

# **Process Safety and Environmental Protection**

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**Refaul Ferdous, Faisal Khan, Brian Veitch, Paul R. Amyotte. *Methodology for computer aided fuzzy fault tree analysis*. Pages 217-226.**

Probabilistic risk assessment (PRA) is a comprehensive, structured and logical analysis method aimed at identifying and assessing risks of complex process systems. PRA uses fault tree analysis (FTA) as a tool to identify basic causes leading to an undesired event, to represent logical dependency of these basic causes in leading to the event, and finally to calculate the probability of occurrence of this event. To conduct a quantitative fault tree analysis, one needs a fault tree along with failure data of the basic events (components). Sometimes it is difficult to have an exact estimation of the failure rate of individual components or the probability of occurrence of undesired events due to a lack of sufficient data. Further, due to imprecision in basic failure data, the overall result may be questionable. To avoid such conditions, a fuzzy approach may be used with the FTA technique. This reduces the ambiguity and imprecision arising out of subjectivity of the data. This paper presents a methodology for a fuzzy based computer-aided fault tree analysis tool. The methodology is developed using a systematic approach of fault tree development, minimal cut sets determination and probability analysis. Further, it uses static and dynamic structuring and modeling, fuzzy based probability analysis and sensitivity analysis. This paper also illustrates with a case study the use of a fuzzy weighted index and cutsets importance measure in sensitivity analysis (for system probabilistic risk analysis) and design modification.

- **Keywords:** Probabilistic risk assessment; Fuzzy probability analysis; Fuzzy weighted index; Fault tree analysis

**P.J. Thomas, R.D. Jones. *The effect of the exposure time on the value of a manSievert averted*. Pages 227-231.**

The basis of the manSievert as a unit for collective radiation dose is discussed and previous recommendations are considered for how much should be spent to avert a collective dose of 1 manSv. New calculations are given using the J-value method. It is shown that the value to be assigned to averting a manSievert depends on the duration of averted exposure as well as on the net discount rate and the loan rate thought to be appropriate. Different figures will result depending on whether the exposed group consists of workers or the general public. The variation with dose duration is so large that it is not possible to recommend a single figure for the value of a manSievert. Instead, tables are given at two conservative, loan and net discount rates for the value of a

manSievert as a function of exposure time. The base data for the J-value method need to be updated annually, and this means that the values given in the tables will increase over time as people live longer and become richer.

- **Keywords:** Health; Safety; Nuclear; Radiation; Short exposure; Prolonged exposure; Life expectancy; Risk; J-Value; manSievert

**Jianfeng Li, Bin Zhang, Mao Liu, Yang Wang. *Numerical simulation of the large-scale malignant environmental pollution incident. Pages 232-244.***

With the development of economy, the expansion in industrial production resulted in the increase in the number of malignant environmental pollution incidents. The dispersion of toxic gaseous materials was chosen for study in detail, which took the '12.23' Kaixian blowout accident in Chongqing as an example. This paper firstly reviewed the '12.23' Kaixian blowout accident. Then, the physical boundary conditions including initial conditions were outlined to form an integrated mathematical problem. Thirdly, the blowout accident was simulated for a period of 5 h. In term of criteria for acute poisoning, simulation results were analyzed using the concentration slices that can serve for the decision-making. Finally, based on the analysis of simulation result, four important conclusions were put forward that can be used for the design of emergency evacuation routes.

- **Keywords:** Dense gas dispersion; Environmental pollution incident; Complex terrain; FLUENT code; Blow out

**P.J. Thomas, R.D. Jones. *Incorporating the 2007 recommendations of the International Commission on Radiation Protection into the J-value analysis of nuclear safety systems. Pages 245-253.***

The newly released findings by the International Commission on Radiation Protection (ICRP) led to a review of the lifetime risk coefficients for fatal cancer used in J-value analysis of nuclear safety systems. The change in life expectancy a safety system brings about by averting a radiation exposure needs to be estimated in order to calculate the safety system's J-value, and this is done following the ICRP's practice of using risk coefficients that are uniform across both genders and all ages in the defined population group (either workers or the general population). The ICRP predicted uniformly lower radiation risks in 2007 than in 1990 on a like-for-like basis, but it was found that the ICRP's new risk coefficients needed to be multiplied by a compensating factor specific to each population when used in calculating the radiation-induced change in life expectancy. Incorporating the new compensating factor leads to a decrease in the J-value calculated of about 5% for workers and 15% for the general population compared with earlier, reported results. These adjustments are not large compared with the uncertainties associated with radiation harm and the economics of installing a safety system, but will strengthen slightly the case for spending on a nuclear safety measure.

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

**Arvind Kumar Mungray, Pradeep Kumar. *Mass balance of anionic surfactants through up-flow anaerobic sludge blanket based sewage treatment plants. Pages 254-260.***

The outcome of a 21-month monitoring study on anionic surfactants (AS) at five (27–70 ML/d) up-flow anaerobic sludge blanket (UASB) based sewage treatment plants (STPs) is described. The average removals of AS were around 8–30%. Appreciable concentrations of AS were being discharged to the watercourse (average 4.30 mg/L;

range 3.60–4.91 mg/L). On an average dried sludge contained 1452 mg AS/kg dry weight. Mass balance at three STPs indicated that, AS load of the order of 5–17% and  $\approx 12\%$  is removed by adsorption in UASB reactors and polishing ponds (PP) respectively. Biodegradation of AS under anaerobic conditions in UASB reactors and PP does not seem to take place. In the sludge stream, appreciable biodegradation ( $\approx 46\%$ ) of adsorbed AS under aerobic conditions on the sludge drying beds takes place. If influent AS mass flux is normalized to 100 units, than average of  $\approx 74$  and  $\approx 7$  units are discharged with treated effluent and dried sludge respectively, while 12 and 6 units are adsorbed/settled in PP and aerobically biodegrade on sludge drying beds respectively. At two STPs (34 and 56 ML/d), the filterable fluxes in UASBR increased so that the mass balance could not be computed.

- **Keywords:** Anionic surfactants; Up-flow anaerobic sludge blanket reactor; Anaerobic digestion; Mass balance; Sludge drying beds

**Reyad Shawabkeh. *Equilibrium study and kinetics of Cu<sup>2+</sup> removal from water by zeolite prepared from oil shale ash.* Pages 261-266.**

Engineered zeolite was produced from oil shale ash by reaction with sodium hydroxide in a closed vessel reactor. This adsorbent was used for removal of copper ions from aqueous solution. The maximum adsorption capacity was 504.6 mg Cu<sup>2+</sup>/g zeolite. Kinetic studies showed that the rate of adsorption of copper is increased with increasing the solution pH and temperature, quantity of the zeolite and agitation speed. The kinetic data were fitted to homogeneous micropore model and found that the mass transfer coefficient and diffusivity of the Cu<sup>2+</sup> are directly affected by the kinetic parameters. The increase in solution concentration will decrease the mass transfer coefficient while diffusivity is increased.

- **Keywords:** A: Oil shale ash; B: Zeolite; C: Adsorption kinetics; D: Copper

**Davorin Kralj. *Experimental study of recycling lightweight concrete with aggregates containing expanded glass.* Pages 267-273.**

The focus is on the issue of waste management when constructing and recycling lightweight concrete (LWC) with aggregates containing expanded glass. The paper analyses the recycling of concrete from lightweight aggregates, and on the important issue of environmental and waste management. The characteristics of recycling LWC such as density, compressive strength and thermal conductivity are investigated, and compared with normal existing concrete from lightweight aggregates. The results indicate that it is possible to recycle lightweight concrete construction waste. The described method shows great possibilities for increasing the use of construction waste materials from LWC containing expanded glass, in order to benefit from better use of the available capacity from existing construction waste. The characteristics of density, compressive strength and thermal conductivity from the new recycled material were compared with normal existing concrete from lightweight aggregates, such as changes in dependency on the type and parts of waste as well as its new binding components. Thus, a new recycled material has been created with new characteristics of density, compressive strength and thermal conductivity, which is conform to the compressive strength class and rules on heat protection and energy efficiency use in buildings (SI OJ RS No. 42/2002). Laboratory density, compressive strength, and thermal conductivity tests results showed that LWC can be produced by the use of waste LWC with aggregates containing expanded glass. However, the use of waste LWC with aggregates containing expanded glass seems to be necessary for the production of cheaper and environmentally friendly LWC.

- **Keywords:** Concrete from lightweight aggregate; Lightweight aggregate (LWA); Lightweight concrete (LWC) with aggregates containing expanded glass; Recycling; Sustainable development; Waste management

**Hai Zhao, Dexiang Zhang, Fangfang Wang, Tingting Wu, Jinsheng Gao. *Modification of Fe–Mn mixed oxide COS removal sorbent by rare-earth oxides addition*. Pages 274-280.**

In order to develop highly active sorbent for COS removal, Fe–Mn mixed oxides doped with CeO<sub>2</sub>, La<sub>2</sub>O<sub>3</sub> or Sm<sub>2</sub>O<sub>3</sub> were studied. The effects of these promoters on the structural properties of Fe–Mn oxides were investigated by XRD, BET, TPR and TEM techniques. XRD results revealed that the degree of crystallinity of Fe–Mn oxide phase decreased due to the addition of rare-earth oxides. Doping with CeO<sub>2</sub>, La<sub>2</sub>O<sub>3</sub> or Sm<sub>2</sub>O<sub>3</sub> led to an increase in BET surface area of the sample. TPR studies showed that the reactivity of the reduction of doped samples increased in the temperature range of 300–450 °C. In addition, the desulfurization test was performed at 325 °C with a gas hourly space velocity of 1000 h<sup>-1</sup>. It was found that the addition of 3% La<sub>2</sub>O<sub>3</sub> greatly improved the absorption sulfur capacity of the sorbent, while the sorbent doped 3% CeO<sub>2</sub> achieved a sufficiently high purifying degree before breakthrough.

- **Keywords:** COS removal; Fe–Mn sorbent; Doping; Rare-earth oxides