

BRIEFING PAPER ON 'THE JAPANESE EARTHQUAKE AND TSUNAMI: IMPLICATIONS FOR THE UK NUCLEAR INDUSTRY'

Produced for the NuLeAF Steering Group Meeting, 21 October 2011

The report was published on 11 October and is available on the Office for Nuclear Regulation (ONR) website at [Chief Nuclear Inspector's report on lessons from Fukushima](#).

This briefing has been prepared to inform discussion with Dr Andy Hall, Deputy Chief Inspector of Nuclear Installations, at the afternoon session of the Steering Group (SG) meeting on 21 October.

The briefing is divided into 2 sections: overview of the report; and material relevant to specific points made by the SG in its letter to Mike Weightman of 14 July 2011.

Potential issues for discussion with Andy Hall are highlighted in ***bold italic*** text.

Overview

The press release from the Department of Energy and Climate Change (DECC) about the publication of the final 'Weightman Report' states that:

"Additional information received since the interim report ... has reinforced and further validated the findings of the interim report. Dr Weightman's final report found that:

- There is no reason to curtail the operation of UK operating sites, although operators should continue to follow the founding principle of continuous improvement.
- There are no fundamental weaknesses in the UK nuclear licensing regime or the safety assessment principles that underpin it ...
- The final report also confirms Dr Weightman's advice ... that he saw no reason to revise the strategic advice given by the regulators on which the Nuclear National Policy Statement was based, or any need to change present siting strategies for new nuclear power stations in the UK.
- The UK practice of periodic safety reviews of licensed sites provides a robust means of ensuring continuous improvement ...
- The events at Fukushima reinforce the need to continue to pursue decommissioning of former nuclear sites with utmost vigour and determination.
- The regulator is satisfied with the responses and plans initiated by the Government and nuclear industry in response to the interim report."

The summary of the final report confirms that "the direct causes of the nuclear accident at Fukushima, a magnitude 9 earthquake and the associated 14m high tsunami, are far beyond the most extreme natural events that the UK could be expected to experience" (page v).

The report states that "the basic cause of the accident was thus that the site was not designed with adequate protection against some foreseeable natural hazards" (para 754, p137). In particular, the report highlights the statement in the report of the Japanese government that:

"compared with the design against earthquake, the design against tsunamis has been performed based on tsunami folklore and indelible traces of tsunamis, not on adequate consideration of the recurrence of large-scale earthquakes in relation to a safety goal ...".

In response to concerns that it may be premature to draw conclusions before the full details of the accident have been established, the final report states:

Uncertainties about the technical details of the accident do not, however, prevent us from drawing conclusions about its causes and about the subsequent emergency response both on-site and in the surrounding area. Above all, we should to seek to draw early lessons wherever we can and to ensure those lessons are put into action in the UK as soon as possible. Although sufficient was known by the time the Interim Report was finalised to enable us to draw out key conclusions and recommendations, the additional information that has become available in the intervening period has enabled us to review, validate, refine and supplement these as appropriate. We will continue to review and act upon any detailed technical information that emerges from future scientific analysis of the accident or subsequent research. (para 716, p129)

On the implementation of interim recommendations, the final report states that:

Given the nature of the recommendations and the relatively short timescale since they were made, at this stage ONR expects the industry to be developing plans and projects to address the recommendations and has met the licensees to confirm this. None of the recommendations have yet been completed; however, an appropriate degree of progress is evident. (para 552, p100)

The final report makes a number of additional recommendations. Amongst these is a new recommendation that will be of specific interest to local authorities:

Recommendation FR-5: The relevant Government departments in England, Wales and Scotland should examine the adequacy of the existing system of planning controls for commercial and residential developments off the nuclear licensed site

The rationale for this recommendation can be found in para 794, p145 of the final report.

Specific Points

1 The interim management of spent fuel

In its July letter, NuLeAF expressed concern about the statements in the preliminary responses from Magnox and EdF at paragraphs 322 and 324 in the interim report. These included that for Magnox sites undertaking defueling, in response to loss of shielding water, "recovery actions by operator would be difficult ..." and for Sizewell B, recourse may be necessary to providing water using a fire tender parked outside the fuel building. The letter stated that member authorities are likely to look for assurance that plans for recovery actions in the event of loss of water are robust and convincing.

On spent fuel management at Fukushima, the final report:

- Discusses the extent to which the spent fuel ponds at Fukushima were affected by, and contributed to, the accident (paras 211-224, p40). It suggests that the structures of the individual reactor ponds remained essentially intact and that it is unlikely that any hydrogen explosions were caused by the uncovering of spent fuel as a result of water loss in the ponds (although "no definitive mechanism has been established" for the explosions). It notes that the improvised ways of providing water to the ponds seems to have been effective in maintaining water levels. It also summarises information about the reactors'

common pond and on dry cask storage, reporting no significant damage to the former and (despite water inundation) no effect on the casks (paras 230-231, p44).

- Concludes that “the ponds appear not to have been a significant contributor to the consequences of the accident” (para 324, p60).
- Points to the “ability to provide make-up water for a prolonged period of time (admittedly by unconventional means and with access enabled by damage to the buildings)” (para 324 p60, but says “it is worth noting that more urgent operator actions to provide make-up would have been required if the spent fuel ponds integrity had been breached and water lost by leakage. This would potentially have exacerbated the overall situation considerably.” (para 382, p71)

On UK arrangements for spent fuel storage, the report notes that:

- the “response to the Interim Report recommendations and the European Council “Stress Tests” being carried out in the UK should demonstrate whether the UK spent fuel ponds are passively “safe” by design, and in some cases whether it is ALARP to impose relatively straight forward minimum cooling times or racking configurations to ensure that with a total loss of active cooling (possibly even a catastrophic loss of water inventory) the fuel should remain substantially intact.” (para 325, p60)
- EdF recognises that there will be a need to carefully assess and make appropriate changes in several key areas, including: enhancements to on-site resilience from the effects of major events; provision of off-site emergency back-up equipment that can readily be connected to the plant; and the potential impact of abnormal natural events on local and national infrastructure (para 602, p107). In addition, EdF has identified a number of specific potential enhancements to resilience, including a larger water reservoir for make-up under severe accident conditions that is seismically qualified (para 616, p110).
- Magnox has undertaken work on Oldbury and Wylfa that identifies a number of potential improvements which could enhance the resilience to various events, in particular extreme seismic or flooding events. Examples of the potential improvements highlighted by Magnox are: enhanced protection of existing facilities to reduce the potential for damage; and storage of existing on-site back-up equipment (e.g. spare pumps and pressure circuit sealing equipment) in diverse locations at various levels (para 624, p111).

SG members may wish to ask for clarification about ONR’s views on what the priorities are for measures to ensure that plans for recovery actions in the event of loss of water at spent fuel ponds at UK sites are robust and convincing.

2 High hazard legacy facilities

In its July letter, NuLeAF expressed concern about the lack of specific consideration in the interim report on review of the management of high hazard legacy facilities, particularly the legacy ponds and silos and HAST facilities at the Sellafield site (although it was understood that non power generating sites would be included in the full report). The letter stated that member authorities would value clarification of review arrangements and outcomes for these legacy facilities.

The summary in the final report highlights that: “The requirement to perform PSRs [Periodic Safety Reviews] applies equally to nuclear fuel cycle and decommissioning facilities. In some facilities that are no longer operational, but are still storing nuclear materials prior to their complete decommissioning, it is neither reasonably practicable nor possible in some cases to close the gap with modern standards sufficiently, or possible to call an immediate halt to storage. The Sellafield legacy fuel storage ponds and intermediate level waste storage silos are the prime examples of such facilities. The licensee, the Nuclear Decommissioning Authority

(which owns the site) and Government, all regard urgent progress with the legacy ponds and silos remediation and retrievals programme as a national priority. This priority is reinforced by the example of the Fukushima accident where the vulnerabilities of older plant were not sufficiently recognised and addressed.” (page vi)

This perspective leads to “Conclusion FR-2: The Fukushima accident reinforces the need for the Government, the Nuclear Decommissioning Authority and the Sellafield Licensee to continue to pursue the Legacy Ponds and Silos remediation and retrievals programme with utmost vigour and determination.”

More specifically, the report:

- Explains that “ONR has established regular liaison with the Sellafield Limited Resilience Project team which is tasked to progress the work programmes that have been established to address the ONR Interim Report recommendations and European Council “Stress Tests” requirements. These ONR / Sellafield Limited discussions have provided, and will continue, to provide an opportunity for ONR Specialist Inspectors (with the support of Environment Agency Inspectors where appropriate) to assess the detailed findings of the on-going review and analysis work currently being carried out by Sellafield Limited. Sellafield Limited has developed a Resilience Evaluation Process which is currently being applied to the major facilities across the Sellafield site and the supporting site utilities systems. This review will analyse various accident scenarios, durations and “cliff-edge” effects and seek to identify robust measures to reduce dependencies within systems and additional effective mitigating /curtailment systems.” (paras 650-651, p116)
- Notes that “it is evident from ONR / Sellafield Limited interactions that Sellafield Limited is now starting to identify a number of improvements and additional contingency measures for facilities across the site and the supporting infrastructure systems. For many of the older legacy facilities, it has been recognised by Sellafield Limited and ONR that the facilities are not as robust as the newer facilities built to modern design standards, and hence the main focus for the site must remain the retrieval of the radioactive inventory from these facilities and the processing of the material into safer waste forms. In the meantime, contingency measures are put in place.” (para 652, p116)

Overall, “ONR considers that Sellafield Limited responses to the ONR Interim Report recommendations demonstrate that Sellafield Limited has made an appropriate commitment to progress work activities to address the recommendations in the ONR Interim Report.” (para 654, p116)

The SG may wish to ask for clarification about the sorts of improvements and contingency measures likely to be put in place on the Sellafield site.

3 Use of MOX fuel and management of spent MOX fuel

The SG’s July letter pointed out that surprise had been expressed that the use of MOX fuel appears not to have contributed to the health impact of the accident on or off the Fukushima site. It stated that member authorities would appreciate further information about what evidence exists to underpin this view.

The final report contains the following statement: “In the information we have reviewed since the Interim Report and from our further analysis there is nothing so far to suggest that any significant health effects have arisen from the use of MOX fuel. Some have questioned whether there would be some on-site implications for the operators dealing with it. This is unlikely to be the case given the dominating isotopes in fuel used in a reactor. Questions have been raised

about the possible use of MOX fuel in reactors in the UK. We have yet to see a safety case for such use and the information to date about Fukushima-1 does not add to knowledge about the safety of the use of MOX." (para 841, p157)

The SG may wish to ask whether the use of MOX fuel would have been expected to lead to any significantly different health impacts in accident conditions compared with the use of conventional fuel.

4 Flood risk

NuLeAF's July letter pointed out that member authorities are particularly interested to see more detail and hear about the review of flooding and climate change studies and the implications for sea-level rise, coastal erosion, sea-level protection, plant infrastructure and layout, and management of legacy facilities.

Overall, the final report notes that a review of approaches to flood risks in site-specific safety cases (in Annex G of the report) "confirms the adequacy of the present site-specific cases and the methodology used. Protection of nuclear sites from flood risks is already a well established part of ensuring safety at nuclear sites. However, it is important to learn any lessons from the Fukushima accident and for the industry to review flooding studies in line with the principle of continuous improvement." (para 827, p153)

More specifically:

- The review in Annex G concludes that: the effects on safety-critical structures, systems and components have been assessed, and found to be acceptable; the safety justifications accept that, in some cases, water will enter the site, but that the effects are tolerable; for some sites the hazard is extremely low, and further detailed justification not warranted; and the effects of climate change and the potential for tsunami have been taken into account in the work. (p180)
- In furtherance of the principle of continuous improvement, it is reported that EdF is reviewing flooding studies to identify any cliff-edge effects and potential resilience improvements. It is also considering a number of potential enhancements to resilience, including flooding protection. (para 616, p110) It is also stated that Magnox is undertaking a critical review of design basis flooding studies to identify any potential improvements needed to the design basis. (para 626, p112)
- The report also comments on the implications of the 6th interim conclusion that: "Flooding risks are unlikely to prevent construction of new nuclear power stations at potential development sites in the UK over the next few years. For sites with a flooding risk, detailed consideration may require changes to plant layout and the provision of particular protection against flooding." The comment is that: "To put in additional flood protection, or revise layouts for nuclear power station sites in Flood Zone 3, would be certain to increase costs. In coming to Interim Report Conclusion IR-6 we were clearly not commenting on the economics of a nuclear power station development but on the likely availability of design solutions, albeit at a cost, and on the ability of our regulatory system, particularly through SAPs, to ensure the adequacy of safety against flooding at such sites, should construction proposals come forward." (para 766, p139)

The SG may wish to seek clarification about ONR's views on what the main priorities are for measures to enhance flood protection at nuclear sites.

5 "Stress Tests"

NuLeAF's July letter explained that member authorities consider it important that further explanation is provided about the development and implementation of "stress tests and how these will relate to the actions that ONR will require as a result of the review, including for the Sellafield site.

The summary of the final report states that:

In response to a request from the Council of the European Union, a specification for "Stress Tests" for nuclear power stations has been developed and we have required the licensees to undertake this work. Licensees' efforts to complete the stress tests are well underway and, once completed, we will assess them and require any necessary improvements in line with the ALARP principle. We will also produce a UK National Report to the European Council. We are currently engaged with our European partners in developing an appropriate peer review process for the "Stress Tests" to enable learning to be shared across all of the countries involved.

There are overlaps between the "Stress Tests" outcomes and the recommendations in our reports. Hence the nuclear industry will, no doubt, produce a common plan for responding to the "Stress Tests" as well as the recommendations in this report. In line with our drive for greater openness and transparency, we expect this plan to be published. (page xvii)

More specifically, the report explains that:

- Each member state will produce an interim and final national report on "Stress Tests" which will be prepared based on licensee reports. The Final Report will be submitted to the European Council (by 31 December 2011) and will be subject to a peer review process to be organised by European Nuclear Safety Regulatory Group (ENSREG) (by April 2012).
- In the UK, the "Stress Tests" are also to be applied to non-Nuclear Power Plant (NPP) licensed nuclear installations. However, the reporting arrangements (which do not require submission to the European Council or the peer review) are yet to be finalised, although the principles of licensee reports and an ONR summary report are established. ONR will report the outcome of these tests in ONR's future implementation report. (paras 680-683, p120)
- The conclusions from the peer review process of the "Stress Test" results could realistically lead to new insights (or an international consensus) that will need to be taken into account in ONR guidance on the application of its Safety Assessment Principles. (para 585, p104)
- Annex H in the final report provides the specification for the "stress tests", including the technical scope and reporting requirements.

The SG may wish to ask whether "stress tests" undertaken in the UK are likely to lead to any additional recommendations for improvements (beyond that in the final Weightman Report).

6 Severe accident preparedness and nuclear emergency planning

NuLeAF's July letter recognised that nuclear emergency planning is being addressed in detail by Government in a parallel review, but pointed out that member authorities would be interested in hearing ONR's views, particularly regarding issues around planning for potential evacuation.

The final report contains a considerable amount of discussion about the need for improvements in severe accident preparedness and nuclear emergency planning.

On severe accident preparedness (see the annex to this briefing note for an introduction), it states that:

- Although extreme events have a very low assessed probability of occurrence, we believe that the industry should consider how it might respond and manage its plant in extreme circumstances... we would expect industry to identify potential strategies and contingency measures for dealing with situations in which the main lines of defence are lost. (para 831, p154)
- The industry needs to ensure it has the capability to analyse severe accident progression to the extent necessary to properly inform and support on-site severe accident management actions and off-site emergency planning. This may require further research and modelling development ... (para 833, p155)
- The review of Severe Accident Management Guidelines (SAMG) should consider not only critical safety functions prioritisation, but also whether and how SAMGs support any dynamic re-prioritisation based on emerging information. Consideration should also be given to operator support requirements relating to tactical and strategic decision making. In addition to the acute phase of a severe accident, consideration also needs to be given to stabilisation, recovery and clean-up, and the personnel involved from the many organisations involved. (para 836, p156)

The final report acknowledges that:

- It is clear from the Fukushima event that the accident was significantly outside of what is covered by the SAMGs, and that the guidance was not adequate to cope with multiple plant failures. (para 504, p90)
- In the UK, it is typical to rehearse the operation of the emergency organisation, including external agencies and services. However, it is not typical to exercise severe, long timescale, multiple hazard events affecting multiple units, involving large numbers of people. (para 508, p90)
- The clean-up and recovery activities are continuing at Fukushima, some months after the acute phase of the accident. IAEA have noted good practices relating to the Fukushima clean-up and recognise that there are lessons to be learnt in this area. Generally, in the UK, there is no detailed consideration given to the resources and facilities required, and co-ordination and control of such activities. This is of particular importance in terms of the arrangements for radiological monitoring and protection of workers, and the need to train many contract workers who may have little or no familiarity with the hazards on a nuclear site. (para 511, p91)

On nuclear emergency planning, the final report explains (paras 543 – 547, p96) that the Nuclear Emergency Planning Liaison Group (NEPLG) has conducted an initial review of emergency arrangements with particular regard to dealing with a prolonged event similar to the devastating one at Fukushima. This is in direct response to Recommendation IR-3 of the Interim Report.

It explains that DECC has the lead department role in bringing together organisations involved in off-site nuclear emergency preparedness and response through the NEPLG. The initial review conducted by NEPLG focused in particular on four key areas: radiation monitoring capacity and capability and co-ordination including radiation monitoring units co-ordination, food and the environment; central government response; extendibility (see below); and capacity and capability of emergency services including emergency exposures.

The report notes that: "NEPLG found current arrangements to be fit for purpose. In light of the events in Japan, however, a number of opportunities for strengthening arrangements have

been identified. A programme of work has been instigated to address the issues found to require strengthening.” It adds that the opportunities identified by NEPLG will form part of a wider programme of work being taken forward by DECC. The timelines for this programme (and any work NEPLG does) will be finalised in October, and will be taken forward by the department as a priority. This will include updating DECC’s published guidance on the UK’s response to an overseas nuclear incident by December 2011.

It should be noted that discussion about nuclear emergency planning often focuses on the size of the detailed emergency planning zones (DEPZs) around a licensed nuclear site (see the overview in the annex to this briefing). The final report states that: “The radii established for emergency planning zones must, of course, depend on the radiological releases that are considered reasonably foreseeable and the practicability of implementation of the emergency plans. However, as it is considered that licensees should review on-site measures to improve resilience to severe accidents in the light of the Fukushima accident, it follows that the practicability and effectiveness of the arrangements for extending countermeasures beyond a small DEPZ in the event of more serious accidents should also be reviewed. It is therefore considered that NEPLG should examine the need to enhance the UK’s extendibility arrangements for extending countermeasures beyond the DEPZ in the event of more serious accidents.” (para 793, p145)

The Interim Report indicated that there is a need to consider extending some emergency exercises in the UK to include severe accident scenarios. The extensive and extended nature of the Fukushima accident high-lighted areas where improvements may be made through exercising in real time such matters as handover arrangements, sustainability of resourcing, the provision of technical advice in short timescales (tailored to the needs of the different recipients) and the vital role of communications and the acquisition of reliable data.

The final report states that as a result (para 590-592, p105), ONR has initiated a review of the existing programme of exercises to evaluate how changes to exercise scenarios supported by longer exercise duration will permit exercising in real time such matters as hand-over arrangements etc. It will also look closely at how automatic decisions taken to protect the public can be confirmed and supported by plant damage control data. It will then make recommendations on what should be included in an appropriate UK exercise programme for testing nuclear emergency plans. Relevant guidance will be provided. ONR aims to produce a report on this review by the end of the year.

The SG may wish to seek clarification about what ONR considers to be the top priorities for improvements to severe accident preparedness and nuclear emergency planning in the UK.

7 Tolerability of societal risk

In NuLeAF’s July letter, the question was raised of whether the accident should cause a rethink to the safety regulator’s approach to judgements of what constitutes a ‘tolerable societal risk’? It noted that clarification about this would also be appreciated.

This issue is not addressed in the final report.

In general terms, the HSE’s approach to risks giving rise to societal concerns is explained in a report called ‘Reducing Risks, Protecting People’, published in 2001. This explains that

“Developing criteria on tolerability of risks for hazards giving rise to societal concerns is

difficult. Hazards giving rise to such concerns often involve a wide range of events with a range of possible outcomes. The summing or integration of such risks, or their mutual comparison, may call for the attribution of weighting factors for which, at present, no generally agreed values exist as, for example, the death of a child as opposed to an elderly person, dying from a dreaded cause, eg cancer, or the fear of affecting future generations in an irreversible way.” (para 134)

“... where societal concerns arise because of the risk of multiple fatalities occurring in one event from a single major industrial activity, HSE proposes the following basic criterion for the limit of tolerability, particularly for accidents where there is some choice whether to accept the hazard or not, eg the risk of such an event happening from a major chemical site or complex continuing to operate next to a housing estate. In such circumstances, HSE proposes that the risk of an accident causing the death of 50 people or more in a single event should be regarded as intolerable if the frequency is estimated to be more than one in five thousand per annum.” (para 136)

The SG may wish to ask what relevance the Fukushima accident has to this approach to judging what constitutes a 'tolerable societal risk'.

8 International reviews

NuLeAF’s July letter explained that member authorities are interested in hearing about the main outcomes from parallel reviews in other countries, particularly where proximity to the UK may mean that large-scale accidents could have impacts on the UK. Members also ask whether Euratom safety standards are under review and, if so, what regulatory changes might be expected in the UK as a consequence?

The final report provides an account of the international cooperation that has taken place to review the implications of the accident (see in particular Annex A, p160). In particular, the report outlines the findings of the IAEA fact-finding mission to Japan (paras 694 – 699, p123) and the report of the US Nuclear Regulatory Commission Near-term Task Force review (paras 713 – 733, p129).

The report includes an additional recommendation about IAEA safety standards: “Recommendation FR-9: The UK Government, nuclear industry and ONR should support international efforts to improve the process of review and implementation of IAEA and other relevant nuclear safety standards and initiatives in the light of the Fukushima-1 (Fukushima Dai-ichi) accident.”

The report also points out that the objectives of the Convention on Nuclear Safety, which was adopted by the UK in 1994, are:

- To achieve and maintain a high level of nuclear safety worldwide through the enhancement of national measures and international co-operation including, where appropriate, safety-related technical co-operation.
- To establish and maintain effective defences in nuclear installations against potential radiological hazards in order to protect individuals, society and the environment from harmful effects of ionising radiation from such installations.
- To prevent accidents with radiological consequences and to mitigate such consequences should they occur.

The report notes that the accident at Fukushima-1 “indicates that international activities to secure these objectives have not been sufficiently effective. The IAEA action plan noted earlier

is part of the initiatives to address such matters. The UK has done much to support international work in the past and should continue to do so." (para 807, p148)

The report also points to the need to "streamline and strengthen" mechanisms for communicating information on accident progression and the prognosis of its further development between national governments, with international agreement on the type of information that needs to be provided and its routing. (para 820, p151)

The report does not however contain much information about the main outcomes from parallel reviews in other countries, particularly where proximity to the UK may mean that large-scale accidents could have impacts on the UK.

The SG may wish to ask whether parallel reviews in countries close to the UK are identifying the need for significant improvements, particularly in arrangements for severe accident preparedness and nuclear emergency planning.

9 Communication of review findings and how they are being implemented

NuLeAF's July letter highlighted the importance of effective communication of the review findings and follow-up actions. It pointed out that member authorities would be interested in hearing about the plans that are being put in place to ensure effective communication.

Members will be aware of the considerable press coverage that resulted from publication of the final report. ONR and DECC press releases are available on their respective websites.

The final report states that: "Given the timescales for the "Stress Tests" and the full response to our recommendations, we have decided to produce a further report in about a year's time which will provide an update on progress in implementing the lessons for the UK's nuclear industry." (page xvii)

The report also notes that:

"... points from Fukushima resonate with the lessons from major events in a range of sectors (e.g. loss of the space shuttle Columbia, explosion at the Texas City oil refinery, loss of the Nimrod aircraft over Afghanistan). The persistent nature of such lessons across a wide range of sectors and countries highlights to all those with responsibilities for safety, and its regulation, the importance of understanding and continually applying the learning. Knowing the lessons is not sufficient; appropriate action needs to be taken and improvements sustained. This is part of a continuous improvement culture." (para 519, p92)

The SG may wish to seek clarification about how ONR will continue to communicate how it is ensuring that appropriate actions are taken and improvements sustained.

Annex: Severe Accident Management Strategy and Nuclear Emergency Planning in the UK

The final report explains the approach that is taken to severe accident management by **site operators** in the UK (paras 489 – 492, p88). This includes the following statements:

“Post-fault operator actions on power reactors are usually governed by a suite of documentation to aid operator diagnosis and mitigation of the event. Severe Accident Management (SAM) involves the application of Symptom Based Emergency Response Guidelines (SBERG) and ultimately Severe Accident Guidelines (SAG). SAGs were developed post-Chernobyl in the mid-1990s (and received a minor revision in 2009), to provide operators with options and actions to consider in the event of a severe accident. They offer less prescription, are generally non-mandatory and aim to support a more innovative or lateral thought process. This reflects the fact that it is not (currently) considered practicable to anticipate the detailed plant conditions that would exist in such low frequency events.”

“Typically, during the transition between Symptom Based Emergency Response Guidelines (SBERG) and SAGs, as the event degrades into a severe accident, strategy and decision making authority transfers from the station / control room operators to the off-site technical support centre, or other “higher level” decision-making authority, and it is at this stage that the SAGs are applied. This reflects the recognition that decision-making in a severe accident situation is highly complex in view of the uncertainties involved, and that mitigation actions may have consequences that go beyond the information available within the control room, or even the plant. In a severe accident situation, the operator’s role usually becomes one of action implementation. This may need to be reviewed in the light of the experience at Fukushima-1.”

“Power reactor licensee training in the SAGs and SAM strategy is principally aimed at off-site technical support roles, rather than station personnel. Severe accidents are not routinely exercised in the UK as, typically, emergency exercises focus on design basis events (although they are extended to test off-site response to release scenarios). However, there have been instances where exercise scenarios have extended into severe accident territory; facilitating training in the application of SAGs. Again, this may need to be reviewed.”

“Our enforcement principles are based on the concept of being proportionate to the risk, and this typically results in a focus of regulatory assessment on design basis safety cases and Level 1 PSA. However, the industry has undertaken a range of assessment relating to severe accident situations, including their treatment in periodic safety reviews, qualitative reviews of SAG usability, and the piloting of Level 2 PSA for example. In recent years ONR has actively encouraged the industry to pursue these activities in order to enhance their knowledge on, and understanding of, the potential severe accident sequences, in particular for the gas cooled reactors, and the Industry’s ability to cope with, and manage potential severe accidents.”

The final report contains the following explanation of the approach to **off-site ‘emergency planning zones’** (paras 787 – 791, p144):

“Less than 24 hours after the earthquake, the Japanese authorities initiated evacuation of the public from within 3km of the Fukushima-1 site. They extended the evacuation radius to 20km less than 24 hours later. Four days after the earthquake the area in which members of the public were advised to shelter in their homes was extended from 3–10km to 20–30km. These measures appear to have been effective in helping to protect the public given the results of the subsequent monitoring programme. This is despite the absence of early information and diagnosis (due to crucial instrumentation and monitoring capability on and off the site being lost after the earthquake and tsunami) and some delay in the issue of potassium iodate tablets.”

“Each UK nuclear licensed site with the potential for accidents with off-site radiation consequences is required to establish a DEPZ, for which the local authority must make detailed plans to protect people in a radiation emergency. The radii of these zones have been set by considering releases of radioactive materials from accidents which can be reasonably foreseen, taking account of the most significant design basis accidents derived from the site safety cases. These zones may also be influenced by local factors, e.g. the presence of a neighbouring nuclear site, and have been subject to the agreement of ONR or its predecessors. Detailed actions have not been identified for beyond design basis accidents, either within or beyond the DEPZ, because it has been considered impracticable to make detailed plans against very uncertain and improbable events. Instead, existing plans are capable of being extended to deal with a larger than “reasonably foreseeable” accident, based on civil emergency contingency arrangements.”

“The radii of the DEPZs around UK nuclear power stations range from 1km for Heysham and Hartlepool to 3.5km for Hinkley Point, which is common to both the Magnox and AGR stations at that location. The minimum DEPZ radius that is permitted for a licensed site for which a radiation emergency is reasonably foreseeable in the UK is 1km. A minimum radius is set to provide a basis for extending countermeasures for the protection of the public to wider areas in the event of an accident with greater off-site consequences than the reasonably foreseeable accident for the site.”

“The licensees also maintain arrangements for monitoring radioactivity in the environment to distances of 15km for the AGR stations and Sizewell B, and 40km for the Magnox stations. This is to inform any decisions in an emergency on the need for restrictions on the consumption of milk and other foodstuffs.”

“Other countries have different approaches, some based on extendibility and others having more detailed plans going out further, including for re-location where there are high external dose rates. The lessons from Fukushima in this area show the need for effective pre-planned detailed emergency zones but which are easily extended in a controlled way.”