Process Safety and Environmental Protection

rok 2010, ročník 88

Číslo 3 (May 2010)

P.J. Thomas, J.O. Kearns, R.D. Jones. *The trade-offs embodied in J-value safety analysis*. Pages 147-167.

The paper presents a new derivation of the *J*-value method for assessing health and safety expenditure that highlights the fact that two trade-offs are involved. The trade-off between safety spend and the resulting improvement in life expectancy rests on a prior trade between free-time fraction and income, made at a societal level. It is suggested that each trade is a specific instance of a more general exchange between expected free-time and income, and that the terms of the trade-off are similar, so that the percentage increase in life expectancy has the same value as a similar percentage increase in total expected free-time. The theoretical framework suggests that the average person values all his time equally, but perceives that he has sold his expected working time to an employer, so that, while he will still place a value on it, he does not see that value as coming to him, but rather going to his employer in exchange for the compensation he is being paid. Thus he values the extra years of life expectancy he obtains from a health and safety measure solely in terms of the extra years of free-time he expects to gain. The value of the exponent in the life-quality index has been shown to be equal to both the modulus of the elasticity of expected future free-time with respect to income and the modulus of the elasticity of life expectancy with respect to income. The indifference curves on the planes of income versus life expectancy and income versus discounted life expectancy have been shown to be the loci of $J = 1$. The actuarial basis for the calculation of working time fraction to the end of life has been explained, and data on the share of wages in Gross Domestic Product have been discussed. Based on recent statistics from the UK economy, the average person would be prepared to forego about 5½% of his income to the end of life in order to increase his life expectancy or discounted life expectancy by 1%, and would require his lifetime income to be increased by 5½% to compensate him for a loss of 1% in his life expectancy, discounted or otherwise. A small degree of asymmetry will, however, occur for larger percentage changes in life expectancy, with the average person requiring somewhat more compensation for a loss of life expectancy than he is prepared to pay for a gain.

- **Keywords:** *J*-Value; Risk management; Safety; Life-quality index; Working time fraction; Free-time fraction; Economic trade-off; Safety trade-off

Sven Ove Hansson. *Promoting inherent safety*. Pages 168-172.

By inherent safety is meant that a hazard is eliminated rather than being managed by various add-on equipment and procedures. Practices of inherent safety have been developed in the chemical industry, and include for instance the substitution of hazardous substances by less hazardous ones. Inherently safer design strives to eliminate the possibility of major adverse events even when the probabilities of these events are small or cannot be meaningfully estimated. Considerations of security can be more easily incorporated into this approach than into most other branches of risk and safety analysis. Therefore, inherent safety has a great potential as a meeting-ground for the much-needed coordination of safety and security work. Its philosophical underpinnings are outlined, and proposals are made for more efficient promotion of its principles.

- **Keywords:** Inherent safety; Primary prevention; Substitution; Substitution principle; Security; Terrorism

Mimi H. Hassim, Alberto L. Pérez, Markku Hurme. *Estimation of chemical concentration due to fugitive emissions during chemical process design*. Pages 173-184.

Fugitive emissions are not an environmental concern alone, but are also a health concern. From occupational health standpoint, fugitive emissions are the main sources of origin of the continuous exposure to workers. Operating plants regularly measure release and concentration levels through a plant-monitoring program. However, for processes which are still 'on paper', predictive estimation methods are required. Therefore, three methods for estimating concentration of the fugitive emissions are presented for the process development and design phases of petrochemical processes. The methods estimate the fugitive emission rates and plant plot dimensions resulting to fugitive emission concentrations. The methods were developed for the type and amount of information available in three process design stages; conceptual design, preliminary process design, and detailed process design. The methods are applied on a real benzene plant; the estimated benzene concentrations are compared to the actual concentration measured at the plant. The results show that as the information mounts up during design, the concentration estimate becomes more accurate. The results indicate that the methods presented provide simple estimates of fugitive emission-based concentrations during the design stages.

- **Keywords:** Fugitive emission; Chemical concentration; Occupational exposure; Process design; Process development

Z. Janour, K. Jurcakova, K. Brych, F. Dittrt, F. Dittrich. *Potential risks at an industrial site : a wind tunnel study*. Pages 185-190.

A gaseous dispersion over a complex urban area after an accident with a leakage of chlorine in a chemical factory is investigated experimentally in a wind tunnel experiment under neutral conditions by using a Laser Doppler Anemometer and Analyser IREX. Diffusion fields in a turbulent boundary layer are simulated using a model of a landscape surrounding the factory at a scale of 1:1000. The obtained results indicate that morphology is one of the important parameters in studying atmospheric diffusion. The strong turbulent mixing inside the urban surface layer has created a rapid decrease in the surface concentrations. Moreover, the diffusion measured in these experiments may be used to develop and evaluate operational models to predict the dispersion of chlorine in a chemical factory.

- **Keywords:** Atmospheric turbulence; Flow visualization; Gas dispersion; Wind tunnel modeling

Maryam Kalantarnia, Faisal Khan, Kelly Hawboldt. *Modelling of BP Texas City refinery accident using dynamic risk assessment approach*. Pages 191-199.

Process industries involve handling of hazardous substances which on release may potentially cause catastrophic consequences in terms of assets lost, human fatalities or injuries and loss of public confidence of the company. In spite of using endless end-of-the-pipe safety systems, tragic accidents such as BP Texas City refinery still occur. One of the main reasons of such rare but catastrophic events is lack of effective monitoring and modelling approaches that provide early warnings and help to prevent such event. To develop a predictive model one has to rely on past occurrence data, as such events are rare, enough data are usually not available to better understand and model such behavior. In such situations, it is advisable to use near misses and incident data to predict system performance and estimate accident likelihood. This paper is an attempt to demonstrate testing and validation of one such approach, dynamic risk assessment, using data from the BP Texas City refinery incident. Dynamic risk assessment is a novel approach which integrates Bayesian failure updating mechanism with the consequence assessment. The implementation of this methodology to the BP Texas City incident proves that the approach has the ability to learn from near misses, incident, past accidents and predict event occurrence likelihood in the next time interval.

- **Keywords:** Dynamic risk assessment; Bayesian inference; Event tree; Predictive model

M. Raynaud, P. Heritier, J.-C. Baudez, J. Vaxelaire. *Experimental characterisation of activated sludge behaviour during mechanical expression*. Pages 200-206.

Even after mechanical dewatering, activated sludge contains a large amount of water. Due to its biological nature, composition and also the type of treatment it comes from, this material is usually highly compressible and known to be difficult to dewater. In the present work various tests are proposed to try to highlight some aspects which could explain the poor dewaterability of activated sludge. Experiments of expression were carried out in a Filtration-Compression Cell for semi-solid samples of sludge. Operating conditions (intensity of the applied pressure, initial thickness of sludge sample) and the composition of the sludge (ionic strength by adding monovalent salt) were modified for the different series of experiments. It was observed that the removal of water from the sludge depended significantly on the pressure gradient throughout the sludge cake. However, the development of a dense layer of cake at the interface cake/filter medium seems to generate a pressure gradient non-uniformly distributed throughout the thickness of the cake. This phenomenon should control in part the efficiency of dewatering. This study also discusses the link between sludge dewaterability and cake relaxation on the basic of an osmotic effect within the flocculated matrix, which tends to resist against compression or deformation. This effect was reduced when both the applied pressure and the time increased. Finally, the activated sludge dewatering during expression stage depends on both the formation of a dense layer of cake at the interface cake/filter medium and an osmotic effect.

- **Keywords:** Activated sludge; Dewatering; Osmotic effect; Dense layer of cake; Relaxation

M. Redolfi, C. Makhloufi, S. Ognier, S. Cavadias. *Oxidation of kerosene components in a soil matrix by a dielectric barrier discharge reactor*. Pages 207-212.

This paper discusses some aspects of the kerosene components oxidation in a soil matrix by a dielectric barrier discharge reactor at atmospheric pressure. The total kerosene components abatement can reaches 90% for an energy density of 960 J g_{soil}^{-1}. The analyses of the discharge cell outlet gas reveals that CO_x and hydrocarbon compounds selectivity is close to 10%. A semi-quantitative approach by GC-FID shows that the carbon content in the oxidized compounds in soil is about 20% of the carbon content in the initial kerosene components. The polar species formed in soil are a mixture of aliphatic and aromatic molecules containing alcohol and carboxylic acid groups. The process of kerosene oxidation in soil matrix is more promoted than kerosene desorption followed by an oxidation in gas phase.

- **Keywords:** Dielectric barrier discharge; Kerosene components oxidation

A. Leybros, A. Roubaud, P. Guichardon, O. Boutin. *Supercritical water oxidation of ion exchange resins: Degradation mechanisms*. Pages 213-222.

Spent ion exchange resins are radioactive process wastes for which there is no satisfactory industrial treatment. Supercritical water oxidation could offer a viable treatment alternative to destroy the organic structure of resins and contain radioactivity. IER degradation experiments were carried out in a continuous supercritical water reactor. Total organic carbon degradation rates in the range of 95–98% were obtained depending on operating conditions. GC–MS chromatography analyses were carried out to determine intermediate products formed during the reaction. Around 50 species were identified for cationic and anionic resins. Degradation of polystyrenic structure leads to the formation of low molecular weight compounds. Benzoic acid, phenol and acetic acid are the main compounds. However, other products are detected in appreciable yields such as phenolic species or heterocycles, for anionic IERs degradation. Intermediates produced by intramolecular rearrangements are also obtained. A radical degradation mechanism is proposed for each resin. In this overall mechanism, several hypotheses are foreseen, according to HOO**.** radical attack sites.

- **Keywords:** Supercritical water oxidation; Ion exchange resins; Polymer; Aromatic compounds; Reaction mechanisms