# "A REVIEW FROM THE REGULATORY POSITION OF THE CONTROL OF OCCUPATIONAL EXPOSURE ASSOCIATED WITH THE FIRST 20 YEARS OF THE UNITED KINGDOM COMMERCIAL NUCLEAR POWER PROGRAMME"

B W Emmerson, HM Nuclear Installations Inspectorate,
Health and Safety Executive, Liverpool, UK

## LICENSED NUCLEAR INSTALLATIONS

The Nuclear Installations Inspectorate (NII) was established in 1959 to implement and administer the licensing and inspection of all nuclear installations in the UK, except those operated by the Crown or the United Kingdom Atomic Energy Authority (UKAEA). The UKAEA was already supplying power from the first of the gas cooled, Magnox type power stations at Calder Hall (1956) and Chapelcross (1958) and was also responsible for the manufacture and processing of nuclear fuel. In 1971, responsibility for the operation of these power stations and for the fuel manufacturing, enrichment and reprocessing plants located at Springfields, Capenhurst and Windscale, respectively, was transferred from the UKAEA to a newly formed Company, British Nuclear Fuels Ltd (BNFL) and consequently these plants became subject to licensing.

When the NII commenced work in 1960, the Central Electricity Generating Board (CEGB) and the South of Scotland Electricity Board (SSEB), together, had four gas cooled, Magnox type nuclear power stations under construction with five more in various stages of planning, all of which became subject to licensing. The first of these commenced operations in 1962, and currently the Boards have nine twin reactor Magnox type stations and (since 1976) two twin reactor Advanced Gas Cooled (AGR) type stations in operation. Three other AGR stations are approaching completion.

## CONTROL OBJECTIVES

Licensed nuclear installations are regulated through a system of conditions attached to the site licence, which cover all aspects of nuclear safety, including radiological protection. The safety principles against which these installations are assessed have been outlined by Gronow and Lewis (ref 1), a fundamental criterion being that an installation should not cause any person to exceed the exposure limits recommended by the International Commission on Radiological Protection (ICRP); currently those incorporated into the Euratom Directive on Radiological Protection (ref 2). The licensee is required to make arrangements covering safety policy and practice and these are assessed, and in some cases formally approved, by the NII. Control extends over the design, construction, operation, maintenance and eventual decommissioning stages of any licensed nuclear installation, and the introduction of any new plant or process on an existing licensed site.

## PRINCIPAL SOURCES OF OCCUPATIONAL EXPOSURE - Power Generation

Annual radiological exposure data associated with the operation of nuclear power stations in the UK are summarised in fig 1. The two main occupational dose components are chronic exposure from plant background, and chronic and acute task oriented exposures. The former depends on the particular plant design and operating power. Earlier steel pressure vessel designs with heat exchangers outside the main biological shield give backgrounds, which although reduced on later designs, are difficult to eliminate. In recent stations, including the AGR's, this background component is virtually eliminated by enclosing the reactor and boilers in a single pre-stressed concrete pressure vessel. The effect of this design development can be seen in fig 2 which shows the annual whole body dose equivalent distribution, expressed as a percentage, and averaged over the years 1971-78, for typical stations at each development stage.

The main task oriented exposures are usually associated with workers carrying out routine operations and maintenance of "on-load" refuelling plant and irradiated fuel storage facilities. A number of chronic and acute radiation and contamination exposure control problems have arisen which were not foreseen at the design stage (ref 3). In particular, the longer than anticipated pond storage time of irradiated Magnox fuel prior to despatch to the reprocessing plant continues to pose difficulties in controlling exposure for this group of workers. To-date, however, these operations have not resulted in any significant pattern of internal exposure. For those tasks not directly associated with the fuel handling route, including those from the internal inspection of gas ducts and boilers during off-load maintenance, the dose contribution remains relatively small.

In general, the radiological control procedures applied at nuclear power stations have proved effective in limiting individual occupational exposures. Annual (50mSv) and quarterly (30mSv) whole body dose equivalent limits are seldom exceeded, the majority of workers not exceeding an annual dose of 15mSv (5mSv at pre-stressed concrete pressure vessel stations). Fig 1 shows that although the annual collective whole body dose equivalent has remained sensibly constant since 1971 there has been a steady reduction in the annual average whole body dose equivalent, due primarily to a significant increase in the occupationally exposed workforce (5007 to 9132). A better indication of the efficacy of dose management is the annual collective whole body dose per unit of electrical energy supplied (Sv/Gwh). Fig 1 indicates a steady reduction in this value for CEGB and SSEB stations; much of this reduction is probably attributable to the increase in the unit size of new stations.

PRINCIPAL SOURCES OF OCCUPATIONAL EXPOSURE - Fuel Processing

Fuel processing is carried out by BNFL at its factories at Springfields (fuel element production), Capenhurst (uranium enrichment) and Windscale (irradiated fuel reprocessing). These processes and their associated radiological problems have been discussed in detail by Clarke et al (ref 4). When the Company was licensed in 1971 much of its plant had already operated for over a decade. Although complying with the recommendations of ICRP-9, it was not reasonably practicable to limit the annual whole body dose to 50mSv, particularly at the irradiated fuel reprocessing plant, and control was based on quarterly rather than annual limits, provided that the 5(N-18) lifetime dose limit was not exceeded. Progressive improvements of existing plants and in administrative procedures for controlling occupational exposures were made by the Company so that in 1977, the radiological protection conditions attached to BNFL site licences were made consistent with those for other licensed sites, and in particular, by limiting the annual whole body dose to 50mSv.

Annual average and collective whole body dose equivalents for the three processing sites are shown in fig 1. This indicates a significant decrease in the average dose, particularly at the irradiated fuel reprocessing plant. The annual collective dose is sensibly constant, with the exception of the reprocessing plant where the occupationally exposed workforce has doubled since 1972 to 9000, partly to deal with increased plant throughput but, also, to reduce the number of persons exceeding 50mSv per annum (fig 3). Some of the resultant increase in annual collective dose between 1971 and 1976 was incurred in the improvement of the plant radiological environment, which in turn should help achieve the longer term objective of reducing the collective dose per unit of plant throughput.

The main potential for internal exposure is at the fuel reprocessing plant, either from chronic or acute intakes of fission products or transuranics (mainly plutonium). Whole body monitoring is used to measure $\gamma$ emitting fission products and lung retained plutonium, systemic plutonium being assessed by urinalysis. To avoid possible over-exposure, it is the Licensee's policy to transfer to non-radiation work any person who receives $>$50% of the maximum permissible body burden for any of the higher toxicity transuranic radionuclides.

Although particular groups of occupationally exposed workers can be identified as receiving above average external exposures, in contrast to power station operation, the annual whole body dose equivalent received by maintenance and health physics staff at the reprocessing plant tends to be significantly less than that received by the plant operators.

## CONCLUSIONS

This review indicates an improving trend in the radiological exposure pattern, despite increasing power generation, fuel burn-up and processing plant throughput. The initial objective of ensuring that individuals do not exceed the statutory dose limits has largely been achieved. There is still, however, a need to ensure that the collective dose for particular working groups within the fuel cycle represents the practical minimum. To achieve this, optimisation procedures, taking into account all the associated detriments and benefits, may have to be employed. A bank of task oriented exposure data will be an essential prerequisite. The NII, therefore, may need to place greater emphasis on more detailed assessment and recording of such task oriented exposure data.

## REFERENCES

1. Gronow, W.S. and Lewis, G. (1978) : Radiation Protection in Nuclear Power Plants and the Fuel Cycle, BNES, London.
2. Euratom Directive (76/579 Euratom) 1976.
3. Emmerson, B.W., Goldfinch, E.P. and Skelcher, B.W. (1971) : Health Physics, Vol. 21, P. 643, Pergamon Press.
4. Clark, L., Emmerson, B.W. and Wojcikiewicz, E.A. (1978) :

Radiation Protection in Nuclear Power Plants and the Fuel Cycle, BNES, London.

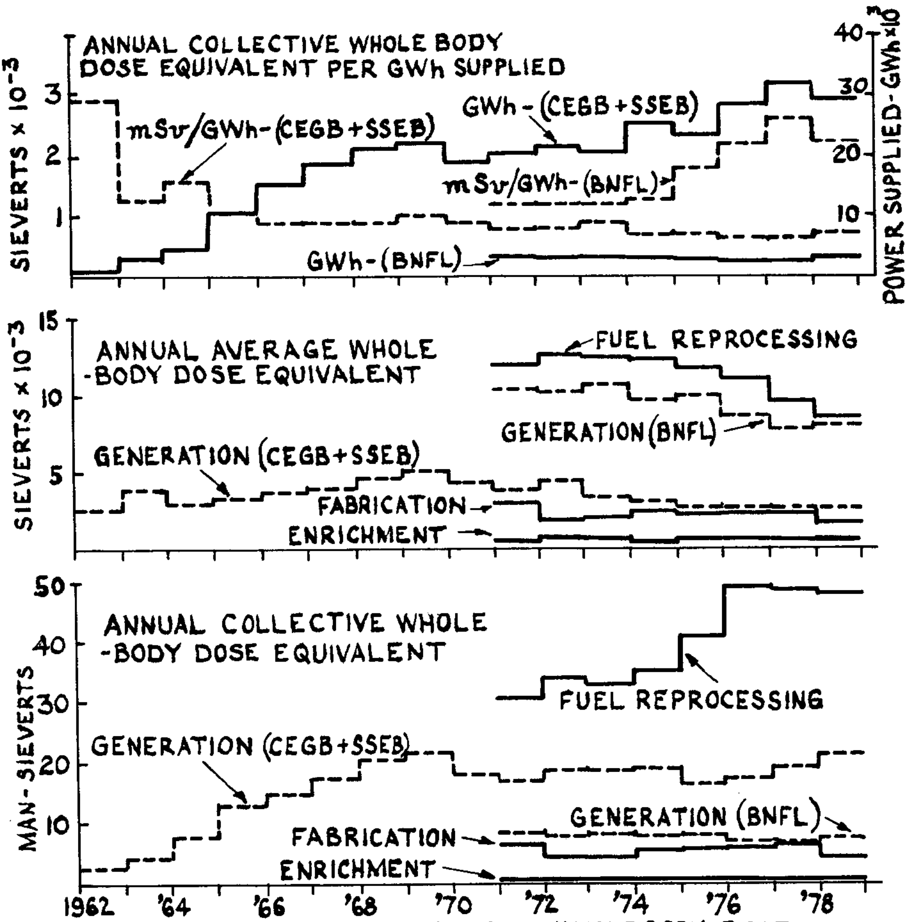


FIG. 1 SUMMARY OF ANNUAL OCCUPATIONAL WHOLE-BODY DOSE FROM EXTERNAL RADIATION.

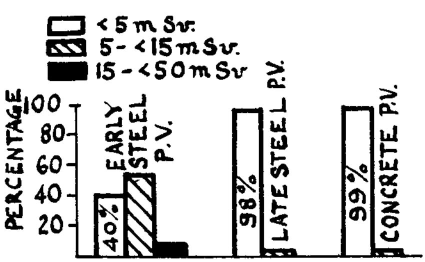


FIG. 2 1971-78 AVERAGE DOSE DISTRIBUTIONS FOR STEEL & CONCRETE PRESSURE VESSELS

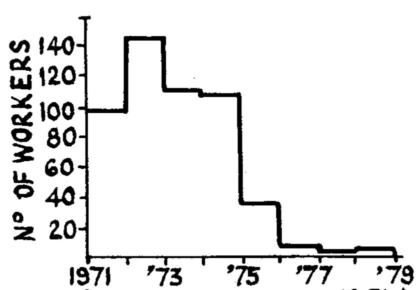


FIG. 3 No OF REPROCESSING PLANT WORKERS > 50 mSv/ANNUM