The Safety of the UKAEA Harwell Establishment and in particular the Safety of the Harwell Materials Testing Reactors.

A special report produced for the Commons Select Committee on Energy.

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Contents.

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Introduction.

a). UKAEA Harwell.

1 Harwell is the largest of all the United Kingdom Atomic Energy Authority's research establishments. It is a major centre for research and development work, in many non-nuclear as well as nuclear fields. The site houses many specialised laboratories, which contain some of the most advanced research equipment in the UK. In short, UKAEA Harwell is one of our best research centres in the country and has performed a great deal of work in many specialised areas which has undoubtedly benefited the UK. However, this success belies a great many problems within the establishment itself. As government funding of the UKAEA has diminished, many departments have been finding it harder to do the extensive research work necessary to carry previous discoveries forward, and since the setting up of the Harwell laboratories as a 'trading fund' an increasing amount of work is being done for national and international corporations in specific areas. The decline in the number of government funded research projects has had a detrimental effect on the scope of the work conducted at Harwell, and already a large number of redundancies have been announced.

2 The day to day workings of Harwell are subject to many laws and statutes, as with any other workplace. However, in the areas of atomic research the regulation of this work becomes a little less defined. For instance, the operation of the nuclear reactors on site do not require a license from the Nuclear Installations Inspectorate to pass them safe to operate (the '*Authority to Operate*'). This is done by a committee which meets annually, comprising a small number of heads of department from within the UKAEA, and two external members. The safety of the day to day operation is also regulated from within the UKAEA itself, and has little input from independent sources outside the UKAEA. Within the next two years this situation will

change and the NII will issue the Authority to Operate, but until that time, and since the reactors at Harwell were first given Crown Immunity (which ended in 1986), the safety of the reactors is entirely a matter for the UKAEA staff involved in running the reactors.

3 The materials testing reactors (MTR's) at Harwell were built in the mid-fifties, to standards which would not be acceptable today. They have been uprated a number of times from the original 10MW (thermal power) to the current 25MW (thermal power). In the past decade the reactors have suffered from under-investment. According to the ex-head of Reactor Research Division Design Department, many of the suggestions put forward for improvement of the reactors were dismissed because of lack of funds. There are also serious problems associated with the age of the reactor. The design life of these reactors was twenty-five years. DIDO was commissioned in 1956 and PLUTO in 1957, but seven and eight years after the expiry of these dates they are still operating. It has been announced that the PLUTO reactor will close in Spring 1990, but it was stressed that this was for economic and not safety reasons. A similar reactor at Dounreay, which was commissioned in 1958, was shutdown in 1981. The question has to be asked why the other MTR is to continue operating when it is already eight years beyond its design lifetime.

4 Whilst recognising the benefits of the work done at UKAEA Harwell to the nation, it is time that the relative independence from regulation in the nuclear side be looked at in detail, and especially the deterioration in plant safety which this state of affairs has brought about.

b). Banbury Environmental Research Group.

5 Banbury Environmental Research was formed in September 1989 to perform research into a broad base of environmental issues, in particular those affecting Oxfordshire and its neighbouring counties. The group consists of a number of individuals performing research in their own areas of interest, but who appreciate the benefit of collaboration and information exchange as a way of tackling specific research problems. These individuals come from a wide area but as the group is administered from an postal address in Banbury, the group took the name Banbury Environmental Research.

6 I personally was involved in researching nuclear issues for the Oxfordshire Peace Campaign (specifically in a small group entitled OPC Research), and coordinated much of the research into safety at Harwell since the end of 1988. Prior to this much of the work was done by isolated individuals, and it was this pooling of resources which brought the issue into the public domain.

7 Whilst recognising the obvious benefits of the work at Harwell, both nuclear and non-nuclear, we believe that the current situation in terms of plant safety, and the safety of the material testing reactors in particular, cannot be justified. The safety and licensing regulations which are required of the rest of the UK nuclear industries should be applied to the UKAEA Harwell site. It is obvious from the research we have done that their privileged position has led to lapses in plant safety.

c). A brief history of the Harwell campaign.

8 OPC Research first became involved with Harwell in Nov/Dec 1988. This was

in response to the activities of two ex-employees. They had been challenging the safety of the reactor plant, and in response, the Department of Energy had the Nuclear Installations Inspectorate conduct a safety audit of the reactor plant. Also around this time the Pollution and Nuclear Issues sub-committee of Oxford City Council also raised concern about safety standards at Harwell. Our initial research suggested that the issue warranted further investigation.

9 It was then proposed that a group be set up comprising concerned individuals, local resident representatives and delegates from other local pressure groups, to discuss the problems and voice a public response. The first 'Research Meeting' was held in February 1989, and was attended by representatives of many local pressure groups, and some local people who were concerned about safety at Harwell. The meeting discussed a wide range of safety issues, and eventually decided upon an agenda of issues to which we wanted responses from Harwell. However Harwell would not directly take our questions, and instead referred us to the Harwell Local Liaison Committee, the next meeting of which wasn't until the end of July.

10 At the same time as this was occurring, Oxford City Council were arranging a tour of the site and a meeting with the Harwell management to express their concerns. A tour had been arranged for Dec. 12th 1988, but it did not go ahead. As none of them possessed a working knowledge of nuclear issues they decided to take a consultant along with them. They proposed to take along Mr Dennis Dawson, the ex-head of Reactor Design at Harwell's Reactor Research Division. It was Mr Dawson who had criticised the safety of the reactor plant at Harwell, both during his 17 years as an employee and after his retirement. Harwell stated that they would not allow the tour to go ahead if Mr Dawson accompanied the councillors, and so the City Council cancelled the tour. However the City Council then employed another consultant, Dr Peter Taylor, and a second tour was arranged for Feb. 23rd 1989, which did go ahead.

11 Following this tour a report was produced for the committee members by Dr Taylor detailing the responses to the questions they had asked, but many of the

members felt that they had been given a very sanitized version of the truth whilst on the tour, and the responses provided by Harwell did not fully satisfy their concerns about safety.

12 The 'Research Meeting' group held another meeting in June 1989. This was attended by not only representatives from local pressure groups, but also a small number of Harwell Liaison Committee members. We had written to all the members of the Liaison Committee inviting them to the meeting. Following this the Harwell management wrote to the LLC members to put their side of the argument across, and to give them information on who we were, and our current stance on Harwell. This was done deliberately to deter LLC members from atending the meeting. We were able to consider new information which had come to light since February, and we were also able to consider the results of the Oxford City council tour. We discussed our concerns with these members of the LLC, and gathered together a detailed list of questions on a number of subjects to present to the LLC meeting in July.

13 The Harwell Local Liaison Committee meeting took place on 26th July 1989. According to one member, it was very well attended and the members were more vocal than normal. This was not only in response to our work before the meeting, but also the recent news that Harwell had sought a new authorisation to incinerate low-level waste on the site. Answers to the questions the 'Research Meeting' group had presented were given in one long document. The responses given will be discussed later, but it is interesting that some of the responses contradicted or confused previous statements from the UKAEA, NII and the Department of Energy. One final point on the 'Research Meeting' group. Harwell addressed the group as being, "CND and Oxfordshire Peace Campaign". It is true that members of CND took part in the research meetings, and that the Oxfordshire Peace Campaign did most of the administrative work for the group (as it was the only group with the resources to do so), but the 'Research Meeting' group consisted of members of Friends of the Earth, Greenpeace, Oxford Anti-Apartheid, and many individual members of the public who were purely concerned about safety on the Harwell site. To lump them all under the

heading of 'CND' is misleading and offensive to those present in the meetings who did not support the aims and objectives of CND.

14 There has been very little activity since the meeting of the Harwell LLC. Very little progress is being made as Harwell seem to be closing ranks to stem the flow of information and dialogue. For this reason Banbury Environmental Research decided that the only course open to us was to take the issue before the Commons Select Committee on Energy and get the problems thrashed out there. Oxford City Council are also having problems in getting information from Harwell. They have now even considered getting their own independent studies done on the effects of a serious reactor incident at Harwell as they cannot get a straight answer from the Harwell management.

15 Banbury Environmental Research will continue its interest in the Harwell establishment for the foreseeable future, and will continue to produce reports for those who maintain an interest. The avenues for future research, and for dialogue with the Harwell management, are rapidly drying up.

The Harwell Nuclear Reactors.

a). Introduction.

16 Harwell currently has three reactors operating on site:

1). GLEEP. This is a small reactor (3kW thermal power) commissioned in 1947. It is graphite moderated and air cooled using natural uranium and oxide fuel. It was initially used for isotope production and general neutron physics. It is now used for routine graphite/uranium and reactor grade materials testing, operator training and neutron flux calibration. We have no firm evidence for the current condition of the reactor, dosage to operators, etc, and the reactor will not be discussed further in the report for this reason. The Select Committee should ask for details of this reactor and have the safety of this reactor considered in any future safety assessments.

2). DIDO. This reactor is used primarily for experimental work for water reactors, irradiation of silicon for the semiconductor industry, and for isotope production. A detailed description of the reactor will be given later.

3). PLUTO. This reactor is used for similar experimental work, but mainly performs work for AGR reactors. The design is basically the same as DIDO, the differences being the arrangement of the core. The slightly different arrangement allows use of different experimental rigs to those on DIDO. For purposes of assessing safety the two reactors can be looked at as being the same as almost all the other features on them are similar.

b). MTR design [1].

17 The DIDO reactor is the oldest of the two large materials testing reactors (MTR's). The design was based on the US Atomic Energy Commissions's CP5 reactor, and it was commissioned in Aug/Sept. 1956. The reactor is heavy-water (D_2O) cooled and moderated and uses 25 fuel rods made from a sandwich of aluminium and 93% enriched uranium. The use of highly enriched fuel gives a much greater power density. The original design power was 10MW (thermal). The reactor has since been uprated a number of times to its current operating power of 25MW. The running temperature of the reactor is $70^{O}C$ which does not boil the D_2O and thus the core itself is unpressurised.

18 The reactor vessel itself is a cylindrical tank 2m in diameter, the thickness of the wall at the dished base is 0.5" and the side walls are 5/8". Is is made from pure aluminium. The 25 fuel rods are laid out in the centre of this tank. A number of openings and thimble-tubes give access close to the core for experiments. There are two sets of control rods. The primary control and shutdown is controlled by six cadmium control rods. These operate like 'signal arms', and swing down between the rows of fuel rods. The second set are for fine tuning, and are situated on the outside and in the centre. These are small rods which only cause slight variations in neutron activity.

19 Outside the reactor vessel is the graphite reflector made from machined

graphite blocks and is around 60cm thick.. The core is encased around the side and bottom by a double walled steel tank 10' 10" in diameter and 9' high. Bonded to the inside of the steel tank is a layer of boral (boron/aluminium) sheet which absorbs thermal neutrons. The top of the core is capped by a hollow steel plug 2' 9" thick, the void inside is filled with concrete. On the lower side of this plug are two steel plates with a layer of lead and a layer of cadmium sandwiched between them. This plug rests just above the reactor vessel, and holes allow access for experiments and fuel rods. The double walls of the steel tank are filled with a layer of lead through which run copper pipes carrying distilled light water coolant. Outside the steel tank is the concrete biological shield, an irregular decagon 22' across and 19' high. This is faced on the outside by steel, and the minimum thickness of the biological shield is 5'. The whole structure is supported on a grid of steel joists encased in the concrete of the biological shield resting upon four steel legs which run down to ground level. This provides clearance below the reactor to accommodate the plant room.

20 The plant room houses three heavy water pumps, heat exchangers, and the D_2O storage tank. The three heat exchangers cool the D_2O with light water. This is then pumped to eight cooling stacks outside the building. An automatic core cooling system operates if a low core coolant level detected following a loss of coolant. This pumps D_2O from the plant room into the reactor core. In the event of a problem circulating coolant the reactor can be flooded with light water from the water main in the building. This system must be manually connected and operated by the reactor staff.

21 The reactor building itself is made from welded preformed sheet steel. This is reinforced by vertical channel sections running up the sides and over the roof of the building. The building is around 70' in diameter, and is roughly the same height from base to the tip of the roof. The air pressure within the building is slightly lower than outside, and so airlocks are necessary to access the building.

22 All spaces within the graphite reflector of the reactor, and the space above the

D_2O in the reactor vessel are filled with helium. A diagram of the reactor is shown on the next page.

23 The design of the PLUTO reactor varies only in the layout of the experiment holes in the core, and the composition of the control rods[(2)]. The most significant feature on the PLUTO reactor is the PLUTO AGR Test (PAT) loop. This is a large experimental gas loop which takes up almost one third of the available core space. Other than this there are few differences.

c). Current conditions of MTR's and associated plant.

24 'UKAEA sites are not subject to the licensing requirements of the Nuclear Installations Act, 1965 (as amended). The UKAEA is required by ministerial direction to have regard as far as practicable to any current safety requirements ordinarily imposed by the NII on licensed operators. The Health and Safety at Work Act 1974 and the Ionising Radiation Regulations 1985 do apply and are enforced by Health and Safety Executive inspectors'[(3)].

25 'The Director of each UKAEA establishment or management unit is responsible for the safety of operation of plant (including reactors and laboratories) under his control. The Director of the UKAEA's Safety and Reliability Directorate is responsible directly to the Chairman of the UKAEA for the independent safety assessment and inspection of all UKAEA sites.'[(4)]. In the day to day running of the reactors the onus on ensuring the safety of the reactor plant at Harwell therefore falls to the Chief Engineer and Director of Harwell, and the Director of the UKAEA's Safety and Reliability Directorate. The 'Authority to Operate' the reactors is however reviewed yearly by a Safety Committee comprising members of the UKAEA and two persons from outside the UKAEA. It is this group of people whose job it is to ensure that the conditions stated in the above paragraph are met.

26 When considering the safety of the reactors we should be looking at the current condition of the reactor plant, and from this we should be able to identify problems and give an overall view of safety. To date, the Harwell reactors have not had a full engineering fault sequence assessment to determine the statistical probabilities of a number of accidents, though they recently stated that such a study was in hand[(5)]. There have only been two reviews of safety in recent years. The first was conducted by the UKAEA in July 1987. This was in response to Mr Dennis Dawson's criticisms of reactor safety. The other was a safety audit by the Health and Safety Executive's Nuclear Installations Inspectorate which was carried out during the first few months of 1988. The terms of reference issued by the Department of Energy required that it should include a comprehensive inspection of the reactor plant. This was not done by the NII. It was not a full survey, as it did not involve a detailed examination of the reactor core. This task was left to the UKAEA, who had to give their results to the NII within one year. The NII have not yet released the results of the Safety Audit, and the only indications of what was found was a five page press release issued by the NII shortly after[(6)].

27 The reactors both have a design lifetime of twenty-five years, and yet after thirty-three years the oldest of the two is still operating and will continue to operate, as stated by the UKAEA, 'for a number of years'[(7)]. Questions must be asked as to whether this is wise, especially in the light of comments made in their review of safety in 1987. PLUTO, the youngest of the two reactors, is due to close in March/April 1990, though it was stressed that this was for economic and not safety reasons[(8)]. I will detail some specific points.

28 <u>i). The safety of the aluminium reactor vessel.</u>

The safety review conducted by the UKAEA[(9)] considered the integrity of the reactor vessel. The effect of neutrons on the aluminium tank over 33 years of operation would have caused some changes in the metal (due to the aluminium transmuting to silicon under neutron bombardment), degrading it slightly by the production of impurities within it. It is stated that a survey was carried out in 1983 by the Design Department of Research Reactor Division and a further review was being carried out. However according to the then head of the Design Dept of Reactor Research Division[(10)], there is no practical knowledge of the damage and corrosion of the material of this tank. The aluminium tank is inaccessible and so a study of the integrity of the tank cannot be fully done, the damage can only be assessed from statistical models of how such materials behave under irradiation, and a limited set of tests upon the reactor vessel.

29 ii). Biological shield and steel tank corrosion.

In their July 1987 report[(11)], the UKAEA admit that leakage of light water from the connections to the thermal shield cooling coils has taken place for the last 15 to 20 years. The water percolates through the concrete of the biological shield to the outer steel cladding and then runs down into the plant room. They admit that corrosion of the outer wall of the steel tank would have taken place over this time, but dismiss the idea that it could have penetrated beyond the outer wall of the steel tank. Currently the concrete of the biological shield is saturated with water. This has caused cracking of the concrete shield in DIDO.

30 At many points around the sides of the reactor holes through the steel tank allow access to the core for experimental work. Where these pass through the steel tank seals should prevent the passage of water, but it has been noted that water has leaked through the steel liner of one of the experiment holes[(12)], and so it possible that water could have moved along the surface of the liner through the steel tank. No evidence of this can be produced as this part of the reactor

is inaccessible, and seepage in the other direction cannot be detected because the concrete around the steel liners is already saturated.

31 iii). Reactor vessel leaks. 'Pinhole leaks have occurred from the small diameter Reactor Aluminium Tank drain lines on both reactors due to pitting corrosion through the relatively thin wall of the tube. The leaks, which were very small and have now been repaired, were contained by the reactor secondary containment system which is designed to retain D_2O in the event of failure of the R.A.T. and associated components'[13]. It is admitted that leaks have occur from the reactor vessel, and the weakness of these pipes leaving the reactor gives cause for concern. They may stand up to everyday operating conditions, but the pressure transients created in an accident within the core may rupture these pipes.

32 iv). Emergency core cooling system. In the event of a leakage from the primary circuit a pump will recirculate the coolant captured in the plant room below the reactor, and additional D_2O can be drawn from the D_2O storage tank. However it is not indicated what the capacity of this system is, and what size of leakage it could accommodate. Great stress is put on the backup light water cooling system, but this has two significant flaws. Firstly the system must be manually connected, which in an accident conditions may not be done at the correct time (eg, Three Mile Island/ Chernobyl). Secondly the flow of water from the buildings water main to the reactor core is limited by the diameter of the delivery tubing. No estimation of the capacity of this system is indicated either.

33 v). Reactor refurbishment. In their 1987 review[14] a list of improvements to the two reactors were detailed. Expenditure for the work was scheduled over two financial years, 1987/88 and 1988/89.

It was also stated in the review that all the items in the three categories, a total of seventeen improvements, were '*already in hand*'. however at the Harwell LLC meeting on 26th July 1989, it was stated in a response to our queries on reactor safety[15] that only five of the seventeen modifications had been completed, and eight more were described as 'in hand'. So two years after the statements made in the 1987 review, three of the most important (category 1) items had not been completed. The will of the UKAEA to bring these reactors up to date must therefore be questioned.

34 The condition of the reactor plant is not in good condition. The reactors, which were built to standards which would not be allowed today, are operating well beyond their 25 year design life, and the integrity of the reactor vessel and its component must be called into question after this length of time. Shield cooling water has been leaking for 20 years and has cause corrosion the reactor structure, and has saturated the concrete of the biological shield. Leaks have occurred from the pipework leading from the reactor vessel due to wear and corrosion over it operating life and the ability of these pipes to stand up to a pressure transients developed within the reactor during accident conditions must be questioned. In July 1989 five out of the seventeen modifications which were due to be completed within two years of the UKAEA's 1987 review were complete. The state of the other twelve is uncertain, though some were described as 'in hand'. All these modifications should have been completed by March 1989. *The day to day safety of these reactors, and the system of internal safety reviews which has allowed the reactors to operate in this condition for so long, must be called into question*.

d). MTR experimental test rigs and loops.

35 The reactors are not pressurised, and work at 70^{O}C. The NII in their safety audit in June 1988 approved the operation of the reactors for a further 12 months in the 'unpressurised mode of operation'[16]. The UKAEA continue to operate high pressure/high temperature gas and water loops within these reactors breaking this condition. Again, because of the exemption from the Nuclear Installations Act 1965, the safety case for each of these pressurised experiments have not been reviewed by the NII, and the only clearance needed is from the UKAEA's own Safety and Reliability Directorate.

36 The use of pressurised experiments in an unpressurised reactor is highly questionable, and in reactors of this age and condition doubly so. The greatest danger is that a fast rupture failure in one of these experiments could cause severe damage within the core. Most of the experiments inserted in the reactor have a double wall to contain the pressure within the test rig. With the larger experiments however these two steel walls are thin and quite close together to conserve space. The ability of these experiment enclosures to stand up to a fast increase in pressure without failure should be independently assessed by the NII. As yet the NII have not looked at the safety case for any experiments operating within the reactors.

37 One experiment in particular gives cause for concern. On the DIDO reactor a large pressurised water loop runs through the reactor core. Due to the size of the loop it has no second wall. According to the ex-head of the Design Dept, Reactor Research Division, a study was done on the consequences of a fast rupture failure of this loop and it showed that enough energy could be released within the reactor core to do serious damage to the reactor vessel and is surrounding pipework. Again, the safety case for the running of this loop has not been assessed by the NII. A full investigation of this loop may be denied on the grounds of National Security as the MoD use this loop to test submarine rector fuel rods.

38 Running these high temperature/high pressure experiments within the core poses a serious threat should a failure occur. The reactor vessel is to all intents and purposes a sealed vessel with a roughly constant pressure within it. In addition to the pressure being released during failure, when the D_2O comes into contact with the hot components of a high temperature experiment (ie a temperature in excess of $250^{O}C$) it will flash to steam and rapidly increase the pressure within the reactor vessel. It has already been admitted that some sections of the pipework are in a weakened state, and in such an incident there is a high probability that these section of pipework below the level of the core could rupture and cause a significant loss of coolant as the pressure within the core forces D_2O out the bottom of the reactor. Of greater concern would be the possibility of the core being disrupted or distorted during such an incident. The 'signal arm' control rods move between the rows of fuel rods, and obstruction of these channels could prevent the control arms moving into the core and shutting the reactor down. As neither reactor has a working ultimate shutdown system (in fact they are the only reactors in the country with a power over 1MW which are not fitted with a ultimate shutdown system) and the consequences of a failure on an experiment leading to disruption of the core could be disastrous. This will be discussed further later in this report.

e). The PAT Loop and its implications.

39 One of the most dangerous experiments which was to be run in the core of these reactors was the PAT loop. This loop was installed into the PLUTO reactor and was to be used to test fuel rods from the CEGB's Advanced Gas-cooled Reactors. With the decommissioning of the Windscale Prototype AGR, PLUTO was the only reactor in the country which was able to perform this work. The PLUTO AGR Test (PAT) loop was a large high pressure/ high temperature gas loop. When installed it

took up a third of the available core space. In an article in 'ATOM'[17] , Dec 1988, the programme of experiments was listed, and indicated that the PAT loop would run for at least seven years. In February of 1989 however it was announced that PLUTO would close in 1990, thus meaning that the PAT loop would not run (no mention of the PAT loop was mentioned in the press release).

40 There are two conflicting versions behind the closure of the PLUTO reactor. The UKAEA maintain that it was closed for economic reasons. However, there is the possibility that PLUTO was closed because the safety case for the PAT loop could not be proved. The implications of a failure of this loop inside the reactor meant that running it could not be justified, despite a number of years of work to improve the safety of the loop. Removing the loop and resuming other experiments in PLUTO was not an option open as so many changes had been made to the reactor that restoring it to its previous condition would be very expensive. Additionally, the cost of running DIDO may rise following the closure of PLUTO. At the moment the two reactors share services, with the revenue earned from both reactors supporting these. After the closure of PLUTO DIDO will have to support these services alone.

41 The knock on effects of the closure of PLUTO will be very serious. The experiments which were to have run in PLUTO were to determine whether it was possible to run AGR reactors at a higher power level to increase efficiency without any detrimental effects on safety. By simulating conditions inside an AGR reactor within PLUTO, observations could be made on how AGR fuel rods behave at higher temperatures. It has been stated that these experiments are not necessary, and that much of the data can be generated by computer models. Even so without practical experimentation the economic future of AGR reactors could be in question. Without these sets of experiments the improvements necessary to make the AGR reactors run economically may never be completed.

42 If it was shown that the highly pressurised PAT loop was unsafe to run, does this not call into question the use of other pressurised experiments in these reactors?

(eg, the DIDO water loop).

f). Emergency Shutdown Systems.

43 The safety of the reactors has been questioned by ex-employees. The main criticism being that the reactors had no emergency/ ultimate shutdown system to closedown the reactor in an emergency. The PLUTO reactor was fitted with a Borated water shutdown system recently, but the DIDO reactor still has no ultimate/ emergency shutdown mechanisms to back up the existing control system. This system is however not operational[(43)]. It was announced this year that due to 'economic reasons' the PLUTO reactor was being shutdown and decommissioned. The DIDO reactor (the one without any ultimate shutdown system) was to continue to operate into the near future.

44 It is now proposed to fit a Borated water shutdown system to the DIDO reactor, but I believe that this system is flawed, and may fail when it is most needed. What is more this system is manually operated, and not tied into any of the emergency trip systems of the reactor. An operator in the control room must manually initiate the system. An example of the usefulness of manually operated systems is the Chernobyl reactor, where because the safety circuits were disconnected the Boron injection system had to be manually operated. The operator did so too late.

45 Most power reactors on the UK have an emergency/ultimate shutdown system using Boron balls which in the event of a problem drop into the reactor under gravity. They fill the pile and arrest the fission process. The exception to this is the SGHW Reactor at Winfrith which has its own unique 'liquid rod injection' system using Boric acid. However the principle is the same. In an emergency which requires the immediate shutdown of the reactor, Boron in some form is injected into the pile to arrest the fission process.

46 The Borated water injection system has a number of fundamental flaws.

i). If an explosion of some type had occurred within the core and the core was already loosing coolant, this borated water would only be effective for a short period of time before it too was washed out of the core by the circulation of the coolant as it is pumped into the core to prevent the pile being exposed.

ii). The pressure for injection must be just right. If it is too low it may not inject, and if it is too high the pressure could break open the core. It is possible that the borated water forcing its way into the core at such a rate could itself rupture some of the weakened pipework of the reactors.

iii). The system could never be tested to ensure that it worked, as you would have to write-off many thousands of pounds worth of D_2O if you did. Once mixed, I cannot see any way of separating it except by electrolysis (which would be half the cost of new D_2O).

iv). The sort of shutdown time which is required is I believe 2 seconds or under. By injecting water into the core of a reactor in which water is circulating you will not achieve a consistent shutdown time because of the time taken for the two waters to mix sufficiently to cessate the fission process. Fluids in a vessel will circulate the fastest through the area of least resistance. In the core of these reactors the water will be circulating more quickly around the wall of the reactor vessel than through the fuel channels. The time taken to saturate the complete compliment of D_2O circulating within the reactor with boron must be taken into account when looking at shutdown times. In a reactor in which there had been some disturbance of the core and there was an irregular flow of coolant, the time taken for the two to mix could be significantly longer.

v). Safety cannot be guaranteed with a manually operated system. If the operators do not react fast enough control can be lost in a few seconds. This is especially true of these reactors which has a high power density.

47 The case for different types of shutdown system was discussed I believe at a symposium of the British Nuclear Engineers Society, some time around 1961. The case for different types of system were discussed, and the Borated water system was rejected for some of the above reasons.

48 In the responses given to the 'Research Meeting' questions(18) the Harwell management show a complete ignorance about the way in which a workable shutdown system could be fitted to the reactors.

49 They state that in a situation where a force great enough to damage or distort the core was release within the reactor such a system would not work because the delivery tubes for the balls would be blocked. They do not note however that if such a force were generated within these reactors there would almost certainly be a large loss of D_2O from the core. If emergency cooling were engaged and more D_2O or H_2O were injected to cool the core this would wash away the borated water and fission could begin again.

50 With a system using boron balls the balls are dropped into special channels around the inside of the reactor core. These channels are constructed to withstand distortion. When tripped the balls fall into these channels and mop up free neutrons to arrest fission. This system could be automatically initiated in a reactor trip because there would be no worries about writing off thousands of pounds of D_2O. The balls can quite easily be retrieved from the core.

51 In other reactors it is standard procedure that when the reactor is shutdown for its regular check, the ultimate shutdown system is tripped to check that it functions. I do not believe that the UKAEA would do this at these reactors if it meant writing off

the complete volume of D_2O within the reactor. So even if fitted, the system would be infrequently checked and its reliability in an emergency could be in doubt.

g). Employee Safety.

52 The radiation dose limits for employees are set down in the Ionising Radiation Regulations, 1985 (made under the Health and Safety at Work Act 1974 to comply with the recommendations of the International Commission for Radiological Protection). This sets the following standards[(19)]:

> i). Employers should take all necessary steps to restrict so far as reasonably practicable the extent to which employees and other persons are exposed to ionising radiations. The restriction of exposure to ionising radiation is to be achieved so far as reasonably practicable by means of engineering controls and design features and by systems of work which include the creation of controlled and supervised areas and the use of protective equipment.

> ii). Employers should ensure that employees and other persons are not exposed to radiation which exceeds specified dose limits. These are:

> *Dose to whole body.*
> Employees aged over 18 years 50mSv.

Trainees aged under 18 years	15mSv.
Others	5mSv.

Dose to individual tissues and organs.

Employees aged over 18 years	500mSv.
Trainees aged under 18 years	150mSv.
Others	50mSv.

Dose to the lens of the eye.

Employees aged over 18 years	150mSv.
Trainees aged under 18 years	45mSv.
Others	15mSv.

There are also dose limits for the protection of the abdomen of a woman of reproductive capacity.

53 In addition to the above dose limits the Health and Safety Executive set a 15mSv investigational dose. This means that if the exposure of an employee exceeds 15mSv an investigation should be carried out by the employer to determine the reasons for this and to propose solutions for preventing such a dose occurring in the future. A copy of this report should also be sent to the Health and Safety Executive.

54 All the above limits are in the process of being revised downward to around 1/3 of their current level. The proposals for this are set out in the NRPB's GS9 statement(20). These new limits should come into force within the next one or two years.

55 The UKAEA has said(21) of the 15mS investigational dose, "this requirement effectively places an individual dose level at which an investigation should be made into whether the 'As Low As Reasonably Practicable (ALARP) principle is being

effectively applied - it is not a dose limit and there is no implication of a requirement to keep individual whole body dose below 15mSv in a year, nor is there any implication that ALARP is being effectively applied if doses are kept below that level. Requiring employers to carry out what is reasonably practicable to achieve safety is a long established principle of British safety regulations."

56 ***It is true that the 15mSv investigational dose is not a dose limit, but neither is this a license to allow the individual dose to employees to rise to near the whole body dose limit!.*** If employees regularly exceed the 15mSv whole body dose it can be questioned whether or not the employer is applying the ALARP principle effectively. Let us take the numbers of employees in the Harwell reactor area who exceeded the 15mSv dose[22]:

Year	1982	1983	1984	1985	1986
No. exceeding 15mSV dose	**99**	**98**	**61**	**54**	**35**
No. exceeding 50mSv dose	**0**	**0**	**0**	**1**	**0**

57 It can be questioned whether or not the Harwell management are applying the ALARP principle within the reactor area. The number of employees exceeding the investigational dose (which will be the new whole body dose limit when the new standards set in NRPB GS9 are made law) give cause for concern. Evidence from ex-Harwell staff also gives cause for concern. For example:

<u>a). Small Sample Handling Cell.</u>

58 The Small Sample Handling Cell is used by operators whilst the reactor is operating. It consists of a lead shielded box with a 6" diameter

lead glass viewing window. This cell is positioned over the reactor and one to three holes are then opened in the reactor. The operator then handles specimens with manipulating tongs while viewing through the window.

59 The dose to the body through the lead shielding of the cell is around 2mSv/h[23], however the dose to the head through the lead glass is up to 6mSv/h[24] because the window provides less shielding. It was calculated that during the course of a year the two operators could exceed the legal dose limit of 50mSv.

60 In 1985 the Design Dept of the Reactor Research Division at Harwell produced a new design for a view cell using television cameras to replace the old cell. This would have made a significant contribution to reducing the operators annual dose. Tenders for construction were obtained in 1985 and the cost of the project was around £90,000. In May 1986 the Head of Operations instructed the Design Dept to cease all work on the project on the grounds that insufficient funding existed to complete the work.

61 In their 1987 report[25] the UKAEA discount the above dose figures calculated by the Design Dept in 1985, but state that the dose to operators ranges from 23 to 35 mSv/year. This dose exceeds the HSE 'investigational' limit. A new view cell was put on the list of improvements in the UKAEA's 1987 report, the funding for which was shedualed over a 2 year period. However in the answers received to the 'Research Meeting' questions on 26th July 1989, this project was describe as being 'in hand', but not complete.

b). Plant Room.

62 The reactor plant room is situated directly beneath the reactor.

Once a month the reactors are shut down to change and check the experiments within the reactor. At the same time maintenance to the reactor plant is carried out. The major part of this maintenance period is devoted to work on the three heavy water pumps. This involves a high degree of exposure to the staff in the plant room, partly due to the position of the plant room below the reactor, but mainly because in 1982 the primary circuit of the DIDO reactor was contaminated with Cobalt^{60}.

63 Again, the Design Dept, Reactor Research Division, devised a scheme to replace the three old pumps with new ones which would require much less maintenance. The cost was around £250,000 for each reactor. This proposal was rejected by the Harwell management.

c). Reactor Control Rooms.

64 The control rooms for each reactor are situated within the reactor containment building. The operators are therefore exposed to radiation from airborne gases, radioactive particles deposited within the building, and radiation given off directly from the reactor. Occasionally the activity in the control room rises to such a level that the staff are temporarily evacuated.

65 A scheme was devised for siting the control room outside the reactor building. Siting the control room outside the reactor containment building is the normal practice in this country, and throughout the world. The cost of scheme was put at £1.4m. The UKAEA's 1987 review[(29)] stated that new control rooms were needed, and put them in the second category of importance. In the responses given to the 'Research Meeting' group in July 1989, it was stated that a new control room for DIDO was 'in hand'. The delay in moving the control rooms has obviously led to larger then necessary doses to the operators of the reactors.

66 It can be questioned whether an organisation the size of the UKAEA is properly administering the ALARP principle. The action of the Harwell management in refusing the above and other improvements to the reactors and associated plant, their commitment to ALARP can be doubted.

h). Decommissioning.

67 It was announced in February 1989 that the PLUTO reactor was to be shut down and decommissioned. It was stated in the press release(27) that it would provide Harwell to develop further its expertise in decommissioning nuclear plant. However, Harwell have no *practical* experience in decommissioning reactors. The only practical experience of decommissioning within the UKAEA is held by the UKAEA's Northern Research Laboratories who are currently decommissioning the Windscale Prototype AGR. The Dounreay MTR, which is almost identical to the PLUTO reactor, and has been shut down for many years. If the safe decommissioning of PLUTO is proposed, it may be useful to decommission the Dounreay MTR reactor first. It has been shut-down for many years and thus some of the fission products within the core have decayed and the dose to workers will be significantly less. This would give a significantly reduced dose to the workers dismantling the reactor. The knowledge gained from this would then help with the decommissioning of the Harwell reactors.

68 The actual method of decommissioning the PLUTO reactor has not yet been fully outlined. Do Harwell propose, in a similar manner to the CEGB, to dismantle the reactor building and then encase the core in concrete for many years whilst fission products decay?. This part of Oxfordshire is very beautiful, and the Ridgeway long distance footpath runs less then a mile from these reactors. Building

a concrete sarcophagus for these reactors would present just as great an eyesore as the reactors do at the moment.

69 Plans have been made for disposing of both reactors. A scheme was put forward by the Design Dept of the Reactor Research Division at Harwell which involved stripping down the reactor to the biological shield. At this point the reactor becomes quite a small object, which could be moved inside the main Harwell site to be put into long term storage until it is safe to break up. This would then enable the perimeter fence of the site to be reduced by a great length, and would return a large area of land to the countryside.

70 Before rushing into decommissioning the Harwell MTR's, the UKAEA should be asked to create detailed plans in association with the NII, the NRPB, and the Department of Energy to ensure that the best possible programme for safe decommissioning. This plan should also be available for public comment.

Emergency Planning.

a). The Harwell Draft Off-Site Emergency Plan.

71 Oxfordshire County Council and UKAEA Harwell are currently revising the emergency procedures to cover the eventuality of an accident on the site leading to a leak of radioactivity beyond the perimeter fence. As a whole the plan is quite comprehensive and some effort has obviously been put into its drafting. However, a large number of deficiencies exist within the plan which could lead to serious complications should the plan ever have to be fully executed.

72 These reactors are, as stated in the previous section, quite old and suffering from many years of underfunding on maintenance and safety improvements. The plan begins by stating that the chances of an accident giving rise to a release of radioactivity are remote. But by Harwell's own admission[28] a full probabalistic safety assessment of the two materials testing reactors has not been carried out on the reactors and thus the true probabilities of an accident cannot be known. Therefore when designing the reference accident on which to base the plan Harwell had no detailed knowledge of just how possible various accident scenarios were. The basis of the entire plan, the reference accident, should be reviewed to ensure that it is a sound assessment of a 'probable' event in comparison with other accident scenarios involving the materials testing reactors.

73 The plan itself is well put together but flaws do exist. Subsequent drafts have, despite my observations on the draft plan being given to the Oxfordshire County Council Emergency Planning Dept, failed to address these flaws which seriously impair the credibility of the plan. These flaws cover a number of areas.

i). Reference Accident.

74 The Reference Accident[29] is not referred to in detail anywhere within the plan. Rather than just referring to it in vague terms, it should be fully explained and the probabilities of various occurrences happening explained. Enough is known about the work conducted and the facilities at Harwell to give greater detail in the reference accident without compromising security.

75 It is planned that counter measures will only be necessary within an area of 2.5km radius from the reactor area. This would be sufficient for coping with a small release, but even a moderate release of airborne radionucleides would very quickly pass beyond this boundary. Greater emphasis should therefore be placed on making the plan more easily scaleable, possibly to cover an area up to 10km in radius. it should be noted that 2.5km is a very small area for countermeasures when compared to the standard emergency planning zones used in other countries with nuclear programmes. The '*small*' size of these reactors makes no difference either, even when comparing them to the other power reactors in this country. By comparison, most other reactors in this country have a much better standard of containment to cope with a release of material from the core.

ii). Exposure pathways.

76 The various exposure pathways[30] are briefly considered, but two faults exist with this. Firstly only very brief details are given on exposure. These details should be greatly enlarged to ensure that those responding to an incident are more aware of the problems of exposure. This would help to ensure the minimum exposure to the public, and those responding to the incident.

77 Secondly one very important exposure pathway is ignored - the resuspension of radioactive particles by the wind. It is not clear whether this was an oversite or whether the planners were unaware of this exposure pathway.

iii). Press Liaison.

78 Brief details are given on the facilities for liaison with the media and warning the public[31]. To ensure the fastest response, and to be certain of the accuracy of the information given out during an incident, press information should be drafted along with the plan. This would enable the fastest response to be achieved if an incident were to occur. The information would already exist - it would not have to be prepared and then cleared for release.

iv). Environmental monitoring.

79 The plans for radiation surveys and environmental monitoring[32] need much work to ensure their effectivness. The National Radiological Protection Board have their headquarters less than 1km from the reactor area. What will be the effects if the NRPB are unable to used their facilities at Harwell due to the need to evacuate all personel from the site?. What backup will be provided if such an event were to occur.

80 At no point are detailed proposals for radiological surveys laid out. A survey of the area of contamination would be essential in the initial stages of an incident if correct decisions are going to be made about evacuation etc.

v). Evacuation.

81 Plans for the evacuation of the local population[33] need review. No mention is made of the use of radiological surveys to decide which areas of population would be the most seriously affected by the spread of contamination. In fact the only specified details on evacuation concern the communities within 1km of the site.

82 Another fault concerns the maps enclosed with the plan. These show all the communities within different distances from the site. However, no details of population are included with these maps. It would be a sensible precaution to include population data for all the communities within ten miles of the site. This would save confusion in a real incident should it be necessary to evacuate a community very quickly because information on population would be at hand and would not need to be requested from the local councils.

vi). Distribution of potassium iodate tablets.

83 The distribution of potassium iodate tablets to the local population is the greatest stumbling point in the whole plan. These tablets would need to be issued to the public if an incident occurred on the site which led to a release of radioactive iodine. The tablets saturate the body with stable iodine and prevent the uptake of radioactive iodine by the thyroid gland.

84 The nearest stock of potassium iodate tablets is held at the John Radcliffe hospital in Oxford. If they were ever needed they would have to be brought by road from Oxford, and then distributed to the population. For the tablets to be +90%[34] effective they need to be administered before the individual is exposed to radioactive iodine. Beyond 6 hours after exposure effectivness rapidly drops below 50%. It

is obvious that such a course of action is not practical as by the time the stock of tablets arrived, many people would have been exposed.

85 A solution to the problem was proposed by Oxfordshire Health Authority's Community Physician[35]. This involved issuing every household near the site with potassium iodate tablets. However this proposal has been shelved for the time being as such a course of action would set a precedent nationally, and the County Council would first need the approval of the Home Office (who handle emergency planning).

86 Unless the distribution of potassium iodate tablets can be sorted out the plan will hold very little reassurance for those living near the establishment.

vii). Possibilities of a serious reactor incident.

87 It is maintained that the possibility of a serious reactor accident is very remote. As stated, how remote is not known as a full engineering fault sequence assessment has not been conducted. The condition of the reactors and the methods of operation make an accident a practical proposition, though the seriousness of such an accident is a matter for debate. The fact is that these reactors are structurally unsound, and an accident is not remote - all accidents can be understood by statistical mathematics which would state that an incident could occur in fifty years time, or tomorrow morning.

88 The plan prepared by Oxfordshire County Council is well researched and they are to be commended for the lengths they have gone to to create such a

comprehensive plan. However, there are a number of problems which can be foreseen should the plan ever be put into operation, and these should be solved before the plan is finalised.

b). Possibilities and consequences of a serious reactor accident.

89 The reference accident for the draft emergency plan was produced by the UKAEA. The basic incident involves a fuel rod which is removed from a reactor. During fuel changes the rods are removed from the reactor and placed in a flask. This flask is then moved by road (about 100m) to the fuel pond building. During this time the only containment is the flask. As the rod is being transported to the fuel pond the coolant circulation to the rods fails and it overheats. The material given off from the rod is largely contained within the reactor building, and only small amounts escape into the environment. However, the reality of this accident can be questioned, not only because of the way the flask is handled but also because of systems which should have been implimented by the UKAEA concerning the handling of fuel rods.

90 In 1988 the Nuclear Installations Inspectorate conducted a safety audit of the Harwell reactors. One of the recommendations outlined in a subsequent press release(36), which should have been instituted by 30/9/88, was that fuel elements should be handled only when the decay heat power would allow a thirty minute period before cooling needs to be re-applied. If this is being carried out the possibility of a fuel rod overheating is remote.

91 If a reference accident is to be chosen then the possibility of a failure of one of the pressurised experiments within the reactors should be considered.

92 Within the unpressurised reactors high pressure/high temperature experimental rigs and loops operate. Some of these experiments are fitted inside the reactor vessel close to the core. Many of these experiments are double walled, but the larger ones have two walls sandwiched very close together (thus reducing the capacity of the outer vessel to withstand fast failure of the inner) and the largest, the DIDO water loop, only has a single wall. Let us consider the implications of a large heated and pressurised experiment failing, and a number of possible consequences from this event.

93 A heated/ pressurised loop within the reactor vessel and close to the core splits and its contents enter the reactor vessel. The pressure within the core immediately begins to rise rapidly. Any D_2O which comes into contact with the hot gases or liquids from the loop could flash to steam, increasing the pressure further. The reactor vessel is sealed and so pressure will increase throughout the primary circuit. One of the weak points, admitted by the UKAEA, are the drain tube leading from the bottom of the reactor. Due to their fragile condition these may rupture, and D_2O would be forced out of the reactor. At this point it is presumed that emergency cooling would cut in and the control arms would be lowered to shutdown the reactor. If this worked then reactor power would drop to below 1MW, and as long as core cooling can be maintained for a few hours the power output would fall to a relatively safe level.

94 However, let us assume that D_2O is still leaking from the drain pipes. This would run into the plant room below. Much of the electrical systems to control both the main D_2O pumps, and the backup pump are in the plant room. There is a possibility that some electrical systems might suffer damage from the amount of D_2O pouring from above (such

a problem was indentified by the NII in their safety audit[37]). If the power supplies to the pumps were affected the pumps may fail. If this were to happen with the reactor shutdown then the backup cooling established manually (by connecting the fire hose from the reactor hall to a special coupling on the reactor) may cope, but with the pumps out of action, the light water may not circulate fully because of resistance within the primary circuit.

95 The effects of such an incident could be similar to those in the existing reference accident, the main danger being that D_2O contaminated with fission products may reach the environment. However, let us take a slightly different view of the original initiating incident.

96 Due to the high power density of these reactors, the loss of cooling for even a short period of time could lead to a fast rise in core temperature. This would be lessened by the control arms being dropped down to reduce fission within the core. However, let us imagine what would happen is some or all of the control arms were damaged by the failure of the loop.

97 The control arms operate like signal arms, dropping between the rows of fuel rods. If these were damaged or distorted by the loop failure, or the core was in some way disarranged, they may not be able the enter the core and shut down the reactor. This would be a considerable problem because a failure with enough power to do this would also breach the primary circuit. Though a more remote possibility than the scenario above, such a loop as the DIDO water loop could conceivably do such damage.

98 If the control rods failed to function fully, certain parts of the

core could begin to overheat. This would be worsened if there was a significant loss of coolant. Let us assume that a borated water shutdown system had been fitted and was working on the reactor. Only the PLUTO reactor has been fitted with such a system, but the system must be manually initiated. It should be noted that the system currently installed on the PLUTO reactor is not in working condition during everyday operation[(42)], as it was planned only to have it operational when the PAT loop was running. The boron shutdown system is activated, it successfully works, and the core is flooded with boron in solution. However, if the primary circuit was damaged, boron could be lost from the system as the D_2O was circulated to cool the core. The introduction of emergency or backup cooling may also dilute the concentration of boron in the core.

99 In such a situation, as the boron was lost the reaction in the core would slowly increase. If nothing could be done to arrest this process, at 100ºC the D_2O in the reactor would begin turning to steam, the resultant increase in pressure doing more damage to the primary circuit pipework, and possibly causing leaks around some of the experiment holes. If this were to get out of hand the quantities of steam produced could be enough to force their way from the reactor building.

100 If the core were to reach around 800ºC it would melt its way through the aluminium of the reactor tank and do damage to the inner steel tank and the lead shielding behind. If the mass of fissile material were to create enough energy to reach 2000ºC, the molten mass of material could burn its way through the biological shield and drop into the plant room. Admittedly the loss of the D_2O moderator as steam may slow the reaction, but if enough material were concentrated in a small space criticality could still be maintained.

101 With the age and condition of these reactors a quite serious incident should be considered. A more sensible reference accident would be the possibility of one of the pressurised experiments within the reactor failing. Such an incident could be contained but there is the possibility that such an incident could trigger a chain of failures within the reactor leading to a serious reactor accident. The UKAEA would criticise this approach as being biased towards a 'worst case' accident, but the scenario chosen does represent a probable incident involving the reactors. It is not a certainty that a pressurised experiment would fail in the reactor, but in terms of reactor safety these experiments are the weakest link and more thought should be given to the idea of their failure initiating more serious faults within the reactor.

102 The consequences of even a minor incident should not be underestimated. This is a highly populated area and even a slight mistake in evaluating the spread of contamination could affect thousands of people. As stated it is doubtful whether the emergency services could respond fast enough at short notice to provide evacuation for those close to the site. Within 10km of the reactors live more than 15,000 people. The River Thames, on of the main sources of water in the South-East, and a major rail link also pass within the same distance. Even a leak of contamination on a very small scale could cause chaos over a large area.

103 A full fault sequence assessment has not been conducted on these reactors and therefore the probabilities of various scenarios cannot be fully confirmed or refuted, by either myself or the UKAEA. In their present condition it appears that there is insufficient redundancy and diversity built into the reactor systems to manage a sequence of serious faults. I do not believe from the research I have carried out that in their present condition these reactor could withstand the fast rupture failure of one of the larger experiments running in these reactors.

Other Issues.

a). Transport of Nuclear Fuel.

104 The Harwell reactors run on 93% enriched Uranium^{235}, otherwise known as 'weapons grade' Uranium. This is manufactured at the UKAEA's plant at Dounreay. The spent fuel from these reactors is also taken back to Dounreay for reprocessing. In a letter[38] the UKAEA admitted that spent fuel is transported by road from Harwell to Dounreay, and though not disclosed, it can be assumed that new fuel rods for the reactors arrive in the same way.

105 The case for transporting spent fuel by road should be investigated. A major rail link lies only a few miles from Harwell, and the reasons for not transporting spent fuel by rail defies logic. The probabilities of a serious accident are much lower on railways than they are on the road. The threat from deliberate tampering with the cargo, eg by terrorists, is also significantly reduced for the plain fact that trains are much harder to hijack.

106 A review of the current transport policies should be carried out and a switch to rail transport considered.

b). MoD Involvement.

107 The MoD used to have their own materials testing reactor at AWE Aldermaston, not very far away from Harwell. In 1986, the last of their reactors, HERALD, was closed down and the work was contracted out to Harwell.

108 The most major experiments conducted by the UKAEA for the MoD involve the testing of nuclear submarine power plants and fuel rods. This is the purpose of the DIDO water loop. It simulates the conditions inside a submarine power reactor. Speculation has also been made about the role of Harwell in atomic weapons research. The MoD have taken over building 220 at Harwell for their own use.

109 The use of the Harwell facilities by the MoD must be scrutinised. As a public organisation the UKAEA are subject to IAEA/EURATOM rules. However, in much of the research on safety done by myself and individuals, the UKAEA have found 'national security' a very useful cloak to hide information of certain aspects of safety of the reactors and other plant. An investigation needs to be done to ensure that the UKAEA are living up to their IAEA/EURATOM commitments.

c). Waste disposal.

110 **i). Low-level.** Harwell have their own low-level waste repository on site. They also incinerate low-level wastes in a special incinerator.

111 Much criticism has been made of the methods used at BNFL's Drigg site in Cumbria. From what can be deduced, the methods used at Harwell are not dissimilar. The practice of depositing waste in an area with a geology of underlying chalk, very close to one of the countries major watercourses needs to be looked into to ensure that there is no danger of leakage of radionucleides off site.

112 The nuclear waste incinerator at Harwell has been operating for a number of years, and yet it was only this year that the Department of the Environment went

through the process of authorising discharges of radioactivity into the atmosphere. Many local people and local authorities are opposed to this incinerator being operated at Harwell. Also, is it wise to carry out such operations in an area of high population density?.

113 The discharge of radioactive effluent into the Thames needs reviewing as well. On its own it may not be a hazard, but only a short distance down stream AWE Aldermaston has its pipeline, and AWE Burghfield also discharges effluent into the Thames via the River Kennet. What are the cumulative effects of these three discharge points?. It has been noted(39) that an enhanced level of beta activity exist in the silt near the outfall into the Thames, and that these levels follow a pattern with the levels of caesium and plutonium isotopes within the silt. What studies have been carried out into the effects of this?.

114 In 1961 the pipeline carrying effluent to the Thames sprung a leak and contaminated $100m^2$ of soil. Yet it wasn't until this year that consideration was given to the radiological hazard this might present to the public. Harwell were always very dismissive of the significance of this contamination, and it wasn't until I gave the information to the local media that they actually rushed to remove the contaminated soil. Even then it was only dug up and then dumped on the Harwell site. If this espisode represents their concern about environmental pollution, can they be trusted to ensure the safety of their future discharges into the Thames?. There was also a leak from the pipeline in 1988 which contaminated the surrounding soil at the Grove Farm commercial apple orchard near Harwell. This leak is still being monitored.

115 **ii). Intermediate level.** Harwell stores many barrels of intermediate level wastes. Some of these are sea-dump barrels left from the ban on sea-dumping in 1983. It was admitted in a letter(40) that no consideration was given to the retention

capacity of these barrels because it was assumed that they would be dumped in the sea. Decisions on the future of these drums need to be made soon so that they can be repackaged in a form more suitable for storage on land.

d). Privatisation.

116 The UKAEA is currently restructuring itself to become more of an independent trading company, and eventually privatisation may be considered. This should be looked at carefully as it could have two detrimental effects.

117 Firstly, what will be the future of much of the research done by Harwell after privatisation. Many different research projects are currently run from Harwell, many of them non-nuclear and in areas where other companies may not readily come forward with funding (eg, renewable energy sources). The future of such projects needs to be considered, and steps need to be taken to ensure that such pioneering work is continued even after any privatisation of the UKAEA.

118 Secondly, there is the future of the reactors to be considered. Who will take over and run the reactors if they are still operational?. In their current condition I cannot imagine any company taking them on.

e). Use of Plutonium.

119 It was recently revealed[41] by the director of the UKAEA's Nuclear Materials Control Office that Harwell handles nuclear materials outside of the safeguards of the IAEA/European Safeguards Research and Development Association. However he added that nuclear materials are only 'very seldom taken out of safeguards' at Harwell because 'the Department of Energy don't like it'.

120 The question must arise as to *why* it is necessary to take nuclear materials out of international safeguards, and what regulations it is kept under while these safeguards are suspended?. Should they be allowed to take such action in the first place?.

121 Secondly there is the question of the use of plutonium by the MoD at Harwell. From the work I have carried out Harwell does not have a plutonium smelting facility. Therefore the plutonium must be transported to Harwell in its natural metal state, rather than as an oxide. This obviously presents problems of safety and security. also, are the precautions taken for the shipment of such cargos done under MoD or IAEA regulations?.

5). Conclusions.

a) General.

122 I am sure that Harwell will waste no effort in producing a report to deny or disprove the allegations made in this paper, and they may even make personal attacks on my own character - this happened with Dennis Dawson when he first published his critique of the state of the materials testing reactors in 1987. In fact the UKAEA's July 1987 paper on safety almost shadows the layout of Mr Dawson May 1987 paper.

123 I feel that I cannot state my position forcefully enough to be believed. I support some of the work that is being conducted at Harwell, though I reserve judgement on some of the work in the nuclear fields on both moral and technical grounds. My position on the materials testing reactors is that one or two small reactors will always be needed for the production of isotopes and other essential materials derived from nuclear processes. However, the safety of these reactors must be of primary importance, and my foremost objection to the materials testing reactors at Harwell is concerned with the poor condition of the reactors. In my own opinion they should be closed as soon as possible and replacements should be considered, but these new reactors should be sited in an area of low population density - not at Harwell.

124 The information drawn upon in this paper is presumed to be accurate. The information I have obtained has come from many sources - Harwell ex-employees, government departments, public bodies, and to my knowledge this information is correct. However, there are certain instances where information gained from different bodies, eg the UKAEA and NII, has conflicted or been contradictory. For example the UKAEA say that a boron secondary shutdown system has been fitted to the PLUTO reactor. The NII[42] state that this is true, but the system is not operational because it was only intended to function when the PAT loop was running. Also it should be noted that the information given by the UKAEA and the Department of Energy has

varied over time, the most stark example being the responses given to the Harwell Local Liaison Committee. There have also been instances where the information given has not been quite accurate, or to coin a phrase, 'economical with the truth'.

125 For example, let us take a response given in the Commons to a question put by Andrew Smith MP (Oxford East). At the request of Michael Spicer, the UKAEA replied to the question in a letter. In this letter they make the assertion that the primary containment of the reactor is the double steel tank and biological shield of the reactor. This is not an accurate statement. The primary circuit pumps and heat exchangers are outside the steel tank, and so it is not correct to describe this as being 'primary containment. In fact the reactors only have a single containment - the reactor building itself. Again we can take an example such as the 1961 pipeline leak. Harwell stated that the leak from the waste pipeline in 1961 presented no danger to the public. If this is so why did they remove the soil from the site, and do so in such a way to avoid any press coverage?. At the time of the leak in 1961 there would have been twice the amount of $Caesium^{137}$ and $Strontium^{90}$ present in the soil (the half life of these isotopes is around 30 years) so why wasn't it removed then?.

126 Concern is also aroused by the recent statements from Harwell concerning the Emergency Reference Levels set by the NRPB. These set 'action levels' at which sheltering, evacuation, distribution of stable iodine etc should take place to ensure the safety of the public. The dose level at which evacuation should take place is 100mSv. Harwell have now been issued with an exemption allowing them to exceed the normal 5mSv maximum dose to the public in exceptional circumstances. The situation should be made clear as to whether or not Harwell have to inform the public should a leak of radiation occur, or if they can wait until such a time as it is thought they might exceed one of these action levels (in the case of the lower 'sheltering' level, this would be 5mSv. The responsibilities of Harwell under this exemption should be defined.

127 Due to the variable nature of the information received, I accept the possibility

that some of the information here presented may not be entirely accurate, but I have had to take much of the information given by the UKAEA, Department of Energy, etc, on face value, and due to the unwillingness of these bodies to enter into open dialogue I have been unable to check the accuracy of all this information.

128 Looking at the evidence I have amassed over the past five years, the main part of which has been found during my dedicated research of the past fourteen or so months, I feel that I can make some definite recommendations concerning the future of these reactors, and the operations of some parts of the UKAEA and the Harwell establishment.
These can be divided into many areas.

b). Recommendations.

I). Reactor Management.

129 i). The system of issuing the Authority to Operate from within the UKAEA should be stopped at once. The state of affairs this has brought about in terms of operating procedures and general reactor safety is intolerable, and the clearance for the further operation of the reactors on the Harwell site should come from the Nuclear Installations Inspectorate.

130 ii). If the reactors are to continue operating, sufficient funds should be made immediately available by the UKAEA to bring the condition of these reactors up to the present day standard. Top priority should be the safety and reliability of these reactors.

131 iii). All of the UKAEA's reactors operating beyond their design lifetimes should have regular inspections by the NII. The situation of the 1988 Harwell safety audit where the NII inspected the outside of the reactors and the Harwell staff had twelve months to give an account of the internal conditions is not good enough. The NII should conduct a full safety inspection and not delegate certain parts of the task.

132 iv). The current practice of having large numbers of Harwell staff on the Local Liaison Committee should be stopped. The numbers of Harwell staff should be cut to at most on third of the numbers on the LLC. The current domination of the LLC by members of the Harwell staff, both directly and as appointees of local parish councils, does not produce the fully open conditions necessary for the effective operation of this committee.

II). Reactor Safety.

133 i). The use of pressurised test rigs and loops should be stopped immediately. It offends all safety principles to have pressurised devices operating in an unpressurised reactor. Given the current age and condition of these reactors all future experiments run in these reactors should have safety assessments conducted by the NII before clearance is given for their commissioning.

134 ii). All steps should be taken, and funds made available, to introduce a programme of modifications to ensure that annual

operator dose rates are as low as possible. The spirit of the HSE's investigational dose limit should be adhered to, with investigations taking place and remedial work carried out if necessary should operator doses exceed 15mSv.

135 iii). As a priority, a full safety inspection should be carried out by the NII, covering not only the external plant but also the internal conditions of these reactors. Inspection of the internal components of the reactor such as the steel and aluminium tanks should be part of this internal inspection. From the data produced a full fault assessment could be done to assess the safety of the reactors under accident conditions.

136 iv). The list of modifications specified in the UKAEA's 1987 paper should be completed as soon as possible, preferably before the NII give clearance to operate these reactors. Included along with these modifications should be the fitting of a credible shutdown system, not based on the injection of borated water. The system should be able to be tested at every reactor shutdown.

137 v). Regular statements on the current condition of all plant on the Harwell site should be produced jointly by the UKAEA and NII for local authorities, to keep them informed and aware of any changes on the site.

III). Emergency Planning.

138 i). A more realistic reference accident should be produced

reflecting the current safety conditions on the reactors. This should involve the results from a probabilistic safety assessment to ensure that there is a sound basis for the accident.

139 ii). A solution should be found to the problem of the distribution of potassium iodate tablets, even if this involves a reappraisal of the policy nationally.

IV). Waste Disposal.

140 i). An assessment of the on site low-level repository should be conducted to ensure that there is no possibility of leakage causing contamination off-site. All policies for the storage of waste on site should also be looked into to ensure that there is little danger of contamination of the local environment.

141 ii). Due to the local opposition, the closing down of the Harwell waste incinerator should be considered, and the centralisation of radioactive waste incineration in the UK considered.

142 iii). A solution to the storage of sea-dump barrels on site should be found quickly. If nothing can be done immediately then they should be overpacked in containers designed to stand up to storage at ground level.

143 iv). The standard of radioactive effluent treatment should be looked into to ensure that as little activity as possible is discharged

into the River Thames. The SIXEP plant at Sellafield shows what can be achieved in terms of effluent treatment if investment in new plant is made. The possibility of reductions in radioactive discharges through improved effluent treatment should be investigated.The results of the survey into 'enhanced beta levels' around the Harwell outfall should be made public.

V). MoD involvement and safety standards.

144 i). Areas of responsibility should be made between the UKAEA and the MoD. The two authorities would then be responsible for their actions in those parts of the site. This should stop the current confusion with the UKAEA hiding behind the MoD over certain areas of the site's work. It would also mean that strict standards could be set within the site, rather than the UKAEA switching between IAEA/EURATOM and MoD standards as they do at the moment.

145 ii). An inquiry should be held into the suspension of international standards governing nuclear materials, and such instances should be forbidden from occurring in future.

VI). Privatisation.

146 i). It has been accepted by the Department of Energy (during

the privatisation of the CEGB) that nuclear reactors cannot viably be privatised. In any privatisation of the UKAEA establishments, control and responsibility for the reactors on site, and at other UKAEA sites, should pass to a body appointed by the Department of Energy.

VII). General.

147 i). The full report produced by the NII after their 1988 safety review should be published.

148 ii). A public inquiry should be held into the continued operation of these reactors, and the further use of the waste incinerator. The public have little faith in the safety of the establishment and this would be the only way to settle these matters once and for all.

c). Summary.

149 To sum up, I will say the following. The UKAEA has conducted pioneering work at Harwell for many years, but the privileged position they hold in terms of the safety of nuclear plant has meant that safety has not been the top priority when considering new investment in the reactors. This has led to a slow decline in safety standards over a number of years.

150 The UKAEA and the Department of Energy now seem to have closed ranks to prevent and further revelations on the safety of the Harwell site becoming public knowledge. This has led to confusing or contradictory statements being made on plant safety. Those of us researching the safety of the Harwell site have come to a point where we cannot get straight answers to straight questions because of the manipulation of truth by the UKAEA and the Department of Energy. For that reason we have brought the issue to the Commons Select Committee on Energy in the hope that this mess can be unravelled and positive moves made to improve safety at the Harwell site, especially in the materials testing reactors. We hope that the power of the Select Committee to request and hear information will bring the true facts to light.

151 The materials testing reactors at Harwell are the most dangerous reactors operating in this country today. They have suffered a long period of under investment, and the state of the reactor plant has deteriorated to a point where the risks of operation outweigh the benefits. Even if the construction replacements were to begin tomorrow, the new reactors would not be running for at least another five years. The unsafe condition of these reactors - the internal corrosion, operator dose rate, lack of safety shutdown systems and insufficient level of redundancy and diversity to withstand plant failures, should be admitted by the UKAEA, and as a priority consideration should be given to the immediate shutdown of these reactors.

END.

Notes and Sources.

1). From 'Nuclear Power', Aug 1956 p165/169.

2). Letter - UKAEA to Andrew Smith MP, 13/2/89.

3). NII Harwell Safety Audit press release, 21/6/88.

4). UKAEA safety statement, 'The Safety of UKAEA Plant With Particular Reference to the Harwell Reactors', July 1987.

5). Harwell Answers to 'Research Meeting' questions at Harwell LLC meeting, 26/7/89.

6). NII Safety Audit press release, 21/6/88.

7). Letter - UKAEA to OPC Research, 28/3/89.

8). Harwell press release, 22/2/89.

9). UKAEA safety statement, 7/1987, paras 21 to 23.

10). D. Dawson, 'The Harwell Reactors DIDO and PLUTO, Cause for Concern', 8/5/87.

11). UKAEA Safety Statement, 7/1987, para 24.

12). UKAEA Safety Statement, 7/1987, para 26.

13). UKAEA Safety Statement, 7/1987, para 22.

14). UKAEA Safety Statement, 7/1987, para 23/30.

15). 'Research Meeting' answers, 26/7/89, point 1.

16). Letter by HSE, 22/7/88.

17). UKAEA 'ATOM', December 1988.

18). 'Research Meeting' answers, 26/7/89, point 1.7.

19). UKAEA Safety Statement, 7/1987, para 10.

20). NRPB - GS9. 'Interim Guidance on the Implications of Recent Revisions of Risk Estimates and the ICRP 1987 Como Statement', November 1987.

21). UKAEA Safety Statement, 7/1987, para 11.

22). UKAEA Safety Statement, 7/1987, para 14.

23). Figures supplied by Mr Denis Dawson.

24). Figures supplied by Mr Denis Dawson.

25). UKAEA Safety Statement, 7/1987, para 15.

26). UKAEA Safety Statement, 7/1987, para 29.

27). Harwell press release, 22/2/89.

28). 'Research Meeting' answers, 26/7/89, point 1.5.

29). Oxfordshire County Council Harwell Off-site Emergency Plan, May 1989 draft, para 1.11.

30). Oxfordshire County Council Harwell Off-site Emergency Plan, May 1989 draft, para 1.13.

31). Oxfordshire County Council Harwell Off-site Emergency Plan, May 1989 draft, paras 2.6/2.7.

32). Oxfordshire County Council Harwell Off-site Emergency Plan, May 1989 draft, para 2.23.

33). Oxfordshire County Council Harwell Off-site Emergency Plan, May 1989 draft, paras 2.12 & 2.24.

34). 'NRPB Emergency Handbook' NRPB-R182, March 1986.

35). Letter - Oxfordshire Health Authority Community Physician to OPC Research, 7/9/89.

36). NII Safety Audit press release, 21/6/88.

37). NII Safety Audit press release, 21/6/88.

38). Letter UKAEA to Jan McHarry, 11/8/82.

39). UKAEA 'Harwell Radioactive Discharges and Environmental Monitoring for 1987', page 20.

40). UKAEA to R.S. Bashford, 16/3/87.

41). Article by David Lowry (European Proliferation Information Centre) in 'SCRAM' No 73, Oct/Nov 1989.

42). Letter, NII to Banbury Environmental Research Group, 29/9/89.

Copies of information.

So far as copyright allows, copies of information used in the production of this report can be obtained from Banbury Environmental Research for a small price. Where copying of documents is prohibited by copyright, details of where copies of the document can be bought can be supplied.

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