DISCUSSION OF PAPERS PRESENTED AT THE FIRST SESSION

Mr. R. J. KINGSLEY asked how the Factory Inspectorate communicated its developing thought to practising design engineers. It seemed to be extraordinarily difficult to ascertain what the Factory Inspectorate, as a body, was thinking. The Factories Acts were limited in scope and by no means covered the whole of the experience and judgment of the Department. It seemed desirable for the Inspectorate to publish recommendations from time to time, based on its very considerable experience of hazards in the chemical field. They need not take the form of legislation.

Dr. MATHESON replied that the Ministry issued a large number of publications in the form of pamphlets, booklets, etc., that dealt with questions of industrial safety. Some of them were concerned with fire and explosion and with health risks. It was realised that more were needed and it was intended that more should be issued, but their preparation took time and individual problems—many of them demanding immediate attention—were keeping the Chemical Inspectors busy. In the absence of published information on a problem, however, it was always possible to ask the District Inspector what information was available in the Inspectorate about the matter in question.

Mr. K. M. HILL said that Thackara *et al.* had considered the likelihood of the various hazards which might occur in different sections of plant, and had rated them accordingly. In specifying protective measures, however, they did not indicate whether, in assessing their likelihood and in applying suitable protective measures, they assumed a number of simultaneous failures. In atomic energy it was the practice to design for two simultaneous failures ; more recently designs were on the basis of more or less three simultaneous failures before a hazard was created, and the implication of Thackara's paper was that one single failure, assumed and guarded against, was in itself sufficient.

Mr. THACKARA said that a little guidance was given in the paper, " Where practicable, all **A** hazards (very serious) and **Bl** and **B2** (serious and possible) and **C1** (less serious but likely) are positively guarded against, others are not." The approach examined the consequences of several simultaneous failures. If the results of such a series of failures were held to be very severe precautions would be taken.

Mr. HILL said that he assumed that " positively guarding against " referred to one single measure.

Mr. THACKARA said that if it was possible to guard against a serious consequence of failure by a protective measure achieved either by change in design which eliminated the source, or by a protective device, they would guard against it. The illustrations were a guide and one built up, over a long period, some better yardstick for applying judgment.

Several measure in combination might be used. A simple example was where rate of temperature rise actuators shut down a fan, doused the system with carbon dioxide and water, closed dampers, etc.

Mr. F. E. REUILL also referred to the paper by Thakara *et al.* where it was stated " . . . mixing of two materials giving rise to a high rate of liberation of heat (*e.g.* sodium and water) ".

Mr. Reuill asked if the authors had actually mixed those materials.

Mr. THACKARA replied that the process which gave rise to that example was sodium reduction in the manufacture of fatty alcohol. The process did not involve the addition of sodium to water. Precautions had to be taken against accidental contact.

Mr. H. A. ANSON asked if it was safe to repair, by welding, steel tanks which had been the subject of corrosive attack by mineral acids and what precautions had to be carried out to remove any residual hydrogen.

Mr. Anson wondered if there were any incidents on record which might be attributed to the presence of residual hydrogen in the structure of the metal.

Dr. MATHESON said that such a vessel could be repaired safely by welding, but stringent precautions would have to be taken in purging the vessel to ensure that hydrogen was removed from every corner and cranny. If further precautions were considered necessary the vessel could be charged with inert gas, or a continuous and copious current of air could be maintained through the vessel to prevent residual traces of hydrogen from forming local flammable concentrations.

There were no recorded incidents of explosions during the repair of such tanks.

Mr. J. A. ROBINS said that Dr. Matheson had mentioned a number of instances of explosions of carbonaceous dust. Could he say whether there were any known cases of explosions due to coal dust in conveyors, for instance, between coal stocks and overhead storage in a power station.

Dr. MATHESON replied that there were not any examples in actual coal conveyance. Certainly, they had had a number of explosions with pulverised fuel. In his recollection, in the earlier days, such explosions were all associated with the cyclones to which the pulverised material was delivered before it was distributed by means of one conveyor to the bunkers in front of the boilers. In more recent times they had been associated with the combined mill and classifying system which had a capacity of a similar order to the cyclones which were used in the earlier days, and were considered to be associated with flash-back from the actual boiler, the pop in the actual combustion chamber striking back and reaching its maximum violence in the classifying system. But, in the actual conveying system for coal as distinct from a pneumatic conveying system for pulverised fuel, he could not think of any.

Mr. G. V. DAY asked if Dr. Matheson would comment on the approach and the standard adopted abroad, particularly on the continent, with regard to some of the hazards and problems he had discussed, and would he mention any differences or particular points.

Dr. MATHESON replied that he had not had much opportunity to make a systematic comparison of foreign standards with those of the U.K. Sometimes it seemed that more reliance was placed abroad on personal protection in the form of overalls and respirators, while in this country first thought would be to provide precautions on the plant to prevent, as far as possible, the dangerous material from getting from the plant to the man. But that was merely a difference of emphasis—both forms of precaution were used generally.

He had noticed that America and Britain had kept pace with one another remarkably closely in developing standards to deal with risks associated with industrial explosions.

Mr. D. M. ELLIOTT referred to bucket elevators which Dr. Matheson had mentioned on page 3 of his paper. What did Dr. Matheson term a safer type of elevator ?

Dr. MATHESON replied that, in the bucket elevator there was an air space down which dust could and did drop from the throw-off point at the top thus giving rise to a dust cloud inside the elevator casing. Experience had shown that, at times, this dust-cloud was present in the form of a flammable concentration.

Certain elevators such as vertical worm elevators and some types of " en masse " elevators did not have a space in which an explosive dust-cloud could form. In addition there were elevators that raised dusts and powders in a fluidised condition. Those were the elevators that he had in mind when he referred to safe types of elevator.

Mr. K. M. HILL said, with regard to the use of instruments for safety protection, if one looked at the instrument maintenance record, one found one had 95% or 90% reliability of a particular instrument ; unless one was going to duplicate all instruments, how did one overcome the problem of probiding real safety from instruments which could not be relied upon all the time.

Mr. ISAAC replied that he had attempted in the paper to stress the important factors in designing instrumentation systems to give a high degree of reliability. He agreed that if any particular installation gave a serviceability of only 90—95% it did not constitute a very positive safeguard. However, most modern instrument installations could give very much better performance. He stressed that simplicity and reliability were the main requirements and that demanded high quality engineering, equipment, and maintenance, which of course involved cost but nowhere on a plant was expenditure better justified.

Failure of instrument power supplies or similar eventualities could be guarded against by the use of " fail safe " systems.

Duplication of alarm equipment and the " 2 out of 3 " principle had been mentioned as the ultimate case. The latter was justified in the field of reactor protection in view of the fact that the complex nucleonic measuring circuits used were not as reliable in performance as, say, a simple thermometer.

The use of two independent and different systems for a single variable was common. For example, on oil pipe-lines pump suction and delivery pressures were the critical variables and these were normally measured by independent recorders and pressure gauges with the alarm from yet another independent pressure switch. For maximum safety independent pressure tappings are used.

In the paper, mention was made of vapour phase oxidation ratio alarms. In such cases it was usual to duplicate the whole measuring installation and the alarm devices for maximum protection.

Mr. P. GRANTHAM asked Mr. Isaac if he had found any way of guarding against fuse failure.

Mr. ISAAC replied that he felt that that was a most critical and practical point. Failure of fuses in alarm circuits was a potential hazard but if interlock shut-down operators were also involved the effect could be very serious as it would shut down the plant. Clearly the solution lay in careful attention to the electrical distribution circuitry allocating the critical circuits individual fuses and connecting them into the supply on mains fuses not normally subject to overload. Careful engineering was needed at an early stage in the layout to select the least vulnerable mains supply. The use of low voltage circuits (*e.g.* 24v) permitted working on an alarm system without isolating the supply.

Mr. V. KENWORTHY said that he had always felt that if one could devise a practical checking system for instruments everyone would be very much happier. For example, when passing a sensitive element point on the plant, as one went past, one could press a button to simulate an effect, and test the whole system throughout, right back to the recorders or controllers.

Mr. ISAAC replied that some measure of test facility not greatly different to that described was frequently available, *e.g.* test switches on multi-point temperature indicators. However, it was more normal to provide test features only on the alarm devices and relays to simulate the initiation device. That had been described. To go further than that the problem lay not so much in the production of the test signal as in the interpretation of its effect. That was more the concern of the skilled instrument mechanic.

It was common practice on plants with comprehensive safety-shut down systems to test them by using them to shut down the plant when it was necessary to cease operation for a period. That is, an alarm condition was deliberately produced and the plant allowed to shut down automatically. That provides the best and most practical test but, of course, only on infrequent occasions.

Mr. A. P. OELE asked if there was an essential difference between the fully electronic installation and the pneumatic system, from the standpoint of safety.

Mr. ISAAC was reluctant to generalise since the answer might well be confused by considerations of the equipment's mechanical performance. Assuming that to be equal the main difference was in the nature and reliability of the power supply. The storage capacity of the receivers in a pneumatic installation did allow several minutes' margin of safety in the event of power failure whereas any electric system would be seriously upset by only a few seconds interruption of power. Normally therefore, standby power supplies of some sort are necessary. Where electric/hydraulic valves were used they did not normally have one direction of failure if the signal failed. Air-operated valves, however, were spring-opposed and would normally open or close as required in the event of power failure.

In general, however, while each type had its own characteristic requirements from the safety standpoint, there was no reason why either should not provide a safe and reliable installation if the requirements were observed.

Mr. C. K. W. COLSON wrote :

Electrical equipment which carries a Buxton flame-proof certificate is not certified as safe in atmospheres of hydrogen. What equipment for lights and motors would Dr. Matheson recommend for use in a building where hydrogen might be present ?

On the writer's works there are pneumatically operated hammer-guns using beryllium-copper needles. Would Dr. Matheson say that it was safe to use them in buildings where inflammable vapours might be present ? They will not themselves cause a spark, but can a spark be caused by fast-flying chips of rust ?

Dr. MATHESON wrote in reply to Mr. Colson :

A pressurised system might be used for hydrogen. Controls for such a system to cut off the supply when the pressure falls are available commercially. In addition, complete pressurised systems are also commercially available. Otherwise the lighting would have to be installed outside the room in question, and the light transmitted through sealed windows.

These remarks also apply to motors. When, however, the motor is outside the room, it drives the plant by a shaft passing through a gas-tight gland in the separating wall.