A Brief Review of the Accident at Three Mile Island

by G.R. Corey

It is too early to draw hard conclusions about the significance of the recent events at Harrisburg However, I believe that a number of preliminary observations can be made and several tentative conclusions drawn. With this in mind, let me pose a few specific questions – and try to answer them.

1. What happened at Three Mile Island?

Answer: A series of apparent errors and equipment malfunctions, coupled with some questionable instrument readings, resulted in loss of reactor coolant, overheating of the core, damage to the fuel but probably no melting, and limited releases outside the plant of radioactive noble gases and iodine.

2. What about the hydrogen bubble?

Answer: Hydrogen gas was formed, primarily by a reaction between zirconium and water, which is not unexpected when core overheating occurs. There was never a danger of the bubble inside the reactor vessel exploding because there was no oxygen present inside the vessel. There was the possibility of small localized explosions or hydrogen puffs within the containment building outside the reactor vessel, but the risk of significant consequences appears small because the force of such puffs was far less than contemplated in the containment design.

3. Didn't the Nuclear Regulatory Commission (NRC) say just the opposite, that the bubble might explode?

Answer: Yes they did. While they have admitted their error, that admission has not received much publicity. As a result, the public's confidence in nuclear power has been seriously undermined.

4. Did the NRC really admit they were wrong about the bubble?

Answer: Yes.

On April 10, NRC Chairman Joseph M. Hendrie, testifying before the Senate Subcommittee on Nuclear Regulation, told Senator Pete Domenici, "The possibility of a flammable mixture turns out to have been a misplaced concern." According to the April 1979 information bulletin of the Atomic Industrial Forum (AIF), Hendrie explained that it took the NRC a couple of days before its analyses showed that "there hadn't been any oxygen involved or very little, if any."

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The AIF bulletin reported that Domenici termed it "very serious" that the NRC was "communicating the possiblity of the worst when merely an analysis, a proper analysis, of the fact would have put that in a different perspective." To which Hendrie replied [according to the AIF]: "I'm not sure the NRC – I'm not sure who – was issuing the kind of drastic reports you indicated, because it is, in retrospect, now kind of a jumble."

Three weeks later, the **Washington Post** of May 2, 1979, quoted Roger Mattson, director of the NRC's division of systems safety, as saying that incomplete information led to erroneous worry about the possibility of a hydrogen explosion that would break open the containment. " 'There was never any danger of a hydrogen explosion' of that much power, Mattson stressed. 'We just asked the staff the wrong questions, and that is a very bitter pill.' "

On the same date, the **Atlanta Constitution** reported on the matter as follows:

"A Nuclear Regulatory Commission official said Tuesday the agency had been wrong when it reported a risk of explosion in the hydrogen bubble that formed inside the stricken Three Mile Island nuclear reactor last month.

" 'We fouled up,' said Roger Mattson, director of the NRC division of systems safety.

"But he said NRC technicians didn't realize for 36 hours that the danger was not present.

" 'The amount of concern was entirely undeserved. There never was any danger of a hydrogen explosion in that bubble,' Mattson said. 'It was a regrettable error .... It originated in the staff.' "

None of the foregoing reports bore the headlines they deserved. Indeed, some of the news media failed to report the matter at all. And virtually no one has stated publicly that, throughout much of the crucial period, numerous experts, both on-site and off, were assuring the government staff people that there was no danger of an explosion inside the reactor. Such assurances were given as soon as the experts were made aware of the worries – certainly as early as Sunday, April 1.

5. What were the maximum radiation levels in the vicinity of Three Mile Island?

Answer: The maximum total increase in radiation measured at ground level, just outside the plant boundaries, was less than 100 millirem, according to the Nuclear Regulatory Commission. While hardly anyone was stationed just outside the plant, 24 hours a day for that entire week, anyone so stationed would have received a radiation dose roughly equivalent to the amount by which annual background radiation in Denver or Manhattan exceeds that in Boston or Chicago.

6. On the average, how much radiation was the public exposed to?

Answer: Less than two millirem per person, according to Secretary Califano's May 3 testimony before a Senate Committee. In that testimony, Califano said radiation levels were double the previous estimates. This part of his message was spread in headlines round the world. But the extent of the radiation exposure was not clearly understood. He said that the 2 000 000 people living within 50 miles of Three Mile Island had been exposed to a total of 3500 man-rem. This works out to an average exposure of 1.7 millirem per person in the Harrisburg area, approximately the same as the additional background radiation which a resident of Manhattan or Denver receives *every week,* compared with say Boston or Chicago – or Harrisburg.

According to the May 4 issue of the **Chicago Sun-Times,** Senator John H. Glenn, Chairman of the Senate Subcommittee on Governmental Affairs "took note of the fact that even 1.7 millirem is a tiny amount of radiation alongside the amount routinely absorbed each year by most U.S residents from natural background and medical X-rays.

" 'This is very encouraging,' Glenn said [according to the Sun-Times]. 'Maybe it will keep people from being scared out of their wits.' "

In reporting on Secretary Califano's testimony, most of the news media understandably played up the doubling of the previous estimate, from 0.9 millirem to 1.7 millirem per person and the possibility of at least one resulting cancer death, possibly more, but failed to mention Senator Glenn's comment. However, the **Chicago Tribune**'s May 4 report of the Seante hearings took note of the fact that approximately 325 000 cancer deaths would be expected to occur naturally in the population living within 50 miles of Three Mile Island.*

7. What about the General Public Utilities (owner of Three Mile Island) employees?

Answer: Twelve received a dose of between two and three rem; three received a dose of between three and four rem. The maximum allowable dose under NRC regulations is three rem per quarter or an annual average of five rem.

8. Nonetheless, wasn't Three Mile Island the worst radiation release ever from an operating reactor?

Answer: No. The release in October 1957, following the accident at Windscale in northern England, was far greater than Three Mile Island.

A fire in the graphite core of the Windscale reactor burned continuously for several days. The radiation fallout resulted in some of the milk from cows in the surrounding area showing radioactivity levels at milking time as high as 800 000 picocuries per litre – 40 000 times the levels observed at Three Mile Island.

According to Dr. John Rundo of Argonne National Laboratory, the environmental consequences of Three Mile Island were significantly less than those of the Windscale accident. (Dr. Rundo was present at Windscale during or shortly after the 1957 accident.)

Even as far as 100 miles away, at Leeds, levels of radioactivity in milk were nearly 40 000 picocuries per litre on October 16, a week after the accident. Also there was a ten percent increase in background radiation at Leeds resulting from radioactivity deposited on the ground.

By contrast, at Three Mile Island, up to May 4, 1979, the NRC had reported no noticeable radiation in soil or water samples taken in the vicinity of the station. There appear to be

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* The estimate of one additional cancer death results from applying to the 3500 man-rem exposure estimate, a U S Environmental Protection Agency formula which suggests that public exposure to radiation may result in one additional fatal cancer for each increase in aggregate radiation over background of approximately 5000 man-rem. Many believe this formula to be too conservative Indeed, the two million people living within a 50-mile radius of Three Mile Island are already subjected to far more background radiation than this – about 200 000 man-rem annually – and this 200 000 figure is, in turn, substantially less – by perhaps 100 000 man-rem – than the annual background dose to which a similar number of residents of Manhattan are exposed every year, due to the radiation naturally occurring from the large concentration of granite, cement and brick.

traces of radioactive iodine in milk – but only 20 picocuries per litre which is far below the Food and Drug Administration's recommended action level of 12 000 picocuries per litre.

9. Will an accident like Three Mile Island happen again?

Answer: I doubt it but it could.

10. Was Commonwealth Edison shaken by Three Mile Island?

Answer: Of course. First, we were all very concerned about the accident itself Second, we were shaken by what appears to have been a significant over-reaction of the news media and various government agencies, in the absence of good information. Third, we are determined to learn all we can from what happened at Three Mile Island in order to reduce the probability and consequences of another such occurrence.

11. What lessons do you expect to learn from Three Mile Island?

Answer: It is probably too early to draw broad conclusions before the various investigating bodies have had time to review and evaluate what happened. Nonetheless, several tentative observations can probably be made, without much fear of being wrong, as follows:

A. Three Mile Island provided a real-life test of reactor safety systems.

In spite of all the errors and malfunctions, the reactor containment systems at Three Mile Island were extremely stable, they stood up under many shocks and, although the fuel was severely damaged, the reactor vessel and secondary containment appear intact. There never was serious danger of catastrophic failure.

B. We at Commonwealth believe that the ultimate effect of the Three Mile Island accident will be beneficial.

The immediate effect of the accident was to raise questions and slow down the development of nuclear power. Its secondary effect has been to stimulate a wide discussion of energy options. Its long run effect, therefore, should be to help us all – both the public at large and the technical community – to face up objectively to our energy supply problems.

Three Mile Island has not changed our energy options. Oil is running out and, for the next 20 or 30 years, we must rely primarily upon coal and nuclear.

The initial reaction to Three Mile Island has coupled demands for a nuclear moratorium with widespread discussion of energy options. Such discussion often terminates with a spirited call for the continued search for new alternatives, which is all to the good. However, like the search for the Holy Grail, such efforts offer no immediate relief to high gasoline prices, shortages of fuel oil and possible economic slow downs if industrial production is curtailed by energy shortages. Thus our energy policy discussions must ultimately come back to hard choices, which democracies are reluctant to make and often must be forced into. We may find Three Mile Island to be the incident which forces us all to face up to the hard choice of continuing to pursue the only available near-term energy options – coal and nuclear.

C. There are several non-technical lessons to be learned from Three Mile Island, beyond those which have already been widely discussed.

(i) Good training of nuclear reactor operators and frequent re-qualification of such operators are essential. This means that existing training programmes will almost surely

have to be modified. It appears that more emphasis should be placed on handling relatively small operating malfunctions to avoid having them grow into big ones, rather than concentrating upon extremely unlikely events.

(ii) Regulatory practices need overhauling. The continued development of new and improved operating procedures requires increased imagination and flexibility on the part of both operators and regulators, a readiness to accept changes for the better, and less emphasis upon procedural requirements (like logging the locking or unlocking of an access door) which are largely unrelated to station operation but which by their unrelenting inflexibility may occasionally detract from the safety they are intended to enhance.

(iii) Substantial financial risks can be involved in a nuclear malfunction. Replacement power is said to be costing General Public Utilities over $20 million a month. This suggests consideration of some form of risk-sharing insurance. I am now heading an Ad-Hoc Committee which is examining the possibility of establishing such insurance for U.S. nuclear plant owners and operators.

(iv) The financial risks, coupled with continuing need for careful management control, suggest that nuclear plants be operated by substantial organizations having responsible management in depth, which is committed to the development of well-trained personnel and the use of expert control techniques.

(v) The increased perception of financial risk may be the most significant deterrent to nuclear power development growing out of Three Mile Island.

(vi) International standards for nuclear power are as vital as domestic standards. We must be sure that nuclear plant owners and operators throughout the world are qualified, well-trained and competent, as measured against internationally accepted standards. Properly administered, such requirements may provide a model for dealing with weapons proliferation as well.

D. It is too early to draw broad global conslusions from Three Mile Island — too early to make final judgements.

The immediate result of the eqpisode has been to encourage a plethora of broad generalizations and conclusions — first, from numerous editorial comments provided by an army of news gatherers who were hampered by lack of hard information; more recently, from all manner of people who would use Three Mile Island as justification for new energy policy directions.

While I am tempted to say that we will find, when the dust has settled, that the potential danger was significantly overstated, I am inclined to delay drawing any broad conclusions about the accident. While I do not know where the discussions growing out of Three Mile Island may lead us, my impression is that these discussions so far have been less emotional and inflammatory in the USA than in Europe.

I am also unwilling to comment on the effect of Three Mile Island on future electric utility financing costs. Only time will tell. The actions of the regulatory commissions will certainly be an important factor in determining the long-run attitude of investors.

IN CONCLUSION

It is unfortunate that there was so much hysterical misinformation about Three Mile Island.

It is unfortunate that the government staff people mistakenly suggested that the hydrogen bubble inside the reactor vessel might explode.

It is unfortunate that the NRC's admission of error on that score received so little attention and that Senator Glenn's May 3 observations as to the small amount of radiation exposure was not widely reported.

It is particularly unfortunate that in this age of instant wisdom many of us feel obliged to draw hasty conclusions and then, like one recovering from an overnight drunk, are reluctant to admit our mistakes when morning comes — reluctant, for example, to assess what the Three Mile Island danger really was when viewed in the cold light of day.

When I first read A.E. Housman's *Shropshire Lad,* I was impressed that, upon awakening after a night on the town, Terence was able to admit his mistakes of the night before:

"Then I saw the morning sky:
Heigh-ho, the tale was all a lie;
The world, it was the old world yet,
I was I, my things were wet,
And nothing now remained to do
But begin the game anew."

Would that we could all be as perceptive as Terence, and as humble in assessing what went on at Harrisburg. And we have more to lose from an incorrect assessment of that accident than a bundle of wet clothes.

Some would have us use the hysterical first impression of what happened there as an excuse to deny a technology which is providing the free world with energy equivalent to nearly a billion barrels of oil a year. As has been said by Chancellor Schmidt of West Germany, the withholding of nuclear technology could mean that the benefits of nuclear will be lost for the future.

In closing let me say that we at Commonwealth Edison know that the Three Mile Island accident may slow down the development of nuclear power, but we also know that it does not justify abandonment of the nuclear option. We are firmly dedicated to minimizing the use of oil in the generation of electricity and we shall continue the development of a judicious mix of nuclear and coal-fired generation.