United Kingdom

PWRs unlikely to be safe, says metallurgist

CRACKS in the pressure vesels of pressurised water nuclear reactors would be very difficult to detect before they led to catastrophic failure, Sir Alan Cottrell, ex head of the University of Cambridge Department of Metallurgy, told the House of Commons Select Committee on Energy last week. Britain should therefore reverse its decision to build a series of PWRs, and adopt the advanced gas-cooled reactor instead, he argued.

Sir Alan appeared undismayed by the delays in the UK's AGR programme. "They are constructional" he told *Nature*. "The Hinkley Point AGR has performed extremely well." (Hinckley Point, the only AGR in operation, achieved 80% of its design capability in 1979, with an output of over 1000 MW, the Central Electricity Generating Board said this week.)

Sir Alan's first objection to the PWR was that it uses water rather than carbon dioxide as a coolant. "There is a natural safety in CO_2 which H_2O lacks" he says in his written evidence. This is that CO_2 remains gaseous under all reactor conditions, whereas H_2O can exist in two phases — liquid and gaseous — "with very different densities, coolant properties, heat contents, and pressure-volume-temperature relationships".

This leads to two safety disadvantages. First, a PWR must be operated at 150 atmospheres pressure to keep the H_2O liquid at its operating temperature of 320°C; and second "the problems of controlling an irregularity in the operation of a reactor are exacerbated if there is a risk of the coolant suddenly changing its physical state and losing its coolant properties".

The problems which faced the operators at Three Mile Island — "the speed of changes in the reactor, the false indications of the physical state of the coolant, the rapid overheating of the fuel due to the disappearance of the water" — would not have arisen in an AGR "with its lower power density, large mass of heat-absorbing graphite and invariably gaseous CO_2 coolant".

The second objection Sir Alan raised was that it would not be possible to detect a crack in the pressure vessel by the leaking of radioactive material until it was too late.

"To hold the water pressure, the walls of a PWR vessel and circuit have to be thick, up to 14 ins in places, and are made of a fairly hard, strong steel. The thickness and hardness deny the possibility of 'leak before break'. For under these conditions, the critical crack size at which a sharp crack will spread rapidly and uncontrollably is expected normally to be about four inches but could be as little as one inch under fault conditions. It follows that, if a wall becomes perforated by a growing crack, while under operational pressure, the crack is already unstoppable and will spread to form a major break within a millisecond."

"The security of the reactor thus depends on the avoidance of critically-sized cracks or similar defects in the steel."

Dr Walter Marshall, deputy chairman of the United Kingdom Atomic Energy Authority, had chaired a study of pressure vessel integrity and concluded, according to Sir Alan, that "the assurance of initial safety depends on meeting a number of exacting conditions about standards in workmanship, care in operational control, and rigour in inspection". These conditions, said Sir Alan, "call for considerable human abilities". It was a matter for general judgement "whether this degree of reliance on human abilities provides an adequately sound basis for the safety of a nuclear reactor".

Another worry, said Sir Alan, concerned the possible growth of small cracks, harmless at first, due to metal fatigue and corrosion. If these were discovered (as they have been in some French PWRs) there would remain the problem of repair in reactor conditions.

"The task of developing new equipment to grind out and soundly weld up cracked regions in radioactive steel, remotely by automatic methods, is a formidable one. But if such cracks were allowed to remain and were then to grow large, a government would be faced with a most difficult decision: either to take the chance of running the reactor . . . or to shut-down the reactor at a fraction of its planned economic life."

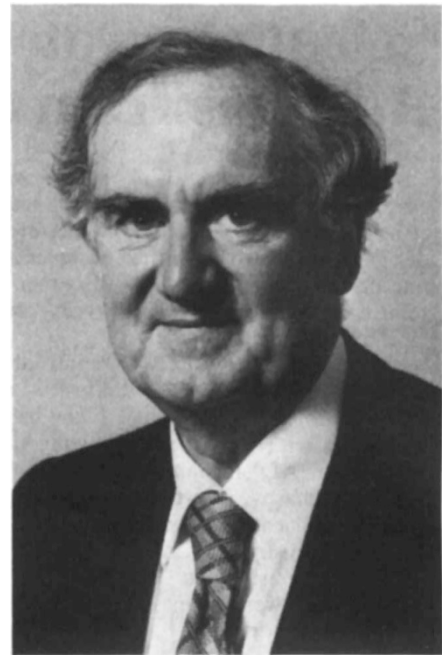
"The long-term value of PWRs may thus depend on the development of a new technology for the remote repairing of thick radioactive steel."

Dr Walter Marshall said on Monday that he accepted the technical basis of Sir Alan's arguments as "correct and completely valid". But "by selecting facts you can give the wrong impression".

For example, on the positive side of water as a coolant is that it is also a moderator — so loss of coolant will also stop the nuclear reaction.

On the "considerable human abilities" required of pressure vessel manufacturers, Dr Marshall said "there are firms abroad that can attain the necessary standards. For example, we could get steel from Japan; and among others Framatome in France and GHH in Dusseldorf could fabricate the vessels."

Was it wise to rely on Framatome, which has discovered cracks in pressure vessels it has built for French reactors? "Well, their big advantage is that they are busy. They may have made one boo-boo but they've learned from it."



Sir Alan Cottrell: doubts about pressure vessel integrity

"The technology is moving to larger and larger forgings" said Marshall "which you weld together. So ultimately it's the steel manufacturer who matters most. In England River Don in Sheffield could do it."

Dr Marshall does not want to be "sloppy" about inspection. "I want to be able to lay my hand on my heart and say, that one's OK." He would like to have "the full resources" of the UKAEA behind him; the authority itself should be the inspectorate.

If cracks are found, they must be repaired *in situ*, a task which will not be impossible, thinks Marshall. "You would grind out the crack, and not bother to replace the cladding. The water would just get a little rusty." Six specially protected divers successfully replaced the complete reactor support structure under water inside the 'Stada' German reactor in 1973, said Marshall.

Monitoring known cracks, like Framatome's, would not be difficult, but "the most sophisticated, the fundamental question is whether your initial inspection misses any cracks. I couldn't emphasise the importance of the initial inspection too much" said Marshall.

Commenting on Dr Marshall's remarks Dr Cottrell told *Nature* that he feels Dr Marshall has underestimated the repair problems but "we agree on most technical questions; we differ on where we go from there. I take a less cheerful view on whether this rigorous inspection can be achieved. In my view, it's simply asking too much."

Robert Walgate

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