THE BNFL LEGAL ELECTRONIC DOSIMETRY SERVICE

By A R Weeks*. M P Pottinger* and PW Clarke#.

**BNFL, Research and Technology, Berkeley Center, Berkeley, Gloucestershire GL13 9PB United Kingdom.*

 # BNFL Magnox Generation, Oldbury on Severn Power Station, Oldbury Nait,, Thornbury , South Gloucestershire, BS35 1RQ, United Kingdom.

INTRODUCTION

BNFL Magnox Generation started a three year scheme in April 1996 to introduce Siemens Electronic Personal Dosimetry (EPD) systems into its reactor sites as part of an initiative to improve the control of doses and the accuracy of dose statistics and to record personal legal dose.

Concurrent with the installation of the EPD systems a successful application was made to the United Kingdom Health and Safety Executive (HSE) for approval of the BNFL dosimetry service to use the Siemens EPD Mk 1.2 for recording legal doses. This paper discusses the experiences of the BNFL dosimetry service in operating the approved dosimetry service since it's approval by the HSE in January 2000

OUTLINE OF THE APPROVED DOSIMETRY SERVICE

Under the auspices of regulation 35 of the UK Ionising Radiations Regulations 1999 (**IRRs)** the Health and Safety Executive have issued a series of documents, "Requirements for the Approval of Dosimetry Services (RADS), consisting of, Part 1: External Radiations, Part 2: Internal Radiations and Part 3: Co-ordination and Record Keeping. This paper relates specifically to the approval of the Service to assess external radiations using EPD under RADS Part 1 External Radiations.

A dosimetry service must show that it can meet the criteria specified in the RADS in order to obtain approval. Applications for approval are assessed on the basis of a Statement of Service provided by the applicant and information gained by the HSE on the Service's organisation, resources, personnel and methods and from reports of performance tests.

The RADS have been written around the concept of the passive dosemeter, but within the guidance the HSE have made provision for the introduction of new technologies such as EPD. Prior to submitting an application for approval the Service and the HSE discussed in detail the format of the Statement of Service and its ability to comply with the RADS. It was concluded that the requirements detailed in the RADS could be followed for active or passive dosimeters.

The Service who are located within BNFL Research and Technology at Berkeley Centre, holds a central approval for the assessment of EPD data from its Clients, who are the BNFL Magnox Generation and British Energy reactor sites. The Client must obtain approval from the Service and the HSE for use of the EPD as the legal dosimeter. This approval is given subject to a satisfactory quality audit of their systems and procedures in order to satisfy the Service and the HSE that they are compliant with the appropriate sections of the Service's Statement of Service. All audit results will be forwarded to the HSE. On completion of a successful audit of a Client the Service will formally notify the HSE in writing. The HSE will include the name of the approved Client on the Services certificate of approval.

Every calendar month, all dose results, dose estimates, and anomalous results are sent, via electronic transfer, to the Service from it's Clients. The Service assesses doses on a Client by Client basis by summation of individual working session results, taking into account any dose estimates. Each working session result will be verified and any anomalous results will be investigated by the Service. All investigations will involve the Client before ratification of results by the Service.

The Service forwards monthly electronic summaries of the dose results to the BNFL Central Dose Records Service (CDRS) where assessed doses are collated for entry on to the Dose Records. CDRS is the BNFL Approved Dosimetry Service for Co-ordination and Record Keeping for reactor sites.

EPD SYSTEMS

The Siemens EPD was developed in the UK in collaboration with the National Radiological Protection Board. (NRPB). The EPD has been designed to measure photons in the energy range 20 keV to 6 MeV, and beta radiation in the energy range 250 keV to 1.5 MeV. It utilises 3 silicon diode PIN detectors, and incorporates sophisticated micro-circuitry powered by a bespoke high-energy battery designed to last at least a year under normal operational use. The EPD stores raw count data from the three detectors in four channels: hard gamma (HG), soft gamma (SG), full beta counts (FB) and beta compensated counts (BC). From this data, the EPD evaluates the personal dose equivalents $H_p(10)$ and $H_p(0.07)$. This data is stored to secure memory every 15 minutes to minimise data loss on battery or other failure.

The Dose Control Software, DCS-3 manages the EPD system on Client sites it stores information on Oracle relational database tables. The EPD wearer and the Task ID are the main set up parameters for dose management with the EPD wearer being the key set up for legal dose measurement. The DCS software requires all legal information such as a valid medical date to be entered before a wearer can issue an EPD. Additional compliance for parameters such as training validity can be introduced by the site. Personal details for individuals are mainly standard entries such as name, date of birth and National Insurance number. Dose Credit ID's are selected for each individual for dose control and regulatory compliance. Department ID can be set up as a four digit code to ease the retrieval of information using relational database query tools.

An individual will issue an EPD by selecting an EPD from a rack and inserting it into a slot in an Access Control Work Station (ACW). The screen instructions will request the individuals Personal Identification Number (PIN) and a Task ID for the proposed work. The Task ID will define the dose and dose rate alarm levels programmed into the EPD on issue. The DCS-3 provides powerful control as it will not issue an EPD to a person unless all compliances such as Medical and Dose Credit are satisfactory.

QUALITY ASSURANCE

The Service's approval is based on it's ability to produce an auditable quality system for ensuring that individual doses recorded in the workplace can without exception be entered onto the correct dose record, having first been independently verified. The Service's Statement of Service states that the issue and control of EPD's at Client sites is covered by the Clients own quality assurance procedures. All Clients prepare an Operating Manual and suit of work instructions which meet their own QA requirements. The contents of the Operating Manual are set out in the Services Statement of Service. The Service will audit Clients against the Operating Manual before applying to the HSE for the Client site to be added to the Services certificate of approval.

Prospective Clients of the Service will submit the documentation discussed above to the Service who will initially carry out an audit of the documentation before visiting the Clients site to audit the EPD systems. Any short comings or non-conformances within the documentation will be raised as a corrective action and discussed with the Client during the site visit. During the site visit the Service will interview key personnel involved with the day to day operation of the EPD systems including staff responsible for operations during silent hours and staff providing IT services. Checks will be made on training records for interviewed staff and the general training arrangements for EPD users. The Service will also look at site protocols for recovery of the computer systems in the event a partial or complete failure and procedures for making dose estimates. Any non-conformances or short comings in the site audit will also be raised as corrective actions.

At the audit closing meeting the Service will present the Client with it's finding in the form of corrective actions and observations. The Client will be asked to sign on to the corrective actions and propose a solution and a completion date for each action. The Service will then formally issue an audit report.

When the Client site has made the appropriate modifications to it's systems to enable it to discharge any corrective actions all relevant information and documentation will be sent to the Service. The Services will review the documentation and evidence supplied by the Client and if satisfied will sign off the corrective actions. An application will then be made in writing to the Health and Safety Executive for the client site to be added to the Services Certificate of Approval. Before issuing the certificate of approval an HSE inspector will normally visit the Client site.

The most commonly occurring corrective actions from the 12 audits carried out by the Service to date relate to the recording of training on specific work instructions, which is fundamental to the success of using electronic dosimeters for legal dosimetry. Many sites have now made improvements in recording work instruction training in dosimetry and other areas as part of their site licence requirements for all staff to be suitably qualified and experienced persons (SQEP).

Another common problem has been the development of robust systems for dealing with a computer system failure either partial or catastrophic. Generic service contracts covering the rebuilding or replacement of systems within given time scales are held by Clients with Siemens in the event of failure. Several Clients had not developed sufficient systems to cope with getting people in and out of the controlled area in the event of a computer systems failure. Procedures had to be developed and staff trained to allow a manual entry system to be before the EPD could be used for legal dose assessment.

DATA VERIFICATION AND DIAGNOSTICS

Data received by the Service from Client sites will undergo several tests and selective verification routine before being assessed. The diagnostics tests allow the assessor to select and evaluate the data of specific interest. The number of working session doses a Magnox site can generate in a month will range from about 3000 to 25,000 The larger British Energy sites can generate up to 50,000 visits a month during outages. As most working sessions generate doses of less than 5 ìSv it is essential for the efficiency of the service to be able to automatically select results of specific interest for further investigation.

An important diagnostic tool developed by the Service is the ability to confirm spurious doses by obtaining detector channel ratios from the raw data. The ratio technique can be used for general guidance when assessing working session data. The ratios will enable the assessor to flag possible problems and if necessary instigate an investigation with the Client. The Client can confirm, for example, the characteristics of the radiation field the individual was working in at the time the dose was received and other relevant information.

The EPD stores raw count data in four channels: hard gamma (HG), soft gamma (SG), full beta counts (FB) and beta compensated counts (BC). From this data, the EPD evaluates the personal dose equivalents $H_p(10)$ and $H_p(0.07)$. Each radiation environment has a fingerprint which is characterised by the following ratios: HG/SG, SG/FB and FB/BC. Figure 1 graphically illustrates the HG/SG ratio data for operational Magnox, Advanced Gas Cooled Reactor (AGR) and Pressurised Water Reactor (PWR) plants, also a decommissioned Magnox plant all using the Mk 1.2 EPD. Data is also shown for Hinkley Point B AGR which uses the Mk 2 EPD. Figure 2 shows a bar chart of HG/SG for most of the UK reactor sites.

From Figure 1. it can be seen that the peaks of the probability curves for the AGR and PWR reactors are sharper than those of the operational and decommissioning Magnox reactors. This is due to the more diverse nature of photon radiation energies that make up the ambient radiation fields on the Magnox plants, due in the main to less efficient shielding when compared to an AGR. The shape of the AGR and PWR curves is due to the mainly outage related ^{60}Co dominated radiation fields that make up the majority of personal doses on these sites.

Figure 2 shows that the magnitude of the ratios for the Mk 1.2 EPD varies from 2.67 at Dungeness B to 3.83 at Chapel Cross. The range of the ratios is dominated by the ambient photon energy. Chapel Cross is the oldest reactor (Magnox) in the group and as such the shielding associated with the reactor is not as efficient as the more modern AGR reactors. This results in a high energy ambient photon (6.1 MeV) radiation field from the exposed gas coolant ducts which contributes significantly to personal doses and also increases the value of the HG/SG ratio. However Hunterson B a more modern AGR power station which has excellent shielding, also has a fairly high HG/SG ratio because most of the dose associated with the plant is acquired during vessel entries (^{60}CO 1.3 meV). Dungeness B (AGR) also has excellent shielding and hence well moderated ambient photon energies, which combined with their 2001 outage not involving vessel entries gave much lower HG/SG ratios.

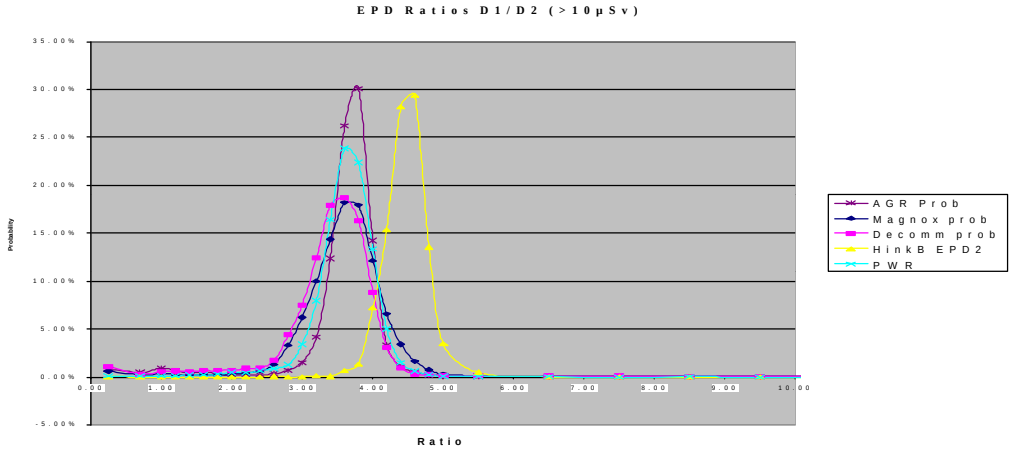

Figure 1. HG/SG by Reactor Type *(Note: Data for Hinkley B is for the Mk 2 EPD)*

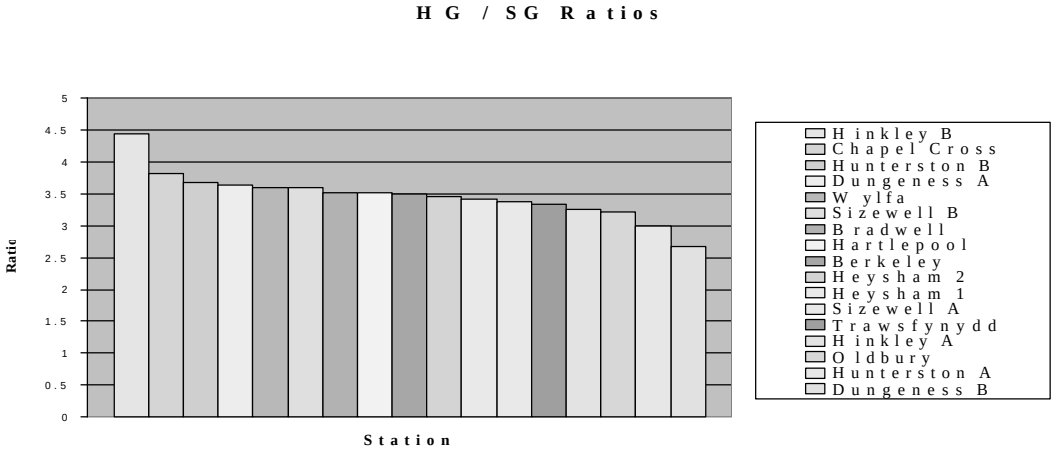

Figure 2. Ratio of HG/SG by Reactor Site. *(Note: Data for Hinkley B is for the Mk 2 EPD)*

MANAGEMENT OF DOSE ESTIMATES.

The IRRs regulation 22 specifies the requirements that must be met for estimating a dose when information is lost for whatever reason. The Service and Clients must ensure that robust management arrangements are in place to meet all the IRR requirements. As part of the management of doses on site amendments may be required. These normally fall into three categories.

1. Manual amendments

   Amendments made due to EPD failure in the controlled area, most commonly due to physical damage which renders the dosimeter unreadable or to a lesser extent battery failure.

2. Site Amendments.

   Amendments made by the site to spurious doses caused for example by radio frequency interference (RFI) from electrical appliances and security tags, electrostatic conduction or light leakage through the beta window. In these cases the dosimeter will be readable but will have an enhanced dose reading.

3. Dosimetry Service Amendments.

   Anomalous doses identified by the Services diagnostics software. These dosimeters will have been read in the normal way but the spurious nature of the dose may not have been picked up by the wearer or the site Health Physics staff. The causes of these spurious doses is usually the same as discussed in 2. above.

In cases 1 and 2 above the site will have performed a dose investigations prior to transmitting the dose to the Service. These investigations are often carried out at the time of, or shortly after the incident. If the amendment required is manual the individual will not be able to re-enter the controlled area due to an incomplete working session (i.e. unable to read the dosimeter on exit) this will require a manual amendment to complete the Working Session. In the case of a spurious dose due for example to RFI there is normally a dose or dose rate alarm associated with the incident which the wearer should report to the Health Physics staff. However this is not always the case as the spurious dose may occur in a high dose rate area where dose alarms may be expected. When the ADS finds doses it thinks are anomalous it informs the Client site giving full details of all information making up the working session. Due to the nature of the diagnostic software the Service can in some cases give guidance on what the true dose may be, if for example a spurious dose is incremented with a real dose. The Client site will then perform an investigation, if they are satisfied that the dose was anomalous they will notify the Service who will amend the record in question before entry onto the legal dose record. Any records amended by the Service are electronically transmitted to the Client site to enable an update of their database. The records are flagged as being amended by the Service.

The Service receives an electronic version of dose investigations performed for both manual and site amendments. For manual amendments the Service has no other information other than the investigation report and the doses. However for site amendments the Service is able to run the original EPD data through the verification software, this allows the Service, to independently verify the sites amended data.

Detailed below in Table 1. is information on the number of amendments made during 2001 for various sites of differing reactor types also shown in the table are the numbers of working session doses above 10 µSv for 2001. Also data for the Mk2 EPD for Hinkley Point B Power Station, which clearly shows an improvement in reliability and sensitivity to radio frequency interference.

Station	Reactor Type	Number of Visits in 2001	No. Manual Amendments	No. Site Amendments	No. ADS Amendments	No. of visits above 10 µSv (% of Total)
Trawsfynydd	Decommissioned Magnox	51261	161	1038	31	3259 (6.36 %)
Dungeness A	Magnox Steel Pressure Vessel	108106	237	1522	316	4594 (4.25%)
Dungeness B	Advanced Gas Cooled (AGR)	126695	262	2360	11	136 (0.12%)
Oldbury	Magnox Concrete Pressure vessel	75424	154	646	78	1177 (1.56%)
Sizewell B	Pressurised Water Reactor (PWR)	55333	47	2035	12	2484 (4.49%)
Hinkley Point B	AGR Mk 2 EPD	91353	47	2	0	3360 (3.68%)

Table 1. Dose Amendments for 2001.

SUMMARY OF SYSTEMS PERFORMANCE

The BNFL Approved Dosimetry Services at Berkeley was issued with it's first certificate of approval with Oldbury Power Station as its first client in January 2000. Oldbury has been using the approval since 1 June 2000 following the cessation of film badge issue on 31 May 2000. Since that time the HSE have given approval to 4 more sites, Wylfa (Magnox) Dungeness B (AGR), Hunterston B (AGR) and Sizewell B (PWR). The HSE is currently considering the applications of 7 more Clients of the ADS who should obtain formal approval over the next few months.

The experience of the Service to date has confirmed that metrologically characteristics the Siemens Mk 1.2 EPD performs well in all radiological environments encountered on operating and decommissioning nuclear power plant. It's low threshold of detection has enabled Client sites to accurately control doses to much lower levels. The use of EPD has also removed the sometimes large statistical uncertainties in calculating site and group collective doses associated with passive dosimeters.

In terms of operating costs the Service and Client sites now require fewer personnel to operate their services, this has proved to be expedient with the downsizing of the nuclear industry in the UK over the last few years. The Mk 1.2 EPD has not been as reliable as first anticipated due to its sensitivity to radio frequency interference and poor battery performance which has proved to be administratively expensive. The return rate for repair of damaged EPD's in the BNFL Magnox population of 2800 dosimeters is currently running at about 20% per annum, which compares to 2% for the Hinkley Point B population (500 EPD's) of Mk 2 EPD's. However the Access Control Work Stations (ACW) and computer systems have proved to be very reliable and robust.

THE FUTURE

Before the end of this year it is anticipated that the Service will have 16 Client sites (all reactor sites) approved for the use of the Mk 1.2 EPD as a legal dosimeter. The Service will also make an application during 2002 to the UK Health and Safety Executive for an approval for the Mk 2 EPD using Hinkley Point B as it's first Client site.

During the financial year 2003 / 2004 BNFL will consider a project to upgrade it's current stocks of Mk 1.2 EPD and associated equipment to the Mk 2 EPD against commercial benefits and other options. Concurrent with this the Service will seek to obtain appropriate approvals from the HSE for it's clients moving to the Mk2 EPD.