Large and ASSOCIATES

STATES OF JERSEY

EXPLORATORY REVIEW OF THE EDF PRESENTATION NOTE:

APPLICATION FOR
AUTHORISATION TO CONSTRUCT AND OPERATE
A 3RD NUCLEAR POWER UNIT
FLAMANVILLE

THIS REVIEW SHOULD BE READ IN CONJUNCTION WITH THE EDF PIECE A & B DOCUMENT BUNDLES

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EXPLORATORY REVIEW OF THE EdF PRESENTATION NOTE OF THE APPLICATION FOR AUTHORIZATION TO CREATE A 3RD NUCLEAR POWER UNIT AT THE EXISTING FLAMANVILLE SITE

At first sight the document bundle accompanying the EdF application for a third nuclear power plant (NPP) at Flamanville seems to be a detailed and comprehensive justification for the project. It claims that in normal operation, the impact of the European Pressurised Reactor (EPR) plant will be less than that the two PWR NPPs[1] currently operating on the site and that any foreseeable accident during its projected 60 year service life will not result in a level of intolerable consequences for members of public residing nearby in the mainly rural and sparsely populated Basse-Nomandie region.

The EdF presentation is a remarkably confident document:

It describes the design and operation of the proposed plant, a so-called Generation III NPP the like of which has yet to be constructed and commissioned worldwide,[2] in tantalising detail but which upon second reading reveals that sections dealing with plant nuclear safety performance to be almost entirely lacking in substantiation (in terms of reference citation), and it becomes obvious that detailed aspects of the plant and its nuclear safety systems have yet to be fully developed and proven.

The presentation refers to the environmental interactions mainly in terms of what will be achieved by the normal, day to day, operation of the plant rather than what *has* to be achieved by regulation and authorisation, and it applies and confines the impact to very local terrestrial, atmospheric and marine environments and population (critical) groups, the coverage of which fall far short of the Channel Island location and the island populations. Accidents and incidents are dealt with in much the same confident way, in that if and when the plant does go wrong then it is assumed that it will tumble down a prescribed cascade of mitigating events to a certain, stable and radiologically tolerable outcome, but the risk of the occurrence of an untoward event beyond the subset of foreseeable accidents, like that of malicious acts, is not at all accounted for.

There is little detail of the emergency planning regime at both NPP operator and Prefecture levels and no indication whatsoever as to when and how the occurrence of a radiological incident would be notified to the Channel Isles. Similarly, how the Flamanville site is to be protected and the plants decommissioned and dismantled at the end of their respective service lives received scant attention and, moreover, there is nothing on how, in the aftermath of a serious radiological (Chernobyl-like) incident, the plants, site and surrounding environs at Flamanville would be contained and safeguarded. In these important respects, EdF's proposal to build and operate a third NPP at Flamanville cannot be judged in terms of a sustainable development.

Areas of the presentation that might be considered to merit more attention (from Large and Associates standpoint) are as follows:

1) TRANSPORTATION OF NUCLEAR MATERIALS TO AND FROM THE FLAMANVILLE SITE

Operational requirements are that new, unirradiated fuel will be required to operate the NPP throughout the 60 year life. The ~150 tonne reactor fuel core will have an annual fuel throughput of 50 or so tonnes per year replacing the irradiated or spent fuel withdrawn from the reactor core during the annual (or 18 month) refuelling outages.

a) The Generation III NPP are designed to receive mixed oxide (MOX) plutonium based fuels and there is a strong national French policy for this and earlier light water moderated (LWR) reactors to be MOX fuelled to at least 30% of the core load. The introduction of MOX fuels to this and possibly the other two PWR NPPs at Flamanville will result in a distinctive change of the hazard environment, particularly the transportation risk locally (and across France from the fuel fabrication plant at Marcoule) requiring assessment and, possibly, justification.[3]

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1 Not surprisingly since the two existing units are rated at 1,320MWe each compared to the proposed 1,600MWe EPR unit.

2 There is an EPR plant presently under construction at Olkiluoto Finland but this plant is now 12 month overdue in only its second year of construction and it is admitted by Finland's nuclear safety regulator, STUK that 20 to 30% of the nuclear safety features had (then 2005) yet to be ratified or indeed submitted by the plant developer AREVA. In fact the AREVA EPR design has yet to be fully licensed anywhere except, apparently in France, with the Finnish NPP proceeding on the basis of a Construction Licence, assuming that the design will be satisfactorily completed – in the United States, the Nuclear Regulatory Commission has yet to complete its assessment of the generic nuclear safety case of the AREVA design which, along with the subsequent detailed safety case approval is likely to occupy four or more years henceforth.

3 Council Directive 96/26/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation – the French enactment of this directive requires to be located and understood.

b) Similarly, the presentation gives no account to the risk of incident resulting in a release during the transportation of spent fuel from the EPR and other NPPs at Flamanville – the presentation (Piece B para 11.3.3 – hereafter cited as B-11.3.3) refers to the spent fuel withdrawn from the reactor core being in the plant ponds *'to cool for several months . . and then it is removed in sealed packets (flasks) to the factory (COGEMA la Hague) that reprocesses irradiated fuel'*. If correct, the *'several months'* is a very short pond storage period prior to transportation across the public sector, since normal practice is for the fuel to remain in the NPP ponds for five or more years to benefit from the natural decay of the volatiles, particularly iodine-131 which is a dominant contributor to the potential dose uptake arising from a spent fuel transportation incident.

c) The International Atomic Energy Agency (IAEA) considers the transportation to be the most vulnerable phase[4] of the nuclear fuel cycle and, accordingly, it might be worthwhile considering the risks of these transportation aspects of the Flamanville development on Jersey.

Recommendation a) Observations are compiled on the lack of consideration of the transportation safety case for i) MOX fuel under delivery to the Flamanville site, ii) spent fuel (including MOX) from the site in terms, both in terms of accidents and malevolent acts, and how a radioactive release could relate to and result in radiological, health and economic consequences to the population of Jersey.

2 ATMOSPHERIC AND LIQUID DISCHARGES

The principle applied to the authorisation of discharges is not clear from the presentation. For example, the tabulated data (B – IV.1.4.2 Table B-IV.1c) refers to *'maximum discharge'* and *'expected performance'* and there is no reference to ALARP (as low as reasonably achievable) and BAT (best available technology) principles in the regulatory and authorisation process. The gaseous discharges are similarly described and these include an unspecified contingency for normal operation, expressed in terms of *'expected'* and *'realistic'* discharge performance.

Recommendation b) The basis of the regulatory and authorisation approach to radioactive discharges might be usefully compared with the present UK system of Authorisation.

Recommendation c) Also, observation be made that the discharge performance of the proposed Unit 3 EPR is not that much better, if at all, than the N^o 1 and 2 existing units which have been in service for 20 years (Tables B-IV.4-a & b). A point to consider here is that fuel burn-up (irradiation) will be developed further for the EPR and, with this, the radioactive effluent (both gaseous and liquid) discharge rates per MW_e generated would also be expected to rise.

Recommendation d) Further information might be sought on the predicted radioactive discharges for the EPR operating with a MOX fuel core (as is expected).

3) RISK AND HAZARD ASSESSMENT

Risks and hazards are identified for both construction and operational phases (but not for the permanent shut-down and decommissioning phases.

Risks identified for the construction phases (D-III.3) relate almost entirely to the continuing safe operation of the neighbouring N^o 1 and 2 Units (eg falling tower cranes, dropped loads, etc), there being no mention of malicious or terrorist act (ie discontented worker act of sabotage, a sleeper device being planted, etc).

Recommendation e) Observations could be made on the lack of consideration of the hazards that could be planted by malicious intent (ie a sleeper device)[5] during the construction phase when security over the many individual construction workers and sub-contractors is difficult.

Risk of accidental events that could result in an untoward incident during normal operation includes aircraft crash and malicious acts. The overall target for core melt failure is 10^{-5} for each reactor for each year of

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4 International Atomic Energy Agency, *The Physical Protection of Nuclear Material and Nuclear Facilities*, IAEA INFCIRC/225 Rev b

5 The Brighton Hotel Bombing of 1984 is known to have been triggered by a sleeper device that lay dormant for six or possibly nine months prior to the explosion.

operation for every type of failure and hazard, which being drawn from probabilistic (a priori) considerations it cannot possibly relate to malicious acts. Initiating events, including external hazards, are classified into four groups of *Plant Category Conditions* (PCCs) with each being defined (D-IV.1.2.2.1) PCC1 to PPC4) with PCC4 reckoned to be lower than one chance per million per reactor per reactor year of operation with, similarly, malicious acts seemingly excluded from this fault categorisation. The severity of damage and the magnitude and impact of the radioactive release are defined in terms of three levels of *Radiation Risk Category* RRC-A, RRC-B and Specific Accidents of 3 categories (D-V.1.2.4.1.1).

Of these, aircraft crash (D III.2.3.7) seems to be limited to civil aircraft up to 5.7 tonnes gross weight and military fighter aircraft (Mirage type) and these are reckoned to be at risk of occurrence 100 times lower that the statutory limit (D-IV.4.7). Resistance to aircraft crash is claimed to have been designed into the *'aircraft shell'* of the containment of building that contain nuclear fuel (reactor, fuel ponds and new fuel store), although no details of the additional strengthening, design changes that have been introduced since 9/11. In fact, even a cursory examination of the pre- and post 9/11 designs suggest that no such changes have been practicably rendered.

Recommendation f) Further information could be sought on the adequacy of the case presented for the nuclear safety case for aircraft crash, particularly relating to i) transmitted shock loading, ii) aviation fuel spillage and ignition (fuel-air explosions) and iii) the size and fuelling capacity of the aircraft that could be involved, arising from a) accidents (the probabilistic risk) and b) terrorist action.

Malicious acts are considered to be (D III.2.3.8) *'the risk linked to malicious acts is mainly linked to the presence of nuclear materials in the installations that must be protected'* and, other than this loose definition and a somewhat generally reassuring statement (D-IV.4.8), there is nothing further in the entire presentation that relates to malicious acts. The unsubstantiated presumption (D-IV.4.8) that the system design and safety provisions *'helps limit the consequences of an act of malice . . . to ensure that the installation returns to the safe state'* suggests that however severe the attack and the extent of the damage sustained by the plant (and indeed if the plant post-incident countermeasures are also subject to interference during a terrorist action), the radiological consequences of any terrorist act will not go beyond those assumed for the reference accident.

In other words, so far as terrorist acts relate, these being intelligently driven, intentional acts that seek out the vulnerabilities of the plant and its safety systems, it is claimed that the damage and consequences will be no more than that of an *'acceptable'* accident as initiated by a PPC3 type of fault event.

Recommendation g) Although it is most likely that no further details relating to any aspect of terrorist action will be released for the consultation, it might be worthwhile venturing an opinion on the inappropriateness of the assumption that the outcome of a terrorist act can be considered to be wholly within a probabilistically derived safety case – this might be applied to both intentional aircraft crash and other malicious acts.

Recommendation h) Further regard should be given to the maximum amplitude assumed for explosive pressure waves (D-IV.4.5), particularly regarding i) over-pressure or blast damage to equipment, containments, etc., and ii) effect on operating personnel.

Recommendation i) *Recommendation h)* this should be applied to a) aircraft crash and fuel-air explosions; and b) intentionally placed explosive charges within the site in or nearby safety critical buildings, or nearby delivered by road vehicle, sea vessel or aircraft.

Recommendation j) Further regard should be given to how the developer has shown the security and safety measures have been proven to be reliable and effective against malicious acts, in terms of a range of defined *Design Basis Threats* (DBTs) and *Operational Safeguards Response Exercises* (OSREs) as required by the United States Nuclear Regulatory Authority in its licensing procedures.

4) CONSEQUENCES OF RADIOLOGICAL INCIDENTS

The radiological consequences are related to the frequency of the fault event. For example, PCC2 (D-IV1.2.21) events - a chance of between 1 to 100 occurrences per unit per year – should not breach any individual receiving an incident dose of 0.3mSv/year , that is no greater than the limit applied to normal operation of the plant. (D-V.1.2.2.1). For the more severe but projected much less frequent PCC3 and PCC4 events (a chance of between one in 100 to one in 10,000 per year and lower than one in one million per year, respectively) the effective radiation dose accruing from the incident is 10mSv (whole body) and 100mSv (thyroid).

However, the Special Emergency Plans in France also include a 10mSv and 50mSv short-term countermeasure (sheltering and evacuation) limit and 100mSv thyroid dose to trigger issue of prophylactic measures for RRC-A events. Medium and long term measures, which apply to RRC-B events, require relocation at a projected dose of 10mSv/month via surface shine or 1,000mSv whole body effective dose.

Recommendation k) A measure of correspondence should be established between the French mainland and Jersey systems of radiological protection, particularly if Jersey is to rely upon the French for notification of any radioactive release, advice on the radionuclide content of the release, and projection of the whole body effective and organ doses that could potentially arise from the release – these comparisons might be compared with the UK systems or Emergency Reference Levels (ERLs) and the pertinent recommendations of expert organisations such as ICRP and WHO.

Radiological consequences for EPR abnormal operation events are based on (D-V.1.2.3.2) a 7 day exposure effective dose of an individual in close proximity to the plant and thyroid dose to a 1 year old child. A 50 year time integrated dose is also applied, derived from both the passing overhead cloud shine, the inhaled dose and persistent shine from ground contamination, and ingestion of contaminated foodstuffs applied at 2km from the plant.

Recommendation l) The 50 year effective dose calculation methodology adopted for the EPR may not readily apply to the population of Jersey when subject to a contaminated situation because of differences in foodstuffs and habits although, that said, managing the radiological situation in the interim and longer terms following a radioactive release may be considered to be a problem for the States of Jersey to manage itself.

A indication that confirms the understanding that MOX fuel will be deployed in the EPR is given in Table D-V.1a with its very significant release rates from fuel pin cladding failure at high fuel burn-up levels. However, there is ambiguity over other data relating to PCC-3 and PCC-4 event triggered accidents, see for example Table D-V.1-b which projects exposures in the aftermath of a number of postulated accidental releases, these being regarded as somewhat low for a MOX fuelled incident.

Recommendation m) Clarification should be sought on the fuelling systems adopted for the PCC 3 and 4 event scenarios – a detailed source term or fuel inventory should be provided to clear any ambiguity (D-V.1.2.4.2.1).

Similarly, the release fractions of the entire core (D-V.1.2.4.2.2) are very low for both uranium dioxide and high burn-up MOX fuels with, for example, the Cs-137 release fraction being projected at 7E-6% (that is seven millionths of one percent). This low fraction seems[6] to be based on the fission product migration from a small percentage of failed fuel pins that exist (and are tolerated) in the primary circuit during normal operation and, if so, the assumption is that for the majority of untoward initiating events there is no fuel pin damage (and additional fission product release) due to the conditions imposed by the fault event.

Recommendation n) Clarification should be sought on the release fractions adopted for the PCC 3 and 4 event scenarios.

For the serious RRC-B type accident in which the fuel core loses a considerable proportion of the first containment provided by the fuel pin cladding (ie a fuel melt) it is assumed (D-4-V.1.2.4.2.1) that the EPR second and third levels of containment (the reactor primary circuit – RPC - and then the reactor building or dome structure - SC) remain intact to a level of surety that limits the release from the RPC to 0.3% volume per day and that, further, downstream filtering abatement retains 99.9% of the aerosols and elemental iodine and 99% of the organic iodine.

Essentially, the strength of the nuclear safety case relies upon, where the event bypasses the PC and RC containments, the event itself not causing further fuel pin failure. For very serious internal reactor incidents where fuel melt is acknowledged to occur, the RPC and RC containments are assumed to remain, essentially,

6 Some sense of this may have been lost in translation.

leak tight or to leak at such a slow rate that the most volatile of radionuclides can be retained by abatement filtration. For one specific accident scenario where the reactor fuel core melts and the molten fuel burns its way through the RPC, it is assumed that an entirely passive core (corium) catcher will, first, spread and then contain and cool the liquid fuel mass, with the 150 tonne, or thereabouts, fuel load and the entire fission product inventory being contained within the RC – this has never been achieved before and not at all demonstrated by trial at any reasonable level of scale.

Of course, a terrorist action would seek to somehow break this train of prescribed control or perhaps some circumstances unforeseen by the EPR designers, like an iceberg to the Titanic, could put paid to this failsafe technology.

Interestingly, the section entitled Consequences of Conventional Accidents provides a ready-reckoner for the extent and severity of malicious act that the plant could possibly resist. The building resilience to blast overpressure is specified at 50mBar which is low and more akin to accidental events rather than for the effects that might be generated in a well planned and implemented terrorist attack. Also, there are no clearly defined fragmentation zones defined for the key safety enclosures and buildings, although it is that system and equipment loss could arise from accidental projection of projectiles (shrapnel, etc – D-V.2.1.1 & V.2.1.5 relating to Unit 2 at Flamanville).

5) EMERGENCY PROCEDURES, NOTIFICATIONS, ETC

The procedures to be implemented in the event of an emergency are prescribed comprising, essentially, local actions by the plant operator at the NPP site via an *Internal Emergency Plan* (PUI). If the release of radioactivity is above the authorised level (or presumed that it will rise to such) then the *Special Emergency Plan* (PPI) is implemented by the Prefect following receipt of information from the NPP. The responsibilities of the Prefect include triggering of measures to inform and protect the public.[7]

The EdF presentation is particularly disappointing in its description of the emergency planning procedures and routines that are to be in place (or are presently in place for Units N^{o} 1 and 2 at Flamanville). Particularly, so far as the States of Jersey are concerned there is no formalised procedure by which (by whom and when) the Channel Islands would be formally notified at a local level (ie by the NPP operator or Prefect).

Recommendation o) Full copies of the *Special Emergency Plan* (PPI) should be provided by the Flamanville local Prefecture.

Recommendation p) Details of when and to whom notification of a radiological incident is addressed to the States of Jersey should be established. The notification should be incident-specific, particularly in that the nature and severity of the incident that triggers notification should be established (ie there should be an agreed colour-code alert or similar system in place) so that there is no opportunity for ambiguity over what level of preparation and response is required of the States of Jersey authorities.

Recommendation q) The foregoing recommendation relating to the fixed NPP site at Flamanville should also apply to transportation of nuclear materials (unirradiated and irradiated fuels) to and from the NPP.

6) DECOMMISSIONING

The section dealing with future decommissioning and dismantling of the proposed EPR NPP is sparse comprising just 10 pages of somewhat vague statements and claims such as ‘*a lot of equipment is designed to facilitate their dismantling* . . ‘. There is nothing in the EdF presentation that relates when decommissioning is planned to finally dismantle the plant structures and dispose of the operational radioactive waste arisings, how these decommissioning operations will be undertaken and what the impact will be on the local environment and future generations of populations in the locality and region.

7 Information to the public is required under Article R 125-9 (D-VI.4) deals with general information provided to the public about the NPP status and operation (magazine, newssheets, etc).

Recommendation r) The projected date and period of dismantling to complete *'green field'* decommissioning of the NPPs at Flamanville should be stated.

Recommendation s) The environmental and potential health impacts of decommissioning in the interim and longer terms should be provided.

Recommendation t) Appropriate regard should be given to the measures and actions required to render the Flamanville site safe (ie by decontamination and containment, etc) in the aftermath of a serious incident that renders to NPP inoperable by damage and/or contamination (for example, the clean-up and radiological management required I nthe aftermath of a Chernobyl scale incident.

Recommendation u) The EPR project, as a whole, from cradle to grave, should be evaluated in terms of its sustainability for this present and future generations.

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