Safety science</i> , 63, 179-190.
	<p>Skill-based error</p> <p>Situations where the person's intention is correct, but the execution of the action is flawed.</p> <p>Example:</p>				Mearns, K., Flin, R., Gordon, R., & Fleming, M. (2001). Human and organizational factors in offshore safety. <i>Work &amp; Stress</i> , 15(2), 144-160.

	<ul style="list-style-type: none"> <li>- Slips (attention failures)</li> <li>- Lapses (memory failures)</li> </ul>				
UH Example: Work Situational Awareness	An individual's perception of the elements in the environment within a volume of space and time, the comprehension of their meaning, and the projection of their status in the near future.	Regularly	Individual Level	Self-report collected by research team	Sneddon, A., Mearns, K., & Flin, R. (2013). Stress, fatigue, situation awareness and safety in offshore drilling crews. <i>Safety Science</i> , 56, 80-88.
UH Example: Job Communication	<p>Level of communication in their job, personal involvement in safety measures</p> <ul style="list-style-type: none"> <li>- Being informed about what takes place on the installation</li> <li>- Being consulted before decisions are made</li> </ul>	Regularly	Individual Level	Collected by the research team	Mearns, K., Flin, R., Gordon, R., & Fleming, M. (2001). Human and organizational factors in offshore safety. <i>Work &amp; Stress</i> , 15(2), 144-160.
UH Example: Safety management	<p>Levels of commitment and emphasis on safety activities from management.</p> <p>Example:</p> <ul style="list-style-type: none"> <li>- Safety arguments in decisions</li> <li>- Consideration of safety in organizational plans</li> <li>- Risk assessments during process change</li> <li>- Safety analyses/documentation</li> <li>- Safety initiatives personnel</li> </ul>	Regularly	Team level	Self-report collected by research team or access to records of management activities	Reiman, T., & Pietikäinen, E. (2012). Leading indicators of system safety—monitoring and driving the organizational safety potential. <i>Safety science</i> , 50(10), 1993-2000.
UH Example: Contractor- subcontractor	<p>Consideration of workplace safety in subcontracting issues.</p> <p>Example:</p> <ul style="list-style-type: none"> <li>- Record of contractor safety performance for decision-making</li> <li>- Contractor trainings on safety culture issues</li> </ul>	Regularly	Team level, facility level	Access to records	Reiman, T., & Pietikäinen, E. (2012). Leading indicators of system safety—monitoring and driving the organizational safety potential. <i>Safety science</i> , 50(10), 1993-2000.
UH Example: Safety culture	Shared beliefs, perceptions and values related to risks and safety within an organization.	Regularly	Team-level	Access to records or collected by the research team	Cox, S. J., & Cheyne, A. J. T. (2000). Assessing safety culture in offshore environments. <i>Safety science</i> , 34(1-3), 111-129.

	<p>– Specific measure: 52 item Safety Attitudes Scale (see Mearns et al., 2001)</p>				<p>Mearns, K., Flin, R., Gordon, R., &amp; Fleming, M. (2001). Human and organizational factors in offshore safety. <i>Work &amp; Stress, 15(2)</i>, 144-160.</p>
UH Example: Safety competence management and training	<p>Identification of current competence profiles and adequate safety training with clear goals, good quality and reasonable feedback.</p>	<p>Regularly; number of programs or frequency recorded</p>	<p>Team level, facility level</p>	<p>Access to records or self-report collected by research team</p>	<p>Swuste, P., Theunissen, J., Schmitz, P., Reniers, G., &amp; Blokland, P. (2016). Process safety indicators, a review of literature. <i>Journal of Loss Prevention in the Process Industries, 40</i>, 162-173.</p>

Table 2. Wellness indicators for offshore workers related to mindfulness and safety

Outcome	Description	Measurement	Sample items	Citation
UH Example: Sleep quality	Tiredness on waking and throughout the day, feeling rested and restored on waking, and the number of awakenings people experience in the night.	Pittsburgh Sleep Quality Index (PSQI), 19 self-report items (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989)	“How will you rate your sleep quality overall?” “How long does it usually take you to fall asleep?”	Litwiller, B., Snyder, L. A., Taylor, W. D., & Steele, L. M. (2017). The relationship between sleep and work: A meta-analysis. <i>Journal of Applied Psychology</i> , 102(4), 682.  Carlson, L. E., & Garland, S. N. (2005). Impact of mindfulness-based stress reduction (MBSR) on sleep, mood, stress and fatigue symptoms in cancer outpatients. <i>International journal of behavioral medicine</i> , 12(4), 278-285.
UH Example: Work-related musculoskeletal disorders	Pain in the muscles, bones, ligaments, tendons, and nerves.	Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms (Kuorinka et al., 1987)	“Have you at any time during the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble in neck?”	Chen, W. Q., Yu, I. T., & Wong, T. W. (2005). Impact of occupational stress and other psychosocial factors on musculoskeletal pain among Chinese offshore oil installation workers. <i>Occupational and environmental medicine</i> , 62(4), 251-256.  Zou, L., Yeung, A., Quan, X., Boyden, S. D., & Wang, H. (2018). A systematic review and meta-analysis of mindfulness-based (Baduanjin) exercise for alleviating musculoskeletal pain and improving sleep quality in people with chronic diseases. <i>International journal of environmental research and public health</i> , 15(2), 206.
UH Example: Fatigue	A subjective experience that includes symptoms such as persistent low energy or lack of energy, physical and mental tiredness, and apathy.	Occupational Fatigue Exhaustion Recovery scale (OFER, Winwood, Bakker, & Winefield, 2007)	“I often dread waking up to another day of my work.” “After a typical work period, I have little energy left.”	Wadsworth, E. J., Allen, P. H., McNamara, R. L., & Smith, A. P. (2008). Fatigue and health in a seafaring population. <i>Occupational medicine</i> , 58(3), 198-204.  Querstret, D., Cropley, M., & Fife-Schaw, C. (2017). Internet-based instructor-led mindfulness for work-related rumination, fatigue, and sleep: Assessing facets of mindfulness as mechanisms of change. A randomized waitlist control trial. <i>Journal of Occupational Health Psychology</i> , 22(2), 153.

UH Example: Depression	A mood disorder that causes a persistent feeling of sadness and loss of interest	Center for Epidemiological Studies Depression Scale (CES-D) (Radloff, 1977)	“I feel sad.” “I feel hopeful about the future.”	Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. <i>Journal of consulting and clinical psychology, 78</i> (2), 169.
UH Example: Stress	A feeling of emotional or physical tension	Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983)	“In the last month, how often have you felt nervous and ‘stressed’?” “In the last month, how often have you felt that you were unable to control the important things in your life?”	Sneddon, A., Mearns, K., & Flin, R. (2013). Stress, fatigue, situation awareness and safety in offshore drilling crews. <i>Safety Science, 56</i> , 80-88.  Chang, V. Y., Palesh, O., Caldwell, R., Glasgow, N., Abramson, M., Luskin, F., ... & Koopman, C. (2004). The effects of a mindfulness-based stress reduction program on stress, mindfulness self-efficacy, and positive states of mind. <i>Stress and Health: Journal of the International Society for the Investigation of Stress, 20</i> (3), 141-147.
UH Example: Recovery Experience	How individuals unwind and recuperate from work during leisure time	The Recovery Experience Questionnaire (Sonnentag, & Fritz, 2007)	“I forget about work.” “I get a break from the demands of work.”	Hülshager, U. R., Lang, J. W., Depenbrock, F., Fehrmann, C., Zijlstra, F. R., & Alberts, H. J. (2014). The power of presence: the role of mindfulness at work for daily levels and change trajectories of psychological detachment and sleep quality. <i>Journal of Applied Psychology, 99</i> (6), 1113.
UH Example: Burnout	A state of emotional, physical, and mental exhaustion	Maslach Burnout Inventory-General Survey (MBI-GS; Schaufeli, Leiter, Maslach, & Jackson, 1996)	“I feel used up at the end of the day.” “I do not feel as though I am positively influencing others.”	Nahrgang, J. D., Morgeson, F. P., & Hofmann, D. A. (2011). Safety at work: a meta-analytic investigation of the link between job demands, job resources, burnout, engagement, and safety outcomes. <i>Journal of applied psychology, 96</i> (1), 71. Goodman, M. J., & Schorling, J. B. (2012). A mindfulness course decreases burnout and improves well-being among healthcare providers. <i>The International Journal of Psychiatry in Medicine, 43</i> (2), 119-128.