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SCIENCE NEWS

SEVERE ACCIDENTS

Utilities worldwide are paying increasing attention to operator training, with emphasis on enhancing operators' ability to recognise abnormal plant conditions — especially slowly evolving small leaks or transients, which are much more likely to occur than potentially more severe accident sequences such as those triggered by major pipe breaks.

The underlying thinking is that slavish adherence to the rule book can sometimes lead operators into error. The TMI-2 accident was triggered by equipment failure of a type which *had* been considered in earlier safety reviews, and for which operating procedures to shut the reactor down safely *had* been devised. But the operators did not correctly understand what was happening, adopted procedures which turned out to be "wrong", and thereby compounded the severity of the accident.

Much the same thing happened at Chernobyl, although in that case the operators did of course depart from the rule book. They did not understand what was happening. But it began with a slowly-developing chain of events which culminated in a catastrophe.

At the post-accident review conference, convened by the IAEA in Vienna in August 1986, the Soviet authorities presented data on the cause of the accident and its consequences within the Soviet Union. After that meeting, the IAEA's International Nuclear Safety Advisory Group (INSAG) presented an analytical summary report concluding, inter alia, that the accident represented "almost a 'worst case' in terms of the risks of nuclear energy." INSAG noted that there had been at least three accidents involving power excursions in reactors before Chernobyl (NRX, EBR-1 and SL-1), and went on:

As described by the Soviet experts and discussed in detail among the experts, the accident was caused by a remarkable range of human errors and violations of operating rules in combination with specific reactor features which compounded and amplified the effects of the errors and led to the reactivity excursion.

There is no escaping the conclusion that however well-trained and for whatever reason, operators have made and will make mistakes. What then can be done to prevent severe accidents? INSAG have recently produced a document outlining *Basic Safety Principles for Nuclear Power Plants*, which promotes the establishment of a "safety culture" to motivate all parties to achieve excellence.

All this forms background to the convening of a symposium on severe accidents — defined as those resulting in significant core damage — held in Sorrento, Italy, in March this year. It was co-sponsored by the IAEA and by the Nuclear Energy Agency of the OECD, and was hosted by the Italian National Commission for Nuclear and Alternative Energy Sources. More than 300 nuclear power plant operators, engineers, industry officials and government representatives, from 35 countries and three international organizations, took part.

The key role of the operator was stressed repeatedly. A. M. Bukrinski and V. A. Sidorenko, from the USSR State Committees for the Utilization of Nuclear Energy, and Safety, for example, stressed the importance of INSAG's *Basic Safety Principles*, terming them "a qualitatively new conception of modern safety philosophy."

They argued that "it has ultimately become clear that design basis accident orientation is insufficient for reaching the highest level of safety... Human factor duality is once more revealed: on the one hand as a source of unpredictable mistakes, and on the other hand as the main figure in crisis situation management." The *Basic Safety Principles* and their possible implementation were further discussed at a special panel session in the course of the symposium.

To many participants the real highlight of the meeting was a presentation by Edward R. Frederick, one of the operators who was on duty at TMI at the time of that accident. He suggested that those concerned with accident prevention and management should recognise that when a transient occurs the operator is faced with an enormous amount of data which is being presented to him, and changing, very rapidly. The operator has to evaluate quickly perhaps several hundred normal and "abnormal" instrument readings, some of which may not be reliable. "To assimilate all the data correctly and take correct action, and verify the effect and evaluate the resultant plant behaviour is something you cannot imagine unless you try it."

Further, although some problems can be avoided by good design, "once a transient begins, with multiple failures, only well-trained operators and excellent procedures can help."

The operator must never be placed in a situation which an engineer has not previously analysed; and an engineer must never analyse a situation without observing the operator's reaction to it. "That is where simulation comes in. It is not just a training tool: it is a tool to test design in-depth of procedures."

Frederick noted that operator training prior to TMI had been based on engineering which tended to maximum conservatism, in an attempt to protect against worst-case accidents; but some more "realistic" scenarios which could lead to core damage had been virtually overlooked. Little consideration had been given to the effects of small leaks or transients that could evolve over long periods of time. It had been a similar slowly developing confusion of events which led to the catastrophe at Chernobyl.

"If I had to choose only one form of training, symptom based emergency procedures is all that I would need," said Frederick. "I don't recommend rejecting engineering modifications, but the most effective weapon an operator has against an unknown problem is the training he has received."

He went on: "Some of the links in the nuclear safety chain are not as strong as we would like them to be. Earlier this year a review reported a transient which should ring some alarms. The operators experienced an undetected LOCA: it sounded very similar to the TMI accident. The similarity between that and the root causes of the TMI accident was remarkable. Some of us would have thought it impossible. In this case, one or more links in the chain were broken..."

"It is not enough to have dusty volumes of data. Each utility should have the attitude: 'It could happen to us.' Accident management happens before the transient, not after."

Frederick also made the commonly expressed point that "each additional back-up system makes the system more complex and therefore more susceptible to failure, and more difficult to understand. It is most important to keep things as simple as possible — easily understood, and based on fundamental principles."

Lastly, there was again criticism of the use of calculated probabilities of transients such as 10^{-5} or 10^{-6} per year. Frederick urged that they really mean very little. Recalling his own experience, he pointed out that if an operator was convinced that a system was working well when in fact it was not, the result could easily be that he took an action which he believed to be correct when it was in fact quite inappropriate. "If your number is 10^{-6} I think you should add at the end 'plus human confusion'."

Policies and practices

There were papers describing national policies and practices for severe accident management from countries including France, Japan, Sweden, the Fed. Rep. of Germany, the United States, Italy and the USSR. It is clear that a great deal of work is being done in attempts to prevent, better identify, and effectively manage potential accidents resulting in significant core damage. Other sessions at the symposium centred on severe accident analysis and related research, including work on the TMI-2 core which is providing a better base for realistically modelling core melt phenomena. The Proceedings of the symposium will be published shortly.

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