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P.J. Thomas, R.D. Jones, W.J.O. Boyle. *The limits to risk aversion : part 1. : the point of indiscriminate decision*. Pages 381-395.

The paper uses utility theory to investigate how much should be spent to avert all costs from an industrial accident apart from direct human harm. These "environmental costs" will include those of evacuation, clean-up and business disruption. Assuming the organisation responsible will need to pay such costs, the difference between its expected utility with and without an environmental protection system constitutes a rational decision variable for whether or not the scheme should be installed. The value of utility is dependent on the coefficient of relative risk aversion, "risk-aversion" for short. A model of an organisation's decision-making process has been developed using the ABCD model, linking the organisation's assets, *A*, the cost of the protection scheme, *B*, the cost of consequences, *C*, and the expected utility difference with and without the scheme, *D*. Increasing the organisation's risk-aversion parameter will tend to make it less reluctant to invest in a protection system, but can bring about such investment only when the scheme is relatively close to financial break-even. For such borderline schemes, the amount the organisation is prepared to spend on the protection system will rise as the risk-aversion increases. The ratio of this sum to the break-even cost is named the "Limiting Risk Multiplier", the maximum value of which is governed by the maximum feasible value of risk-aversion. However, the mathematical model shows that increasing the risk-aversion will reduce the clarity of decision making generally. Although the reluctance to invest in a protection scheme may change sign and turn into a positive desire to invest as the risk-aversion increases, the absolute value of this parameter is a continuously decreasing function of risk-aversion, tending asymptotically to zero. As a result, discrimination will gradually diminish, being lost altogether at the "point of indiscriminate decision". Here the decision maker will be able to distinguish neither advantage in installing the scheme nor disadvantage in installing its inverse. There is a close correspondence between this mathematically predicted state and that of panic, where an individual has become so fearful that his actions become random. The point of indiscriminate decision provides a natural upper bound for the value of risk-aversion. This bounds the Limiting Risk Multiplier in turn, and so sets an objective upper limit on the amount that it is rational to spend on an environmental protection system.

- **Keywords:** Risk aversion; *J*-value; ABCD model; Reluctance to invest; Point of indiscriminate decision; Limiting Risk Multiplier

P.J. Thomas, R.D. Jones, W.J.O. Boyle*. The limits to risk aversion : part 2 : the permission point and worked examples*. Pages 396-406.

Part 2 extends the analysis to show that it is possible to find the "permission point", the value of (the coefficient of relative) risk-aversion, at which decisions to sanction environmental protection are most likely to be made. The mathematical model describes the process by which the decision maker varies his risk-aversion over a range of feasible values to find the risk-aversion that will give him the greatest desire to invest in the protection system under consideration. If he can find such a risk-aversion before losing discrimination (because the system is too expensive, given its performance), he will adopt it as his "permission point" and decide in favour of the expenditure. The permission point is, of course, bounded above by the point of indiscriminate decision. A maximum Risk Multiplier calculated at the point of indiscriminate decision may be applied to the protection expenditure at monetary break-even to give the maximum, rational outlay on protection. Moreover, it is possible to model how the average UK adult should take decisions on protection to maximise his utility. Different situations will call for different values of risk-aversion, which may explain why economists have come up with differing estimates of this parameter in the past. However, a central, average risk-aversion may be calculated for the average UK adult as 0.85, which is within 4% of the value, 0.82, found from the newly reported method based on a trade-off between income and future free time, and is consistent with several recent economic estimates. Worked examples assess how much an organisation should spend on a protection scheme to prevent accidents with very large environmental consequences.

- **Keywords:** Risk-aversion; *J*-value; Reluctance to invest; Point of indiscriminate decision; Permission point; Elasticity of marginal utility

Ashwani Srivastava, J.P. Gupta. *New methodologies for security risk assessment of oil and gas industry*. Pages 407-412.

The oil and gas industry forms a vital and large part of the economy of any country. It provides crucial support to transport, manufacturing and energy sectors, produces valuable exports and provides huge employment. This industry along with fertilizer plants, petrochemical plants, etc., which handle hazardous chemicals, are potential targets for deliberate actions by terrorists, criminals and disgruntled employees. The process industries face different levels of threats. It is imperative to analyze the entire threat scenario before taking steps to counter it, otherwise each and every threat will have to be treated as most severe, thus resulting in a huge and wasteful expenditure. The Security Risk Factor Table (SRFT) and a Stepped Matrix Procedure (SMP) have been developed to assess the security risk of oil and gas industry as well as the other chemical process industries. While the SRFT deals with the effects of individual threats, the SMP deals with the cascading/domino effects which a lone, low probability event can cause. A case study of a refinery has been performed to show the application of the ideas presented.

- **Keywords:** Security of oil and gas industry; Security Risk Factor Table; Stepped matrix; Character-state tree; Security of chemical process industry

Chun-Ping Lin, Yi-Ming Chang, Jai P. Gupta, Chi-Min Shu. *Comparisons of TGA and DSC approaches to evaluate nitrocellulose thermal degradation energy and stabilizer efficiencies*. Pages 413-419.

This study investigated the thermal degradation energy (activation energy, E_a) for nitrocellulose (NC) with low nitrogen content of 11.71 mass%, so-called NC3, by using two different kinds of thermal analysis instruments: thermogravimetric analyzer (TGA) and differential scanning calorimetry (DSC). A comparison of E_a for various nitrogen content NC samples at two scanning rates (5 and 10 °C min^{-1}) tested by TGA and DSC is

also discussed in this paper. Meanwhile, our aim was to analyze the anti-degradation of E_a for NC with high nitrogen content, as so-called NC1. Thermal stability for NC1 with diphenylamine (DPA) was tested via DSC with 10 DPA concentrations in weights of 0, 0.25, 0.50, 0.75, 1.0, 1.25, 1.50, 1.75, 2.0, and 3.0 mass%. Experimental results indicated that E_a of NC3s was 319.91 kJ mol^{-1}. Moreover, that while dosing DPA into NC1 the best recipe could be employed to avoid any violent NC1 runaway and also can be used to distinguish the differences of thermal decomposition E_a between NC with different nitrogen contents. This study established a fast and efficient procedure for thermal decomposition properties of NC, and could be applied as an intrinsically safer design during relevant operations.

- **Keywords:** Thermal degradation energy (activation energy; E_a); Nitrocellulose (NC); Thermogravimetric analyzer (TGA); Differential scanning calorimetry (DSC); Intrinsically safer design

Daniele Panza, Vincenzo Belgiorno. *Hydrogen sulphide removal from landfill gas*. Pages 420-424.

Control of odours should be considered to be a fundamental issue in order to site, design and manage sanitary landfills. With regard to construction and demolition (C&D) debris, landfilling was the mainly adopted solution in many European Countries; in particular, gypsum drywalls can produce high concentrations of hydrogen sulphide (H_2S) in landfill gas ranging from 7 ppm to 100 ppm. In some cases also dangerous concentrations until to 12,000 ppm were detected. In this paper H_2S removal efficiency in a lab-scale vertical packed scrubber was investigated. Hydrogen sulphide abatement was evaluated for inlet H_2S concentrations of 1000–100–10 ppm, adjusting scrubbing liquid pH in the range 9–12.5 by means of caustic soda (NaOH 2N solution). Moreover, best operating conditions for the system were defined as well as H_2S abatement along the tower and liquid recirculation effectiveness in case of inlet H_2S concentration of 10 ppm (typical odour concentration). Results showed that pH of 11.5 in scrubbing liquid could be considered the best value for removal of different inlet H_2S concentrations, also taking into account parasitical consumption of NaOH due to CO_2 absorption. Moreover, in case of continuous working of the system at H_2S concentration of 10 ppm, strong removal efficiency was already obtained with a packed bed height of about 70 cm. Significant performances were ensured after 1 h of constant activity, consuming about 3 ml of soda per cubic meter of polluted air. Subsequently liquid blowdown was necessary.

- **Keywords:** Hydrogen sulphide; Odours; Construction and demolition wastes; Packed scrubber; pH adjustment

Kuihua Han, Shengli Niu, Chunmei Lu. *Experimental study on biomass advanced reburning for nitrogen oxides reduction*. Pages 425-430.

Advanced reburning (AR) is effective for nitrogen oxides (NO_x) reduction, which integrates the basic reburning (BR) with the injection of nitrogen agents and additive compounds. The basic reburning of poplar, cornstalk, wheat-straw and peanut shell, is studied on a boiler simulator facility (BSF). The influence of operating parameters and the synergistic effect of the injection of ammonia, urea or/and sodium carbonate on NO_x reduction are investigated. The results show that an efficiency of 54–67% NO_x reduction could be achieved during the basic reburning process under the optimum operating conditions and the efficiency would be increased if nitrogen agent is injected with the over-fire air or into the burnout zone. Further, co-injection of sodium carbonate with the nitrogen agent could make the NO_x reduction process more thorough. On the whole, 85–92% NO_x reduction could be achieved during the advanced reburning process with a reburning fuel heat input of 15–20%. **Research highlights:** ▶The herbaceous biomass, such as cornstalk and wheat-straw, is abundant in north China and has being used as single or co-firing fuel in some small power plants. ▶If biomass could be used as the

reburning fuel for NO_x reduction in the conventional coal-fired boilers, more environmental benefits will be achieved. ▶The primary object of this study is to evaluate the performance of different biomass during BR and AR process, and optimize the parameters to get a better condition for NO_x reduction.

- **Keywords:** Biomass; Advanced reburning (AR); Selective non-catalytic reduction (SNCR); Sodium carbonate

Hengyi Lei, Hualiang Li, Zhong Li, Zhaoxu Li, Kai Chen, Xinghong Zhang, Huiqin Wang. *Electro-Fenton degradation of cationic red X-GRL using an activated carbon fiber cathode*. Pages 431-438.

We reported the study of the degradation of the azo dye cationic red X-GRL by the electro-Fenton process using an activated carbon fiber cathode. The electrogeneration of hydrogen peroxide in solution using different material cathodes fed with air was investigated, and the results revealed that the activated carbon fiber cathode was more effective compared to the graphite cathode. The decolorization and mineralization of cationic red X-GRL were also determined. The effect of the operating parameters, such as the initial Fe^{2+} concentration, temperature and initial dye concentration, was investigated. The optimum Fe^{2+} catalyst concentration values for the degradation of cationic red X-GRL was found to be 5 mM. The rate of decolorization and mineralization of dye could be accelerated by increasing the temperature. In addition, the decolorization and total organic carbon (TOC) removal efficiency decreased with the increasing initial dye concentration, while the TOC removal increased. Two different transition metal ions (Cu^{2+} and Mn^{2+}) were applied as substitutes for ferrous sulfate for evaluating catalytic effect. The results indicated that Cu^{2+} and Mn^{2+} were more effective than Fe^{2+} in catalyzing the degradation of the dye. **Research highlights:** ▶The activated carbon fiber cathode was more effective compared to the graphite cathode. ▶The rate of degradation was accelerated by increasing the temperature. ▶The total organic carbon removal efficiency decreased with the increasing initial dye concentration, while the TOC removal increased. Cu^{2+} and Mn^{2+} were more effective than Fe^{2+}.

- **Keywords:** Electro-Fenton; Activated carbon fiber cathode; Cationic red X-GRL; Transition metal cations

Jinghui Zhang, Zhiwei Hao, Zhen Zhang, Yueping Yang, Xinhua Xu. *Kinetics of nitrate reductive denitrification by nanoscale zero-valent iron*. Pages 439-445.

Nanoscale zero-valent iron (Fe^0) was synthesized for nitrate denitrification. The reduction efficiency of nitrate decreased quickly with increasing initial pH value, increased considerably with the increasing dosage of nanoscale Fe^0, and did not vary much with initial nitrate concentrations changing from 20 to 50 mg l^{-1} when the excessive amount of nanoscale Fe^0 was utilized. With reductive denitrification of nitrate by nanoscale Fe^0, the removal rate of nitrate reached 96.4% in 30 min with nanoscale Fe^0 dosage of 1.0 g l^{-1} and pH_{in} 6.7, and more than 85% of the nitrate was transformed into ammonia. Kinetics analysis in batch studies demonstrates that the denitrification of nitrate by nanoscale Fe^0 involves reaction on the metal surface, which fits well the pseudo-first order reaction with respect to nitrate concentration. The observed reaction rate constant of reductive denitrification of nitrate was determined to be 0.086 min^{-1} with a nanoscale Fe^0 dosage of 1.0 g l^{-1} and pH_{in} 6.7. Fast and highly effective denitrification can be achieved by nanoscale Fe^0 compared with commercial Fe^0 powder, this is due to the extremely high surface area and high reactivity for nanoscale Fe^0, which can enhance the denitrification efficiencies remarkably. **Research highlights:** ▶The denitrification of nitrate by synthesized nanoscale Fe^0 is fast and effective. ▶The denitrification depend on initial pH value and the dosage of nanoscale Fe^0. ▶The main end product of the

denitrification is ammonia instead of nitrogen. ▶The denitrification by nanoscale Fe^0 fits well the pseudo-first order reaction.

- **Keywords:** Nitrate; Reductive denitrification; Kinetics; Nanoscale zero-valent iron