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Updating the economic cost of large-scale industrial accidents Application to the historical analysis of accidents

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Abstract

This paper analyses the feasibility of applying different update rates of industrial prices to the economic assessments of accidents with special emphasis on those related to the chemical process industry. The advantages and disadvantages of applying this technique to the historical analysis of accidents are analysed and compared with the results obtained with the five most widely used indexes. The results of a general analysis of the historical evolution of the cost of accidents recorded in two prestigious databases are also presented. Valid data are obtained for decision-making with regard to insurance premiums, revaluation of assets and risk management (administration, safety management of large chemical complexes). © 1999 Elsevier Science Ltd. All rights reserved.

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1. Introduction

The historical analysis of accidents is one of the most commonly used techniques for carrying out complete risk analyses. Its application makes it possible to identify the presence of real hazards in similar situations that have given rise to known accidents. Furthermore, it makes it possible to estimate the consequences that can be expected in a given accident by studying the consequences that the same type has had in the past.

Nevertheless, the results thus obtained cannot be considered definitive, since there are many factors that distort them, including:

1. some hazards present in a given plant may not be taken into account if they have not previously triggered any significant accidents that were adequately recorded. Nevertheless, it is highly probable that the primary accident did manifest itself but that a set of fortunate and random circumstances permitted it to be controlled efficiently. In this regard, according to modern techniques for total loss control, it is important to record all the accidents that occur in a plant even if their consequences are minimum or even null;
2. the scale of a past accident is not necessarily an indication of what can be expected in other similar cases. A large number of factors can alter, aggravate or attenuate the consequences of the event studied; and
3. past experiences, although valid, cannot be directly extrapolated to the present. Modern production techniques, new technologies, and the process conditions and procedures used at a given point in time are not necessarily comparable to those of the past. New hazards are constantly being introduced that were not present in the past and, therefore, have not generated any record. On the other hand, greater safety measures are adopted and more effective means of intervention are available.

In addition, from the point of view of the economic assessment of damage derived from an accident, the following aspects should be taken into account:

4. the concentration of control instruments and the increasingly widespread use of high technology in process plants considerably increases the economic damage derived from accidents, although their scope may be very similar to those that occurred in the past;
5. the criteria for assessing accidents must be revised

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and assumed with caution since currently many factors come into play that were unknown before, such as the analysis and testing of equipment to verify the absence of damage or proper repair after an accident, environmental reparation requirements (clean up) after an industrial accident, increase in the productivity ratio of the equipment, etc. Any assessment of an accident based on past experiences will always have to take an update factor in this regard into account; and

6. if losses for plant downtime were considered, and taking into account that the productivity of modern facilities is much higher than their equivalents in the past, it is not enough to simply update the economic amount for the losses due to downtime, but rather the value of this loss must be updated with the corresponding productivity factor.

After taking all of this into consideration, it is evident that any measure that tends to lessen the discrepancies that exist between information from the past and current reality will contribute to obtaining more accurate and valid predictions. Thus, updating accident costs can allow a much more realistic and accurate economic estimate of the damage that can be expected in a given accident scenario.

Numerous update indexes[1] are published periodically and, since the information available about the economic scope of damage is very limited, any one of them is, a priori, applicable. This paper aims to analyse the feasibility of this application and, if applicable, establish the criteria considered optimum for its use in this field.

2. Application methodology

A cost update index is a value indexed to time which makes it possible, if we know a cost at a given time, t_0, to estimate the cost at time t_1 by simply multiplying the original value by the ratio between the current value of the index and the value applicable at the initial time. This procedure can be expressed as:

$$C_1 \approx C_0 \frac{I_1}{I_0}, \quad (1)$$

where:

C_1	cost at time 1;
C_0	cost at time 0;
I_1	index value at time 1; and
I_0	index value at time 0.

[1] The American Association of Cost Engineers in its Cost Engineers' Notebook (1989) mentions 28 indexes for the USA and Canada and a similar number for other countries.

In any case, the objective is merely to estimate the current cost, and thus figures can sometimes diverge very significantly.

3. Description of the indexes considered

This study considers the following indexes, since they are the most widely used in the process chemical industry: Marshall and Stevens Equipment Indexes (M&S) (Stevens, 1947), Chemical Engineering Plant Cost Index (CEPC) (Arnold & Chilton, 1963; Kohn, 1978; Matley, 1985; Chilton 1959, 1966; Norden, 1969; Thorsen, 1972; Ricci, 1975), the Engineering News-Record Construction Cost Index and Building Cost Index (ENR-CCI and ENR-BC1) (Engineering News-Record, 1988) and the Nelson Farrar Refinery Construction Cost Index (NFCC) (Oil and Gas Journal, 1985).

The Marshall Index, known as Marshall & Stevens, was created in 1937 and provides reference indexes from 1913 (base 100 in 1926). Though not specific to the chemical industry, the index relating to the process industry considers eight sectors with the following proportions: Chemical, 48%; Petroleum, 22%; Paper, 10%; Rubber–plastics, 8%; Paint, 5%; Glass, 3%; Cement, 2%; Clay products, 2%. It can be observed that 70% of this index is based on the chemical or petroleum industries, so it is sufficiently significant for this type of activity. It takes into account the cost of machinery, installation costs, tools, facilities, office furniture and complementary equipment.

The Chemical Engineering Plant Cost Index started in 1963 and provides indexed values starting in 1947. It is specific to the process chemical industry and its main components are: Equipment and machinery, 61%; Construction and installation costs, 22%; Buildings and materials (including labour cost), 7%; and Engineering and supervision, 10%.

The indexes published by the Engineering News-Record, the Construction Cost Index and the Building Cost Index, are applicable to general construction costs and, therefore, are not specific. The main difference between them is labour cost, which is 200 h for the former and 68.38 h for the latter. Moreover, its estimation is based on the average price in 20 United States cities of the following items: 2500 lb of structural steel, 1088 fbm of wood and 2256 lb of cement. Data are available from 1908 onwards.

The Nelson Farrar Refinery Construction Cost Index is specific to the petroleum industry and takes into account the following components: 30% skilled labour, 30% unskilled labour, 20% iron and steel, 8% sundry construction materials and 12% for complementary equipment.

Fig. 1 shows the evolution of these indexes from 1913