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Clive Timms. *Hazards equal trips or alarms or both*. S. 3-13.

Abstract: Anyone who has been involved in the application of IEC 61508 and IEC 61511 by undertaking the Safety Integrity Level (SIL) determination for Safety Instrumented Systems (SIS) will appreciate the amount of effort and tenacity that is required to undertake the task. SIL determination of Safety Instrumented Systems requires considerable commitment and tenacity to get the job done, but it is like climbing to the top of a hill only to be faced with a mountain when we come to consider what is involved in reviewing or configuring a typical alarm system. A medium sized process facility may have a few hundred or so primary Safety Instrumented Functions (SIF) or trips configured into a Safety Instrumented System, but the number of alarms configured into a process control system (PCS), that need to be assessed and prioritised, can often run into the thousands. There is synergy between safety instrumented functions and alarms because they both make a contribution to reduce the risk of having unwanted events, and both need an assigned appropriate criticality. This paper details various methods of criticality assessment which have been successfully applied to set the appropriate priority, identify the critical alarms that need to be upgraded to trips and to rationalise those of no value. It will also cover the use of software tools which can significantly reduce the effort involved in this process.

- **Keywords:** Alarms; Trips; Prioritisation; Rationalisation; SIF; SIL; Risk

Jaffee A. Suardin, A. Jeff McPhate Jr., Anthony Sipkema, Matt Childs, M. Sam Mannan. *Fire and explosion assessment on oil and gas floating production storage offloading (FPSO) : an effective screening and comparison tool*. S. 147-160.

Fires and explosions have been identified as major potential hazards for Oil and Gas Floating Production Storage Offloading (FPSO) installations and pose risk to personnel, assets, and the environment. Current fire and explosion assessment (FEA) tools require physical effect modeling software and follows standards from API, ISO, and engineering practices. However, the tools are not specific to any particular system such as an FPSO, and do not provide comprehensive guidance for safety engineers to perform FEA. This paper discusses the development of a screening and comparison tool for FEA on FPSOs and the incorporation of an expert system into the tool. The results are computerized using MS Excel/VBA to provide a structured and comprehensive assessment on each equipment and module handling natural gas, crude oil, methanol and diesel on FPSO

topsides. This tool features built-in calculations for jet and pool fire size estimation for gas/liquid releases, and the ability to perform Quantitative Risk Analysis (QRA) to specify the personnel and equipment risk for varying leak sizes and process conditions. Control and recovery measures are incorporated as an expert system based on report findings, engineering practices, and relevant standards. Bowtie analysis is applied in the tool to define detailed control and recovery measures for the FPSO based on the incident scenarios. An explosion assessment is performed by incorporating physical effect modeling software results. Unique features provided in the tool include fire and radiation contour mapping on an FPSO layout to help determine personnel and equipment risk more accurately and fire pump sizing that can be used to verify the amount of water deluge system required to mitigate fires and explosions. In addition, flexibility of data input (process data, failure rate data, etc.) and user interfaces assist safety engineers to screen and compare process alternatives, check design quality, and evaluate design options at any design stage.

- **Keywords:** FPSO; Risk analysis; Fire and explosion assessment; Expert system; Consequence analysis; Control and recovery measures; Bowtie analysis

P.J. Thomas, R.D. Jones. *Calculating the benefit to workers of averting a radiation exposure lasting longer than the working lifetime*. S. 161-174.

The J-value method enables health and safety schemes aimed at preserving or extending life to be assessed on a common, objective basis for the first time, irrespective of industrial sector. For this it requires an estimate of the improvement in life expectancy that the health and safety scheme will bring about. This paper extends the range of nuclear-safety-system lifetimes for which it is possible to calculate the increased life expectancy amongst nuclear-plant workers whose radiation exposure the safety system has reduced. Whereas the previous mathematical technique was able to cater for a nuclear-safety-system lifetime up to the working lifetime of the nuclear-plant workers (typically between 45 and 50 years), the new method extends without limit the range of tractable, safety-system lifetimes. This is important now that the design lifetime of nuclear power stations can be up to 60 years. The development will also facilitate the assessment of safety systems and procedures to protect workers on long-term nuclear decommissioning and waste sites; in the latter case, the service life-time could be hundreds of years. The case when the safety-system lifetime is greater than the working lifetime is addressed by splitting the workforce into a set of three cohorts, one for existing workers and two for new recruits. The discounted life expectancy is found for each cohort, and then a weighted average is used to give the overall value. An additional mathematical device is then used to reduce the number of cohorts required from three to two, namely existing workers and new recruits. A similar mathematical device is applied (in Appendix A) to reduce from three to two the number of workforce cohorts needed when the length of the safety system's service lifetime is less than the working lifetime. Finally, a further mathematical instrument is incorporated in the model equations, which allows a unified treatment to be applied to each of the cohorts, existing workers and new recruits, across all possible service lifetimes of a nuclear safety system. Since new results on gain in life expectancy may be fed into a J-value analysis, this development extends significantly the range of nuclear-safety systems for which the J-value technique may be used to measure cost-effectiveness.

- **Keywords:** Health; Safety; Nuclear; Radiation; Prolonged release; Life expectancy; Risk; J-value

Songbai Cheng, Guohua Chen, Qingguang Chen, Xueying Xiao. *Research on 3D dynamic visualization simulation system of toxic gas diffusion based on virtual reality technology*. S. 175-183.

A three-dimensional (3D) model of toxic gas diffusion was advanced based on Monte Carlo method with the presupposition that toxic gas diffusion process can be considered as random walk process of a large number of toxic gas particles. Compared to other existing models, this model includes analysis of both movement and non-movement attributes of toxic gas particles, and can well meet the need of dynamic simulation. Then, a 3D gas diffusion visualization scene management subsystem, including leak hazard source (tank), leak background (ground and sky) and surroundings near the leak area, was developed based on virtual reality (VR) technology. In this system, diffusion scene can be designed in accordance with the reality, which embodies the reunification between VR technology and engineering application. Finally, according to OpenGL particle system theory, by using Delphi and OpenGL as main programming tools, the diffusion simulation subsystem of toxic gas diffusion process and real-time concentration prediction and consequence simulation subsystem was completed. Application shows that by using VR technology in the accident consequence simulation, the whole system is of real-time, lifelike and visual characteristics, which not only embodies the great engineering value of virtual reality technology in the field of safety engineering, but also provides references for accident impact prediction, assessment and emergency plan.

- **Keywords:** Virtual reality technology; OpenGL; 3D dynamic visualization; Toxic gas diffusion

John Bond. *Professional ethics and corporate social responsibility*. S. 184-190.

Sharing accident information and learning the lessons is an important way of reducing errors in any industry. All human beings make errors at some time and it is necessary that design and operational work must be capable of dealing with human fallibility. It is necessary for a management system in all companies to deal with the sharing of information and the learning of lessons from the information. Companies have been reluctant to share information and engineers reluctant to provide information on accidents for fear of the consequences. This paper deals with the ethics issue of the engineer and the social responsibilities of companies to their employees and the public. It is proposed that the professional bodies should make efforts to ensure companies share accident information so that the risks involved in the industry are reduced for the benefit of all.

- **Keywords:** Professional ethics; Sharing information; Corporate social responsibility

K.W. Pi, Z. Li, D.J. Wan, L.X. Gao. *Pretreatment of municipal landfill leachate by a combined process*. S. 191-196.

Biodegradability enhancement of landfill leachate using air stripping followed by coagulation/ultrafiltration (UF) processes was introduced. The air stripping process obtained a removal efficiency of 88.6% for ammonia nitrogen (NH_4–N) at air-to-liquid ratio of 3500 (pH 11) for stripping 18 h. The single coagulation process increased BOD/COD ratio by 0.089 with the $FeCl_3$ dosage of 570 mg l^{-1} at pH 7.0, and the single UF process increased the BOD/COD ratio to 0.311 from 0.049. However, the combined process of coagulation/UF increased the BOD/COD ratio from 0.049 to 0.43, and the final biological oxygen demand (BOD), chemical oxygen demand (COD), NH_4–N and colour of leachate were 1223.6 mg l^{-1}, 2845.5 mg l^{-1}, 145.1 mg l^{-1} and 2056.8, respectively, when 3 kDa molecular weight cut-off (MWCO) membrane was used at the operating pressure 0.7 MPa. In ultrafiltration process, the average solution flux (J_V), concentration multiple (M_C) and retention rate (R) for COD was 107.3 l m^{-2} h^{-1}, 6.3% and 84.2%, respectively.

- **Keywords:** Landfill leachate; Biodegradability; Air stripping; Coagulation; Ultrafiltration

Raymond R. Tan, Denny K.S. Ng, Dominic C.Y. Foo, Kathleen B. Aviso. *A superstructure model for the synthesis of single-contaminant water networks with partitioning regenerators*. S. 197-205.

This paper presents a novel superstructure-based optimization model for the synthesis of industrial water networks with partitioning regenerators. Such regenerators function by splitting a contaminated water stream into a regenerated lean stream and a low-quality reject stream. Membrane separation-based processes are examples of these types of regenerators. The optimization model presented in this work integrates a single, centralized partitioning regenerator with a source–demand superstructure under the assumption that the processes within the plant are of the fixed flow rate type. The formulation is non-linear as a result of the presence of bilinear terms in the regenerator balance equations, but global optimal solutions can be found using commercial software. The features of the model are illustrated by solving case studies from the literature. It is notable from these examples that considerable design flexibility exists in networks of this type, since potentially both the lean and reject streams from the partitioning regenerator can be reused/recycled within the plant.

- **Keywords:** Water reuse/recycle; Water regeneration; Partitioning regenerator; Process integration; Waste minimization; Optimization

Ivan Petric, Almir Šestan, Indira Šestan. *Influence of wheat straw addition on composting of poultry manure*. S. 206-212.

Poultry manure is a significant source of nitrogen, but small amount of carbon needs to be added for faster degradation of organic matter in composting process. Composting of poultry manure mixed with wheat straw was carried out in specially designed reactors (32 L) under controlled laboratory conditions over 13 days. The aim of the study was to determine the influence of wheat straw addition to poultry manure on performance of composting process in terms of the following: the substrate temperature, carbon dioxide, ammonia, pH, electrical conductivity and organic matter. According to the results, the mixture of 83% poultry manure and 17% wheat straw (dw) among three different mixtures used in this research provided the best conditions for composting process.

- **Keywords:** Composting; Poultry manure; Wheat straw; Reactor