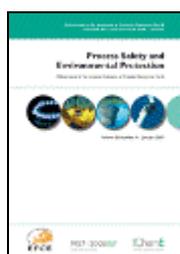


Process Safety and Environmental Protection

rok 2009, ročník 87

Číslo 1 (January 2009)

dostupný plný text článků



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

M. Traoré, O. Dufaud, L. Perrin, S. Chazelet, D. Thomas. *Dust explosions : how should the influence of humidity be taken into account?* S. 14-20.

Abstract: In this work, the influence of humidity on dust explosions of metallic (aluminium) and organic materials (icing sugar, polyethylene and magnesium stearate) has been studied. The impact of pre-humidification of powders on their ignition sensitivity, their volume resistivity and charge decay time has been assessed. The influence of humidity on explosion severity has also been studied by two methods: on the one hand, the dust sample was stored in a controlled workstation at constant relative

humidity; on the other hand, the dry dust was dispersed in a humidity controlled atmosphere in the vessel. As expected, the effect of humidity strongly depends on the chemical nature of the particles. Experiments on powders volume resistivity and charge decay time have shown typical trends but have especially pointed out the inadequacy of some standards. Inhibition phenomena have been verified for polyethylene and magnesium stearate, whereas both inhibition and promotion have been observed for icing sugar and could be explained by an evolution of sucrose structure. Dry aluminium dust explosions in humid atmosphere show that water vapour inerts the explosion. However, when aluminium is stored at controlled humidity, the maximum rise of pressure rate increases with the water content, which is probably due to hydrogen generation.

- **Keywords:** Dust explosions; Ignition sensitivity; Equilibrium relative humidity; Static electricity; Standards

Andrew G. Rushton, David A. Carter. "Total risk of death" : towards a common and usable basis for consequence assessment. S. 21-25.

Abstract: Assessment of the risk of exposure to a "dangerous dose" (DD) is the basis of the UK Health and Safety Executive's HSE's current risk assessments for land-use planning (LUP). Some years ago, a hybrid approach using both DD and "significant likelihood of death" (SLOD) was proposed as an improvement, but was not adopted. Here, an alternative, weighted multiple threshold approach, provisionally titled "total risk of death" (TROD), is described. TROD improves the comparability of assessed risks from diverse hazards. This is achieved by first performing assessments for more than one threshold of consequence (such as DD assessment and SLOD assessment). The predicted risk for each threshold is then combined into a single risk value (at a specified location) by weighting the contributions to risk according to the predicted consequences for each threshold. This paper makes the case, in principle, for using TROD and illustrates how TROD values are constructed. TROD overcomes some of the objections that have barred progress to more widespread use of risk assessment, it is more comparable between different installations and hazards than DD, it is more sensitive than SLOD and more adaptable than probits (which can introduce a false sense of precision). It could support more direct comparison with other risks (e.g. everyday risks and transport risks) in the future. The appropriate "weightings" for addition of risks predicted for different consequence thresholds (contributing to TROD) are discussed here. A three-threshold scheme for evaluation of TROD is described. The thresholds are DD (assumed to approximate to a dose leading to $\sim 1\%$ fatal consequences or LD_1), LD_{10} , and SLOD ($\sim LD_{50}$). TROD has been used in HSE sponsored research and in HSE's exploration of societal risks.

- **Keywords:** Risk assessment; Land-use planning; Harm criteria; Risk criteria; Fatal risk profile

Emilio Palazzi, Fabio Currò, Bruno Fabiano. From laboratory simulation to scale-up and design of spray barriers mitigating toxic gaseous releases. S. 26-34.

Abstract: Simulation of a process by means of physical models at a reduced scale is an essential tool in many application, allowing to perform a large number of experimental runs, so as to obtain a quantitative representation of the involved phenomena, at relatively low cost. Some difficulties can arise when the mathematical model derived from the simulation is applied to a real scale problem, in that the scaling of some empirical coefficients with the system size is not obvious at all. As fluid barrier scaling is a difficult task, still not deeply investigated in the scientific literature, the focus of this study is to translate knowledge from research on this topic into practice for industrial application. Following an extensive and accurate experimental work in wind tunnel, the main parameters determining the effectiveness of containment, absorption and dilution

of chlorine releases were determined and a mathematical model is developed. In order to frame proper scale-up strategies, the most important result of this study rests on the explicit formulae giving, as a function of the aforesaid parameters, the single pass efficiency, the global absorption efficiency, and the toxic gas concentration downwind the barrier. In the far field, the gas concentration is practically determined only by the rate of atmospheric dispersion of the mass flow-rate of gas escaping the abatement. The absorption efficiencies are related to the drop size and to the mass transfer coefficients in the gas and liquid phases. The mean drop diameter plays an essential role in the absorption efficiency, since it simultaneously acts on air entrainment, interfacial surface and mass transfer coefficient in the gas phase. The evaluation of the mitigation effect for an industrial installation requires the scaling of the entrainment coefficient experimentally determined from wind tunnel testing. All the scaling criteria needed for adapting the proposed model to the design of a spray curtain suitable for the protection from a chlorine release, are amply discussed presenting some carefully designed simulations. Owing to its rather general structure, the model can be applied to different gaseous releases and/or absorbing solutions, provided that proper values of the parameters related with the chemical and physical absorption of the involved substances be theoretically or experimentally obtained in advance.

- **Keywords:** Chlorine; Mitigation; Modelling; Nozzles; Scale-up; Toxic release

Paul R. Amyotte, Michael J. Pegg, Faisal I. Khan. *Application of inherent safety principles to dust explosion prevention and mitigation. S. 35-39.*

Abstract: The aim of the current work is to explicitly link the inherent safety principles of minimization, substitution, moderation and simplification with strategies for dust explosion prevention and mitigation. A brief review of inherent safety and its basic principles is first given. This is followed by a discussion of various ways in which the dust explosion hazard can be minimized, substituted, moderated and simplified. Particular attention is paid to the relationship between each inherent safety principle and (i) various dust explosibility parameters, (ii) alternate methods of processing, (iii) selection of process equipment, and (iv) development and implementation of safe-work procedures. Original research results are presented, along with industrial case studies and previously published results that have been reinterpreted in terms of inherent safety and its basic principles. It is anticipated that this research will be of value to industry as a complement to the relatively well-established suite of engineered and procedural dust explosion risk reduction measures.

- **Keywords:** Inherent safety; Dust explosion prevention; Dust explosion mitigation

Hangzhou Wang, Bingzhen Chen, Xiaorong He, Qiu Tong, Jinsong Zhao. *SDG-based HAZOP analysis of operating mistakes for PVC process. S. 40-46.*

Abstract: As modern chemical plants are becoming more complex and bigger in scale, the associated chance of things going wrong is also increasing rapidly. Due to the flammable, explosive, toxic and corrosive nature of chemical process, any single accident may trigger a major catastrophe that brings tremendous environmental, social and economical loss. In order to prevent any accident from happening, hazard and operability (HAZOP) analysis has been brought in to monitor chemical process and provide early warning for signs of accident. However, most existing HAZOP is carried out manually, and there are always obstacles in terms of cost overrun and incompleteness of the analysis. To address the difficulties in current HAZOP method, this paper proposes a signed digraph (SDG)-based HAZOP analysis method. It is used to identify the most likely operating mistakes that may cause certain process variable deviating from its normal value, which is the main source of safety concern. A case study on polyvinyl chloride

(PVC) plant is presented to demonstrate the effectiveness of SDG-based HAZOP analysis method in providing complete analysis result.

- **Keywords:** SDG; HAZOP; Analysis method

A.A. Pekalski, H.J. Pasman. *Distinction between the upper explosion limit and the lower cool flame limit in determination of flammability limit at elevated conditions. S. 47-52.*

Abstract: Previous research showed that at certain conditions, close to the flammability range exists a regime where cool flame may develop either due to elevated temperature or it may be initiated by an ignition source. Propagation of the cool flame in a closed test vessel may double the initial pressure. Such pressure increase exceeds recommended ignition criteria for explosion limit determination that are based on 5 or 7% of pressure rise leading to inaccurate classification of the oxidation phenomena, i.e. cool flame propagation may be classified as hot flame propagation. Two mixtures were tested: *n*-butane-oxygen (extensively) and C1-C2-oxygen (in limited range), which represent a typical composition in ethylene oxide production, at elevated conditions at their upper explosion limits. Flame development was analysed by flame emission spectroscopy and the post-oxidation mixture was analysed by gas chromatography (GC) to characterise the oxidation mechanism of the flame. Additionally explosion pressure rise, flame temperature, and maximum rate of pressure rise were measured. In all experiments with the pressure rise ratio below two the low temperature oxidation mechanism assisted the flame propagation.

- **Keywords:** Flammability limit; Ignition criterion; Elevated temperature; Cool flame; Flame propagation; Low temperature oxidation mechanism

Alexis Pey, Pablo Lerena, Georg Suter, Jordi Campos. *Main differences on European regulations in the frame of the Seveso Directive. S. 53-58.*

Abstract: Since the first Seveso Directive was issued 25 years ago, each Member State of the European Union developed own regulations to enforce its application. The lack of a common approach generated differences between Member States, or even between regions within a Member State, which in practical terms caused that establishments falling under the field of application of the Seveso Directive face a different level of requirements. This situation causes significantly different impact on social, technical and financial aspects. Factors like industrial background, accidental history, actual land use, social attitude towards risk, economical and political structures play an important role in how the decisions about hazardous activities are perceived and handled. Answering the question: "Is there a right methodology for the assessment of the risk of major accidents?" may be sterile or impossible. Many tools are appropriate and the main concern is to use them properly. Technically, the causes and consequences of, e.g., a fire in a port in Spain on the Mediterranean Sea or in the port of Basel (Switzerland) in the Rhine River could be assessed using the same methods and criteria, but this is not usually the case. This paper shows, with practical examples, the differences existing while applying different regulations in the field of prevention of major accidents and the potential effects that these differences may generate regarding the definition and management of emergency plans outside establishments. If the existing unequal situation is not faced, the comparative disagreements between Member States will prevail. Therefore, the application of the Seveso Directive will generate a different impact on the society, operators and regulators, and may become a factor which may cause a risk transfer between Member States. Efforts should be addressed to harmonize criteria in this subject.

- **Keywords:** Seveso; Major accidents; Risk assessment; Scenario definition; Thresholds

M. Considine, S.M. Hall. *The major accident risk (MAR) process : developing the profile of major accident risk for a large multi national oil company.* S. 59-63.

Abstract: The paper describes a programme to develop the profile of major accident risk across a large multi national oil company. It describes the concepts, tools and processes for constructing the risk profile and some of the key learnings from the exercise.

- **Keywords:** Major accident; Risk profile

Martin Glor, Patrice Müller, Christian Kubainsky. *Measurement of charge transfer during filling and emptying FIBC.* S. 64-69.

Abstract: Filling and emptying normal FIBC (flexible intermediate bulk containers) in hazardous areas represents a high electrostatic ignition hazard. Manufacturers of FIBC have therefore designed different measures to reduce the ignition risks from static electricity. Depending on the measures applied FIBC are categorized into types A, B, C and D. End of 2005 a new international standard for testing type D FIBC has been published. Type D FIBC have now to be certified according to this standard. Since this standard requires comprehensive ignition testing on a test rig especially designed for this purpose, industry is looking for a simpler test method, which can be used for the development of new FIBC fabric and in production quality control. In the present paper it is attempted to apply the method of charge transfer measurement to assess the ignition probability of static discharged from FIBC during filling and emptying and to correlate the results with the ignition tests performed on the standard test rig.

- **Keywords:** Flexible intermediate bulk container (FIBC); Static electricity; Charge transfer; Ignition by static electricity; Gas explosions; Dust explosions