A REGULATORY PROGRAMME TO ASSESS LICENSEES' ARRANGEMENTS FOR MONITORING THE PUBLIC IMPACT OF DIRECT RADIATION FROM CIVIL NUCLEAR SITES IN THE UK

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ABSTRACT

Civil nuclear sites in the UK are licensed by HM Nuclear Installations Inspectorate (NII) which forms part of the Nuclear Safety Division of the Health and Safety Executive. Licence conditions include a requirement for site operators to have an adequate safety case for any operation that may affect safety. NII expects these safety cases to include arrangements that ensure that doses received by members of the public from direct radiation from nuclear sites are acceptably low. In 1993 NII decided that there would be advantages in supplementing existing techniques for assuring itself of the adequacy of the licensees' arrangements by making independent measurements of direct neutron and gamma radiation dose-rates near the perimeter fences of nuclear sites. A five-year programme was established covering all civil licensed nuclear sites in the UK.

This paper presents the measurement protocol adopted and discusses some early results from this monitoring programme. Technical aspects of the interpretation of measured air kerma rates in terms of operational dose quantities are outlined. Appropriate conversion factors are applied, and 'occupancy' data considered, in order to assess the effective doses likely to be received by the most exposed members of the public. These are considered in the light of the current UK statutory public dose limit, the ICRP-recommended limit of 1 mSv per year and other factors, including the basic safety limits and objectives established in NII's published Safety Assessment Principles (SAPs) for Nuclear Power Plants.

INTRODUCTION

The regulatory background to this work has been described by Bacon et al[1] in 1994. The purpose of this work has been to increase NII's confidence in the adequacy of licensee's arrangements for ensuring that direct radiation doses to the public from site operations are acceptably low. In order to achieve this, we have ourselves assessed licensees' arrangements and independently measured gamma dose rates at site perimeter fences. At selected sites we have also arranged for independent measurements of neutron dose rate to be carried out by the National Radiological Protection Board (NRPB), and for surveys of local public occupancy to be performed by the Ministry of Agriculture, Fisheries and Food (MAFF), in each case under contract to NII.

PROTOCOL

Gamma dose rates were measured using Mini Instruments Type 6.80 environmental gamma dose rate monitors. We subtracted background count rates due to instrument noise and cosmic radiation and applied a calibration factor to obtain measurements in terms of the quantity air kerma, Ka, relative to ^{226}Ra. Air kerma rates due to terrestrial background radiation were assessed (by reference to published data[2] and to our own limited background measurements) to obtain an estimate of the air kerma rate from direct gamma radiation from the site. Energy-dependent conversion factors were then applied to interpret measured air kerma rates in terms of the quantities ambient dose equivalent ($H^*(10)$) and effective dose equivalent (H_E). Our contractors, NRPB, measured neutron dose rates at specified locations near the perimeter fences of relevant sites using a Studsvik 2202D dose rate meter calibrated in terms of $H^*(10)$ with respect to $^{241}Am/Be$. The response of this instrument is dependent on neutron energy and a knowledge of the neutron energy spectrum is therefore required in interpreting measurements. The highest neutron dose rates encountered in our monitoring programme have been associated with Magnox power stations. We consider that the neutron energy spectra near these stations are such that the Studsvik instrument provides a reasonably accurate response in terms of effective dose equivalent.

Occupancy surveys carried out by MAFF, under contract to NII, have sought to identify those members of the public who comprise the critical group for direct radiation from the sites, evaluate the annual period of exposure to elevated dose rate fields from the site and consider any shielding effect of building construction materials. This work, which has sometimes involved the measurement of gamma dose rates inside and outside occupied buildings, has enabled us to intepret the results of our dose rate measurements in terms of public impact.

PROGRAMME

The following programme has been established:

YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5	
Bradwell	*nc*	Hinkley Pt	*nc*	Trawsfynydd		Oldbury	*nc*	Wylfa	*nc*
Dungeness	*nc*	Sizewell	*nc*	Heysham	*nc*	Hartlepool	*nc*	Berkeley	
Chapelcross	*nc*	Calder Hall	*nc*	Hunterston	*nc*	Sellafield	*c*	Torness	*nc*
Amersham		Springfields		Cardiff		Capenhurst		RR Derby	
Winfrith		Rosyth		Dounreay		Devonport		Harwell	
								Barrow	

n: Neutron Monitoring (NRPB) *c*: Occupancy Survey (MAFF)

UK PUBLIC DOSE CRITERIA

The statutory dose limit for members of the public in the UK is specified in the Ionising Radiations Regulations 1985 (IRR 85)[3] at 5 mSv per year (in terms of the quantity effective dose equivalent, H_E). More recent guidance from ICRP[4] has recommended a principal dose limit to members of the public of 1 mSv in any single year (in terms of the quantity effective dose, E). NRPB[5] has endorsed this view but has gone further to say that a dose constraint of 0.3 mSv from a single source should be a realistic target for most UK nuclear sites. The ICRP advice is also reflected in NII's Safety Assessment Principles for Nuclear Plants[6] (SAPs). Principle 14 sets a Basic Safety Limit (BSL) of 1 mSv per year and a Basic Safety Objective (BSO) of 0.02 mSv per year for doses to the public. These values are related to risk figures published by HSE in the Tolerability of Risk from Nuclear Power Stations paper[7]. NII expect licensees to have an adequate safety case to show that this BSL is not exceeded and that doses in excess of the BSO are kept as low as reasonably practicable (ALARP).

CASE STUDIES

It is our policy to make our findings available to members of the public via local liaison committee meetings. At most sites we have found that no member of the public receives more than 0.1 mSv per year from direct radiation. However, higher dose rates were found at the three sites which are discussed below.

Nuclear Electric plc, Dungeness Nuclear Power Station (gamma, neutron monitoring and occupancy survey)

This site features relatively high gamma and neutron dose rates at the eastern perimeter within 100 m of two inhabited cottages. These aspects have previously attracted licensee and regulatory attention as part of NII's assessment of the licensee's long term safety review for the Magnox power station at Dungeness "A"[8]. Our independent gamma and neutron dose rate measurements results were broadly consistent with those reported by the licensee. Our findings provided confidence in the licensee's assessment at that time, based on comprehensive measurements and conservative assumptions regarding occupancy and reactor operating conditions, that the most exposed occupant of these cottages might receive an effective dose equivalent of approximately 0.83 mSv y^{-1}. The licensee has since arranged for neutron dose rates to be reassessed following the installation of additional polythene shielding on the roof of one of the reactor buildings. This work has shown that neutron dose rates at the cottages have been significantly reduced. We now believe that the most exposed member of the public is unlikely to receive an effective dose equivalent greater than 0.53 mSv y^{-1}. Considering the licensee's neutron energy spectrum data in the light of the revised radiation weighting factors for neutrons, as recommended by ICRP, we have estimated that this corresponds to an effective dose, E, of approximately 0.64 mSv y^{-1} (0.44 gamma, 0.20 neutron). Our work at Dungeness has highlighted a number of interesting aspects. For example, the gamma energy spectrum at Dungeness "A" is dominated by a component of energy ~ 6.3 MeV (from decay of N^{16} in the external ductwork of the reactor). We therefore needed to allow for the over-response of our instruments to this component and to apply modified factors in converting from Ka to H*(10) and H_E. We found that there was virtually no significant terrestrial gamma dose rate above the shingle surrounding the Dungeness site and that gamma dose rates measured in some buildings near the site were higher than those measured immediately outside. We consider that the elevated dose rates are probably attributable to natural radioactivity in the building construction materials.

Amersham International plc, Amersham Laboratories (gamma monitoring only)

As at Dungeness, occupied buildings are located very close to part of the perimeter fence of the Amersham site. The results of our gamma dose rate measurements were broadly consistent with those reported by the licensee (there being no neutron component). As a result of our work, the licensee has completed an assessment of the dose to the public using revised occupancy data and is making further improvements to shielding. We are currently examining the licensee's assessment that no member of the public is likely to receive an effective dose equivalent exceeding 0.2 mSv y^{-1} from direct radiation from the site.

British Nuclear Fuels plc, Chapelcross Nuclear Power Station (gamma, neutron monitoring and occupancy survey)

As with the previous two case studies, occupied buildings are located very close to the nuclear site. The radiation field features gamma and neutron contributions, including a high-energy gamma component of ~ 6.3 MeV. NII's independent assessment has broadly confirmed the licensee's safety case. This shows that the most exposed members of the public are residents of a nearby farm who might receive an effective dose equivalent of up to 0.12 mSv y^{-1} (0.10 gamma, 0.02 neutron). Key features of this work were the identification of the appropriate terrestrial background, the inclusion of a neutron component, and assessment of additional members of the public. The licensee is currently carrying out further investigations, which will include neutron energy spectrum determination, at this site.

SUMMARY

We have found that licensees have employed a variety of approaches and technical methods in seeking to ensure that doses received by members of the public from direct radiation from nuclear sites are acceptably low. Our independent assessment has, in some cases, prompted licensees to review and refine their arrangements for assessing the impact of direct radiation from their sites and to seek means of reducing off-site dose rates, in accordance with the ALARP principle. We have found that members of the public living close to nuclear sites have received effective dose equivalents (and effective doses) significantly less than 1 mSv per year as a result of direct radiation from the site. This work has provided useful supplementary information in support of discussions on ALARP. Nothing has emerged which has reduced our confidence in the adequacy of the licensees' arrangements for meeting public dose limits. No significant deficiencies, requiring regulatory enforcement, have been identified.

The views expressed in this paper are those of the author and do not necessarily represent those of HSE.
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