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Your reference

Our reference

Date 30 November 1979

D A R Howell Esq., MP
Secretary of State for Energy
Thames House South
Millbank
London SW1P 4QJ

Dear Mr Howell,

The Health & Safety Executive has asked me to send you their report prepared in response to your letter to the Chairman of the Health & Safety Commission dated 9 November 1979. The Executive plans to have copies of the report available for publication early in the week beginning 10 December. If an earlier publication date is needed I should be grateful for an early telephone call from your office.

I am sending a copy of this letter and the report to Mr Younger and copies of the report to your department. Subject to your views I have no objection to its going, in confidence, to the other recipients of your letter of 9 November.

*Yours sincerely
H J Dunster*

H J DUNSTER
DIRECTOR OF NUCLEAR SAFETY

- cc. Rt. Hon G Younger
Mr B G Tucker
Mr W Simpson
Mr J F Locke
Dr K P Duncan
Mr R Causden

SECRETARY OF STATE FOR ENERGY

Tim Hirst

FOR AT THE ...
DATE ... IF ...
12/12/79

*Miss ...
Miss ...
Miss ...
Mr. Scientist
Mr. Tucker
Mr. ...
Mr. ...*

MEMBERS IN CONFIDENCE

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HSC/79/132

HEALTH AND SAFETY COMMISSION

A Report to the Secretary of State for Energy on the Three Mile Island Incident.

Note for Information

Members of the Commission will be aware of the accident which occurred in March this year at the Three Mile Island site in America involving a Pressurised Water Reactor.

Because this class of power reactor is being considered for adoption for use in this country this accident and the subsequent investigations are of particular interest. Foremost among these investigations is the work of a Presidential Commission set up shortly after the event; the report of that Commission has now been published.

The principal conclusion to be reached both from the findings of the Presidential Commission and the study of much additional material is that the underlying causes of the accident are attributable to weaknesses and failings within the US Regulatory Body and the Nuclear Industry. Such conditions would not be expected to arise in the UK because of the substantially different nature of the respective institutions. No evidence has been produced as a result of these investigations of any fundamental weaknesses in the pressurised water reactor concept or its engineering.

In a letter dated the 9th November 1979 the Secretary of State for Energy wrote to the Chairman of the Health and Safety Commission asking for a report on the accident which could be published. The attached document is the report which has been produced in response to that request.

Nuclear Installations Inspectorate

30 November 1979

THE ACCIDENT AT THREE MILE ISLAND

COMMENTS BY THE HEALTH AND SAFETY EXECUTIVE

- 1 On 28th March 1979 there was an accident on Nuclear Power Plant No. 2 at Three Mile Island (TMI) in Pennsylvania, USA. The reactor core suffered considerable damage, the full extent of which has still to be ascertained, but the release of radioactivity to the environment and the radiation doses received by workers and members of the public were small.
- 2 It has always been recognised that there is a possibility of accidents occurring in nuclear reactors and causing damage to the fuel. The reactors and their safety systems have been designed to minimise the consequences of such damage, should it occur. The accident at Three Mile Island was not the first to involve fuel damage but it is certainly the one which has attracted most attention.
- 3 The accident has been the subject of many reports of which the most authoritative have been those of the Nuclear Regulatory Commission (1, 2, 3) the Electrical Power Research Institute (4) and, most recently, the President's Commission (5). These reports, supplemented by information obtained on individual visits to the United States, have been under review by the Executive's Nuclear Installations Inspectorate. Additional information is still coming forward and a major technical report is expected from the Nuclear Regulatory Commission in the New Year. However, with the publication of the report of the President's Commission, it is appropriate to provide an interim review of the situation to date. This report uses the report of the President's Commission - the Kemeny Report as a convenient framework for reviewing the principal issues raised by the accident.

THE VIEW OF THE HEALTH & SAFETY EXECUTIVE

- 4 In addition to the more detailed comments later in this report, the Executive has reached the following general conclusions.
 - 1 In the light of all the information so far available, the Chief Inspector of Nuclear Installations and the Executive consider that the accident did not arise from any serious inherent weakness in the concept or design of the Pressurised Water Reactor. An accident of this kind was not "unforeseen", although the particular sequence of events had not apparently been predicted. The accident has not therefore led to any change in the Executive's view (6), reported to the Secretary of State for Energy in July 1979, that a Pressurised Water Reactor can be designed, constructed and operated in a way which would satisfy the Executive's conditions for a licence in Britain.
 - 2 The organisational arrangements for licensing, constructing and operating power reactors in this country are already similar to those recommended in the Kemeny Report. The possible need for detailed changes is still being examined but no fundamental revisions are thought to be necessary.

- 3 Human errors, training, and emergency plans all receive considerable attention in the Kemeny Report and there are detailed lessons to be learnt in this country. Emergency arrangements in the immediate vicinity of nuclear sites are already thoroughly prepared and exercised, but it now seems desirable for the Executive to establish & publicise more thoroughly co-ordinated arrangements at the national level.
- 4 Additional emphasis is needed on a range of detailed points including the performance of instruments in emergency conditions, the presentation of information to operators in reactor control rooms and communications in general in the period immediately following an accident.
- 5 The Executive will be taking account of the information and recommendations in the reports so far published and of additional information as it becomes available in the work on the licensing of future reactors and the continued inspection of existing ones.

THE ACCIDENT

- 5 The basic form of the accident to Reactor 2 at the Three Mile Island plant was simple - the details were extremely complicated. Essentially, the pumps providing feed water to the boilers stopped and the safety system operated to shut down the turbine. A relief valve in the reactor primary cooling circuit opened correctly and the reactor was automatically shut down. The second fault was the failure of the relief valve to close when the pressure fell. The control room instrument gave a false indication of successful closure. As the pressure continued to fall in the primary circuit, high-pressure emergency cooling water was automatically injected into the circuit. A few minutes later the operators substantially reduced this flow of cooling water in the mistaken belief that the reactor was too full of water. This belief stemmed from instrument readings which correctly showed that the water level in part of the system was abnormally high, but this was because water was being forced out of the core by the generation of steam. The water level in the core was not indicated in the control room. Steam is a much less effective coolant than water and eventually the residual release of energy from the fission products in the core caused severe damage to the fuel elements.
- 6 Steam and, at a later stage, fission products released from the damaged fuel left the reactor by the unclosed relief valve and the condensed water was retained in the containment building. This was designed to seal automatically in the event of a pressure rise, but this accident caused no such rise and it was four hours before the building was sealed. Meanwhile, moderate amounts of noble fission product gases such as krypton and xenon had escaped to atmosphere. These gave rise to the radiation exposure of members of the public. Further releases took place later as slightly contaminated waste water was discharged from the containment building. Hydrogen emitted from the chemical reaction of steam with the heated cladding material of the fuel elements caused a bubble inside the primary circuit. This resulted in confusion and some alarm but appeared to have had little real significance. Part of the hydrogen reached the containment building and there was at least one hydrogen explosion. The building withstood and contained this explosion as it had been designed to do.

- 7 No member of the public was exposed to serious radiation doses as a result of the accident. A convenient yardstick for indicating the magnitude of these exposures is the radiation dose received by everyone as a result of the natural background of radiation and radioactivity in our bodies and in our environment. The average dose out to 50 miles from the site corresponded to about 3 days of natural background while the average dose out to 5 miles was no more than about one month of natural background. The highest exposure was well below one year of natural background. The overall effect of these exposures on the public is certainly negligible and may well be zero.
- 8 The Nuclear Installations Inspectorate has reviewed all the technical information so far available and has come to the conclusion that the accident was largely the result of organisational and human failures compounded by some detailed weaknesses in the design of the control room and its instrumentation. None of this information casts doubts on the basic concept or design of the Pressurised Water Reactor.

THE PRESIDENT'S COMMISSION

- 9 Two weeks after the accident, President Carter established a Commission to assess the causes and consequences of the accident and the implications for organisation and the provision of information to the public. The Commission, chaired by John G Kemeny, an outstanding mathematician, philosopher and academic administrator, comprised eminent people with a wide range of experience. It was supported by staff of over 150 and by more than 50 consultants. It produced its report - The Kemeny Report - in about six months.

THE KEMENY REPORT - GENERAL ISSUES

- 10 The Report was prepared in the context of the American system of government regulation and industrial organisation so that many of its findings and recommendations have little reference in Britain or more generally in the European Community. It is therefore appropriate first to identify particular issues relevant to this country and then to review the other principal recommendations of the report.
- 11 The Kemeny Commission state that their "findings do not, standing alone, require the conclusion that nuclear power is inherently too dangerous to permit it to continue and expand as a form of power generation". They also state "To prevent nuclear accidents as serious as Three Mile Island, fundamental changes will be necessary in the organisation, procedures, and practices - and above all - in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry,"
- 12 One important aspect of the recommendation is that the nuclear industry should accept all responsibility for safety and reduce its dependence on compliance with detailed regulatory requirements. This would bring the US system much closer to that in Britain. Underlying the domestic organisational issues there are many comments which may have implications in the British context. These comments will need analysing in some detail even if the recommendations that stem from them are irrelevant to the needs of this country. The Health & Safety Executive is already reviewing ways in which some parts of the licensing procedure might be modified to give even greater emphasis than at present to the responsibilities of the licensee.

- 13 Another general issue in the report is the importance of human factors and of training. Human failure is at the root of most accidents and much of the work on reactor safety is aimed at neutralising the effects of human error in design, operation and maintenance. The Kemeny Report gives additional impetus to this process. Training arrangements are already better in Britain than they were at Three Mile Island but the arrangements for training and for exercising emergency procedures are being examined, and can probably be improved.
- 14 The third general issue is that of siting. The Kemeny Report deals with siting in the context of the United States where there are large areas of low population density. The Report does not contain any assessment of the additional margin of safety that might be achieved by more remote siting than at present and does not consider the broader consequences of such a siting policy. The comments in the report are not relevant to the situation in Britain and Europe more generally and do not cast doubts on the validity of the choice of existing British sites. Meanwhile work has already started in Britain and in the Commission of European Communities on the possible need to improve and unify siting policy and emergency plans.
- 15 Finally, there is the problem of public information. At Three Mile Island the problem was grossly exacerbated by the confusion of local, State and Federal agencies and by the genuine lack of certainty about the facts. The provision of information to the public is already an important feature of emergency arrangements in this country, but further studies are in hand with the aim of avoiding a situation of the kind that occurred at Three Mile Island.

THE KEMENY REPORT - DETAILED ISSUES

- 16 The measures identified by the Kemeny Commission as being prime contributors to the incident arise mainly from the structural form of the industry: for example, the large number of separate power producing companies, the division of design responsibility between reactor plant engineers and suppliers and the architect-engineers and, finally and especially, the inherent nature of the regulatory process and manner in which the Nuclear Regulatory Commission discharged its responsibilities.
- 17 No comparable conditions exist in the UK either in respect of the industrial organisation or the regulatory philosophy. Nevertheless, where lessons can be learned from the accident and where risks can be further reduced, that should be done as far as reasonably practicable. The Kemeny Commission's recommendations have therefore approached in that light and are discussed in the rest of this section. A more detailed commentary on the recommendations has been prepared by the Executive's Nuclear Installations Inspectorate and is attached as Appendix A.

Regulatory arrangements

- 18 The remedy proposed by the Kemeny Commission for weaknesses discovered in the Nuclear Regulatory Commission is the abolition of the five man Commission with a view to providing stronger management with discretion to reorganise and redirect the activities of the regulatory staff. Other major structural changes are recommended with the objective of increasing the effectiveness of the regulatory operation. While the Kemeny Commission commented adversely on the body of regulations used by NRC in its formal licensing process, no recommendations were made which would fundamentally change this approach. The UK view, exemplified in the document entitled "Safety Assessment Principles for Nuclear Power Reactors" is that undue detail in formal regulatory requirements tends to be counter-productive and tends to reduce the responsibility of the licensee and industry for safety, a point emphasised by the Kemeny Commission and referred to below.

The power producing industry and its suppliers

- 19 The emphasis in this section of the recommendations is a strengthening of the responsibility of the licensee. This has always been a cornerstone of nuclear regulatory policy in the UK. Attention is drawn to the inadequacy of the arrangements for learning and sharing the lessons available from operating experience, for defining responsibilities, and for establishing and reviewing plant procedures. The structure of the British electricity industry makes it easier to deal with these problems, but the points made by the Kemeny Commission are being examined in the British context.

Operator training

- 20 The Kemeny Commission made a number of recommendations concerning the training of operators. Although a system of formal licensing based on examinations is a requirement under the regulations, the Commission found that the standards applied were inadequate in a number of ways. It is the lack of training, particularly in respect of emergencies, that explains the confusion on the part of the operators at TMI. The Commission propose that the training of operators be substantially improved and that higher grade entrants be required.
- 21 No formal licensing process for operators is required in the UK but the quality of individual employed in this area is significantly higher than in the US. Recruitment and training is the responsibility of the licensee and the Inspectorate must be satisfied that a suitable standard of competence has been achieved. Emphasis must be placed on an understanding of the plant and a corresponding ability to diagnose conditions reliably. This requirement calls for persons of graduate or equivalent status, which is the standard currently required of nuclear plant operators in UK plant.

Technical assessment

- 22 The detailed recommendations made under this heading do not reveal any unease on the part of the Kemeny Commission concerning the fundamental concept of the Pressurised Water Reactor or its engineering in general. Some detailed comments are made concerning the provision of information to operators, certain design and maintenance inadequacies, and the use of probabilistic fault analysis as an aid to assessment, with greater attention being paid to the human element. In general, the implied standards are currently employed in UK nuclear plant and could readily be adopted for a PWR.

Worker and public health and safety

- 23 The Kemeny Commission recommends better and more co-ordinated research on the health effects of radiation and better inter-departmental arrangements for establishing public health policy. They also refer to the inadequacy of the professional response in the event of a serious emergency.
- 24 In this country there is already adequate co-ordination on the research side, and the National Radiological Protection Board has the role of advising on radiation protection policy. The arrangements in the UK for mitigating the consequences of accidents are also well laid and exercised. On the question of professional education, this too is adequately covered. Liaison arrangements established by the licensee at each nuclear site provide a route for communication between specialists on the site and those with health and safety responsibilities in the vicinity. The arrangements for the professional appraisal of emergency information at a national level still require further attention.

Emergency planning and response

- 25 Arrangements for emergency planning in the US rests with the State Governments. The NRC has no regulatory control over these arrangements but none the less informally reviews them. It had not endorsed the arrangements relating to the accident at Three Mile Island because they were considered inadequate.
- 26 Under a condition of the nuclear site licence, no nuclear power plant can operate in this country unless an emergency plan has been approved by the Nuclear Installation Inspectorate in respect of that plant. These emergency plans lay down actions including damage control, evacuation and, where appropriate, medication on and off the site. The involvement of appropriate local authorities is an important feature of each plan. It is believed that all the essential features of the Kemeny recommendations are accounted for in these arrangements. Information for the public is provided through the local liaison committees. More generally, the Health & Safety Executive will continue to publish and to encourage others to publish information concerning nuclear power. Nevertheless, it is clear that communication arrangements were seriously inadequate at Three Mile Island and the entire issue of communications is being reviewed in this country to ensure that adequate provision is made at all our nuclear power stations.

REFERENCES

- 1 NUREG 0585 - TMI - 2 Lessons Learnt Task Force - Final report
US Nuclear Regulatory Commission 1979
- 2 NUREG 0560 - Staff report on generic assessment of feed water
transients in pressurised water reactors designed
by Babcock & Wilcox Co.
US Nuclear Regulatory Commission 1979
- 3 NUREG 0600 - Investigation into the March 28 1979 Three Mile Island
Accident by Office of Inspection and Enforcement
US Nuclear Regulatory Commission 1979
- 4 NASC 1 - Analysis of Three Mile Island - Unit 2 accident
Nuclear Safety Analysis Centre,
Electrical Power Research Institute 1979
- 5 The need for Change - The Legacy of TMI. Report of the President's
Commission on the Accident at Three Mile Island
- 6 The Generic Safety Issues of Pressurised Water Reactors.
An account of the study carried out by the Nuclear Installations
Inspectorate of the Health & Safety Executive. HSE 1977
- 7 Safety Assessment Principles for Nuclear Reactors.
HM Nuclear Installations Inspectorate, Health & Safety Executive 1979

APPENDIX A

A Commentary on the Main Recommendations of the Kemeny Report prepared by HM Nuclear Installations Inspectorate

- A.1 This Appendix presents the main recommendations of the Kemeny Report, together with any necessary background, and comments on their relevance to the UK. Where issues have been dealt with in sufficient detail in the main text, they are omitted here.

Regulatory arrangements

- A.2 In addition to the recommendations regarding restructuring of the NRC (see main text, para 18), a number of more specific points concerning the regulatory approach are made in the report which are summarised below.

- A.3 The NRC or its successor should

- (i) be directed to employ a broader definition of matters relating to safety
- (ii) review control room design
- (iii) increase their safety research capacity
- (iv) assess the need to introduce new safety improvements recommended in the report before issuing a new construction permit
- (v) improve on performance in resolving generic and specific safety issues
- (vi) define rule making procedures to provide a meaningful opportunity for participation by interested parties
- (vii) conduct systematic reviews of operating plants to assess the need for retroactive application of new safety requirements
- (viii) arrange for licensing procedures to foster early and meaningful resolution of safety issues before major financial commitments in construction can occur
- (ix) arrange for the systematic assessment of experience in operating reactors
- (x) locate nuclear power plants in areas remote from concentrations of populations

- A.4 From consideration of these comments in the light of the UK approach to safety, the following observations can be made

- (i) It has always been NII policy to adopt a broad approach to the consideration of nuclear reactor safety. NII staff are not constrained in their judgement by detailed rules.

- (ii) The essential aspect of control room design is that the presentation of information is arranged so as to be readily intelligible to the operator. It is also necessary to ensure a proper link between plant designers and operators so that interface problems are recognised and dealt with properly. Control rooms and information processing in UK nuclear power plant currently makes use of advanced technology. It is also the view of NII that the present industrial organisation is best suited to ensuring that machine/operator problems are dealt with and that the maximum use of actual plant experience is made available to those concerned with design. NII would require that the standards achieved in this area on recent gas cooled reactors, along with proven advances, be applied fully to any PWR installation in this country.
- (iii) While NII sponsors a limited research effort for the information of its assessment staff, the main responsibility for demonstrating plant safety in the UK rests with the licensee and his suppliers who must sponsor such research as may be necessary.
- (iv) This is essentially a US procedural issue. However, the engineering implications of the incident are well known and NII will evaluate any UK proposal with these issues in mind.
- (v) This is a further feature of the US licensing procedures. NII is well aware of all outstanding generic issues and will take into account those relevant to any UK application to license a PWR.
- (vi) This is yet another feature specific to US licensing procedures. In this country, the main opportunity for public participation in discussions of safety issues is the public enquiry.
- (vii) As a matter of course and arising from its inspection and enforcement activities, NII conducts periodic reviews of operating plant. However, it is not always appropriate to apply new developments to existing plant.
- (viii) It has for some years been the practice for NII to review proposed reactor types which might be employed in the UK long before a formal application is made for their use. This provides an opportunity for important safety issues to be raised with the design organisation before a commitment is made to substantial capital expenditure.
- (ix) NII collects and analyses data arising from its inspection activities. The fact that the UK industrial organisation is simpler than in the US leads to greater assurance that experience from operation will be passed on and used. Arrangements are also being developed to improve the sharing of experience in the European Community and OECD.

- (x) Siting has always been a factor in nuclear power safety, but in the context of the population distribution in Europe it cannot be a major factor. The Kemeny Commission emphasised that siting determinations should be based on technical assessments of various classes of accident. NII does not expect such an assessment of any proposed PWR to lead to a need to revise current UK reactor siting policy.

The Power producing industry and its suppliers

A.5 The Commission recommends that the US nuclear industry "dramatically change its attitude toward safety":

- (i) It must "set and police its own standards of excellence to ensure the effective management and safe operation of nuclear power plants".
- (ii) It should establish a program that specifies appropriate standards.
- (iii) There should be a systematic gathering, review and analysis of operating experience coupled with an industry-wide international communications network to facilitate the speedy flow of this information to affected parties.
- (iv) Each nuclear power plant company should have a separate safety group that reports to high level management
- (v) There must be a single accountable organisation with the requisite expertise to take responsibility for the integrated management of the design, construction, operation and emergency response functions and the organisational entities that carry them out.
- (vi) Clearly defined roles and responsibilities for operating procedures and practices must be established to ensure accountability and smooth communication.
- (vii) The licensee must be responsible for the management of the plant in normal operation and accident conditions and he must therefore prepare clear procedures defining management roles and responsibilities
- (viii) Substantially more attention must be devoted to the writing, reviewing and monitoring of plant procedures
- (ix) Management of both nuclear power plant companies and suppliers must insist on early diagnosis and resolution of safety questions that arise in plant operations.

A.6 The emphasis in this section of the recommendations is a strengthening of the responsibility of the licensee, which has always been a cornerstone of nuclear regulatory policy in the UK. Most of the recommendations above are a statement of long-standing established UK practice. They are needed because of the large number of power producing companies in the US. The weaknesses identified have also probably been encouraged by the nature of the US regulatory process which tended to relieve the operator of direct responsibility.

It is also clear that the industrial organisation and regulatory approach used in the UK would not encourage development of the conditions which led the Commission to make these recommendations.

Operator training

- A.7 See main text, paras 20 and 21

Worker and public health and safety

- A.8 The Kemeny Commission recommends:

- (i) expansion and better co-ordination research on health-related radiation effects,
- (ii) mandatory review and comment on NRC policy statements on this topic by the Department of Health and Human Services (previously the Department of Health, Education and Welfare),
- (iii) an increased program for educating health professionals and emergency response personnel in the vicinity of nuclear power plants,
- (iv) that power companies make advance preparation for the mitigation of emergencies.

- A.9 These points have been discussed in the main text, paras 23 and 24.

Emergency planning and response

- A.10 The Commission recommended that:

- (i) Before a nuclear power plant company is granted an operating licence for a nuclear power plant, the State within which the plant is sited must have an emergency response plan reviewed and approved by the appropriate agency.
- (ii) Emergency plans must be based on technical assessments of various classes of accident.
- (iii) Plans should exist for protecting the public at radiation levels lower than those currently used in NRC-prescribed plans.
- (iv) If the emergency planning and response is to be effective the public must be better informed about nuclear power. A program should be initiated to educate the public.
- (v) Decision makers may have over-estimated the human costs, in injury and loss of life, in many mass evacuation situations. A study is recommended into the human costs of radiation-related mass evacuation and the extent to which the risks in these situations differ from those in other types of evacuation.

- A.11 Most of these points have been dealt with in the main text, paras 25 and 26. In relation to item (iii), advice on emergency reference levels is given by the National Radiological Protection Board. The application of countermeasures at lower levels of exposure is a matter for local judgement at the time.

A.12 The Public's right to information

The right of the public to be promptly and accurately informed is an undisputed requirement in any emergency situation as it is in normal conditions. The Three Mile Island incident demonstrated that for this requirement to be properly met, advance planning is necessary. This should include clear definitions of responsibilities, adequate communication facilities, suitable provisions for briefing of the media and definition of the channels of communication with the media. While the local and state and governmental structures and responsibilities in the US lead to different detail in the communication arrangements, the importance of this issue is equally significant for the UK. One difficulty is in communicating information regarding an advanced technological industry to the layman in terms that allow a rational understanding of a situation which is inherently frightening and probably ill-defined. Furthermore, it is essential that the need to communicate does not distract unnecessarily those who have important responsibilities for the control of the incident. The entire issue of communication is being reviewed to ensure that adequate provision is indeed made at all UK Nuclear Power Stations.

Summary and Conclusion

A.13 Consideration of the detailed technical reports so far available on TMI accident and of the Kemeny Report leads to the firm conclusion that the underlying causes of the event were organisational rather than due to serious inherent weakness in the concept or design of the Pressurised Water Reactor.

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