Séveso: the crucial question of reactor safety

A technical report on what caused Italy's dioxin disaster has too many loopholes, writes **Alastair Hay**

ITALIAN chemists and engineers investigating the causes of the trichlorophenol reactor accident in which the toxic chemical 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (dioxin) was discharged over the town of Séveso on 10 July 1976 have recently completed their report. Results of the investigation, carried out on behalf of the Italian Judiciary, form the first of several reports being prepared for the prosecution case against ICMESA, Givaudan and Roche, the owners of the trichlorophenol reactor. Other reports expected soon will cover the medical, agricultural, environmental and veterinary consequences of the accident.

The dioxin discharged contaminated a large area forcing over 700 people to be evacuated from their homes. Over 100 children in the area developed mild to severe forms of the disfiguring skin disease chloracne following contact with dioxin. And over 100 Séveso women are reputed to have had abortions — either in Italy or in other European countries — fearing the teratogenic properties of the contaminant; official Italian figures only refer to 34.

Many of the medical consequences of the Séveso accident are not subject to dispute. The long term effects, however, are still a matter of controversy owing to the recently confirmed carcinogenic properties of dioxin. But the subject which still generates real heat is the design and operation of the Séveso reactor. The latest Italian report will add more fuel to the controversy. But sadly, the report has some serious faults, chiefly because it makes claims without supporting evidence and accusations which are not borne out by further investigation. If used as the basis of the prosecution case against the reactor proprietors in its present form, much of it will not stand up to a rigid cross-examination.

The process to make 2, 4, 5-trichlorophenol involves the alkaline hydrolysis of tetrachlorobenzene with sodium hydroxide at a temperature of 170 — 180°C, in the presence of ethylene glycol as a solvent. In the course of the reaction, and particularly at elevated temperatures, two molecules of 2, 4, 5-sodium tricholorophenate condense to form 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin.

Dioxing formation is unavoidable during this process, but the quantity produced can be controlled by keeping down the temperature. Should the temperature rise and reach 230°C an exothermic reaction involving some of the reactor contents is initiated, heat is generated, the temperature rises rapidly and a considerable quantity of dioxin is formed. In a closed reaction vessel such as that used for trichlorophenol manufacture, the rising temperature leads to an increase in pressure and the eventual rupture of the reactor. At Seveso, the pressure blew the safety valve, venting the reactor contents over the residential area nearby.

It is the view of the report that the reactor was unsafe and the three companies involved are charged accordingly. The companies are: ICMESA — owners of the trichlorophenol reactor; Givaudan, ICMESA's parent company; and F. Hoffmann La Roche, of which Givaudan is a subsidiary. The report's clear intention is for all three to share the blame for what happened at Séveso, and the trio have never questioned this.

Also unlikely to be challenged is the report's statement that the condition of the reactor when it was closed down at the end of the run on 10 July 1976 was unusual and that it was the first time it had been left in that condition. Givaudan say this is true. But when confronted with this in court, the company is expected to argue that the reactor should never have been left as it was, but that water should have been added to the reactor after the run to cool the contents. The company also considers that it should have been informed by its subsidiary ICMESA, of any changes in operating procedure before they were introduced.

Solvent ratios — a dangerous deviation?

One of the more serious charges which Givaudan claims it can dismiss concerns the operating conditions of the reactor. The report says that the ratio between the solvent ethylene glycol and the starting product tetrachlorobenzene was too low, and this, it insists, was a "deviation from the process originally developed in [Givaudan's] patent USP 2,509,245, where the critical nature of this ratio was expressly mentioned". In the report's judgement the alteration in this ratio increased the risk of accident.

Givaudan admits that the molar ratio of the two solvents used at Séveso was 5.6 whereas the initial patent recommended a ratio of 8. However, the patent taken out in 1950 makes clear that this ratio was important only for the yield and quality of the trichlorophenol product.

The company's claim is surported by a recent review in the Italian journal *La Chimica el'Industria,* **61,** 108 (1979). Dr Giuseppe Ferraiolo of the University of Genova refers to the critical nature of the ratio between these two compounds. Mentioning various patents for the production of trichlorophenol Ferraiolo shows that only if the ratio is less than 5 is there a danger of an uncontrolled exothermic reaction occurring. Even at a ratio of 5 the reaction remains stable up to a temperature of 240°C.

Givaudan have confirmed they will contest one of the report's suggestions — concerning the relationship between the temperature reached by the Seveso reactor and the quantity of dioxin produced. In the conclusions of their report, the Italian chemists say that it is impossible to calculate the quantity of dioxin produced in the incident from the temperature of the reactor contents, and the concentration of dioxin in the residue left after the accident. No experimental evidence is advanced in the report to support this claim. Givaudan, on the other hand, claim that they have their own to refute it.

For the past three years the company has carried out numerous experiments in an attempt to recreate the conditions which precipitated the Séveso accident. So far this research has been unfruitful and the company is still unable to explain what happened at Séveso. However, what Givaudan does claim is that on the basis of its experiment it can predict how much dioxin is produced simply by knowing the temperature of the reactor contents. The company spokesman claimed that dioxin concentration increases with increasing temperature. This he says has already been reported (see *Nature* **273,** 582; 1978). From their evidence Givaudan claim that 530 g of dioxin was produced of which 240 g was ejected from the reactor. Givaudan calculated that the dioxin content of the reactor was 115 ppm; the Italian report says the measure value is 100 ppm.

Givaudan's experiments are to continue; some results, such as those concerning the nature and properties of the chlorinated phenols produced in trichlorophenol reactors, are expected to be published shortly. Asked to put a time limit on the experimental work Givaudan's spokesman was unable to do so. In the company's eyes, he admitted, this research might be considered "unproductive work". He still regretted, however, the fact that the company had not come up with any answers yet to explain the Séveso accident.

Much of the evidence in the medical and other spheres which will be presented in court aginst the reactor owners will be irrefutable. This, however, is unlikely to be the case where the operation and design of the reactor is concerned. Perusal of this first report of the Italian investigators suggests that they have not done enough homework, and that their prosecution case will be anything but convincing.

It is regrettable that the chemists have not focused more attention on inadequate safety devices for example the lack of a dump tank to contain any overspill from the reactor. The chemists would have been on surer ground here, for in spite of Givaudan's claims that the Séveso accident was 'unforeseen' it happened, and the consequences were appalling. □

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