CDRL - Company Dose Restriction Level

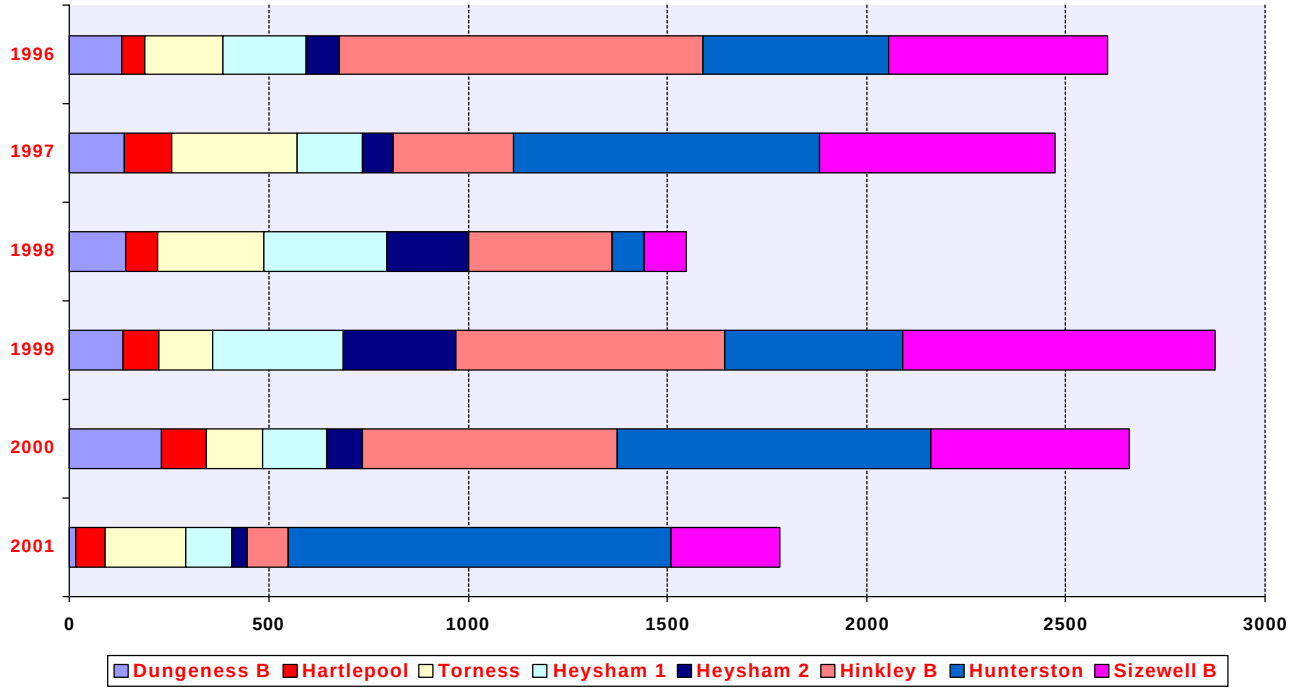
S. N. Morris, Corporate Radiation Protection Adviser, HSED, British Energy Generation Ltd

Introduction

For a number of year's dose constraints and controls have been used as effective measures in aiding restricting exposure to ionising radiation. Predecessor companies to British Energy Generation (BEG) originally established the Company Dose Restriction Level (CDRL) as a consequence of the revision of risk estimates, then with the revised Ionising Radiations Regulations 1999 (IRR99) [1] the CDRL for BEG was also revised. The background, influences and consequences of CDRL appliance in a commercial organisation in calendar year 2000/1 are presented below.

Background

The British Energy Group is an energy company, which operates 15 nuclear units in GB supplying about 22% of the electricity market [2]. One BEG site, Sizewell B, has one Pressurised Water Reactor (PWR) whilst the remaining seven sites each have twin Advanced Gas cooled Reactors (AGR).



The annual collective dose trend for the previous 6 years for each site is provided in fig.1. Evidently three BEG locations predominate Company dose, Sizewell B, Hinkley Point B and Hunterston B. Hinkley and Hunterston are sites where entry to the reactor vessel is routinely performed during their triennial outage periods; other AGR locations rarely undertake vessel entry. Typically 90% of a BEG sites' annual dose is accrued during outage periods.

Fig 1. BEG Annual Collective Dose by Site in man mSv

Internal influences for CDRL development

Predecessor companies to BEG formulated a CDRL to restrict radiation doses to employees and contractors to 15 mSv in any calendar year. This CDRL was imposed irrespective of where exposure to radiation was received, so was not source-related. The CDRL should not be misunderstood as an exposure limit since the restriction level can be exceeded, but only under very particular circumstances. It is important to note that by ensuring individuals did not exceed the CDRL there would not be a need to perform the annual or 5-year investigations required by statutory provisions. There has been only one case of an individual exceeding the 15 mSv CDRL since its introduction in 1991 up to 1999.

The BEG Company Radiation Protection Adviser (CRPA) decided to use the opportunity of the introduction of the IRR99 [1] to completely revise the Radiological Safety Rules and Instructions. The CRPA also considered the implications for changes to the CDRL based upon the reduced statutory dose limits, its prior success in dose management and upon previous and future maximum individual dose across BEG sites (where Sizewell B was considered to be the restraining case). Apart from a reduction of the CDRL, due consideration was given to the constraint being source-related such that the CDRL was made applicable to doses received whilst specifically working on BEG sites. This provides a non BEG individuals' employer the flexibility to establish their own dose constraint and dose limit philosophy.

BEG Company Dose Restriction Level (Table 1)

The CDRL is the annual maximum dose that can be planned for any employee, or contractors' employee to receive from work on BEG locations. In exceptional circumstances, (and with the agreement of the contractor) the BEG Company Executive Director of Health & Safety (HSED) may authorise (or approve) the exposure of personnel to doses which are greater than the CDRL provided doses are maintained as low as reasonably practicable (and remain within statutory dose limits). BEG adopted under the IRR99 [1] the statutory effective dose limit of 20 mSv per year.

Table 1: Company Dose Restriction Level

Category	**Restriction Level**
Employees and contractors aged 18 years or over (not being a trainee or other person).	10 mSv effective dose per calendar year.
Any female employee who has informed her employer that she is pregnant.	1 mSv equivalent dose to the surface of the abdomen for the remainder of the pregnancy.

Dose constraints & pre-work ALARP assessments (Table 2)

Within BEG a dose constraint is defined as the dose that is anticipated for a particular task at the planning stage. Dose constraints can be expressed as the dose to an individual team member, or the collective dose to all persons involved in the task. The Rules require dose constraints to be specified in formal ALARP reports that have to be prepared in advance of major projects involving exposure to radiation.

Table 2: Pre-work ALARP Assessment requirements

Action Level	**Action**	**Responsibility**
All work in controlled areas	Carry out an ALARP assessment as part of the work planning process. Where it is planned that a person will receive a dose of more than 0.5 mSv in a month from the task. The radiation protection supervisor must be notified. A health physicist may provide advice on dose reduction practices.	S.Q.E.P. Radiation Protection Supervisor
Predicted dose for work greater than 3-mSv individual or 10-man mSv collective.	An ALARP report must be prepared at the planning stage to ensure that doses are kept ALARP. The report must contain a dose constraint for the work.	Health Physicist
Predicted dose for work greater than 6 mSv individual or 100-man mSv collective	The ALARP report required by the section above must be sent to the Director of HSED for review prior to work commencing.	Station Health Physicist
Predicted dose for work greater than 10 mSv individual.	No work should be planned to exceed any CDRL. Only where a justification and ALARP case can be made in exceptional circumstances will sanction to exceed a CDRL be given.	HSED Director

Pre-work ALARP assessments must estimate radiation doses to groups of workers for activities performed across **all** BEG sites. Clearly, where contract staff is employed, it is prudent to co-operate with the employer, share dose constraint policy and predicted dose levels. In some cases, because of the special nature of the work or the skills required by key specialist staff, including foreign nationals, exposures may approach a CDRL. Dose management and budgeting is exercised, with a clear profile of activities and dose uptake. Dose estimates should be maintained during the course of the work by using direct reading dosemeters to give real time dose information and allow for adjustments to be made to the work procedures. Work must incorporate a contingency factor to ensure that a CDRL is not approached or planned to be exceeded. In exceptional circumstances the Director HSED may authorise exposure of personnel to doses above the CDRL, provided doses are maintained ALARP and below statutory limits. Before sanction is provided a review is undertaken where justification, ALARP, future work and special circumstances are considered. This information is required to support the subsequent mandatory requirement for an investigation. Pre-work ALARP assessments contain as a minimum the following elements:

An overview of the work and why it has to be done,
An assessment of alternative methods of working,
A prediction of the dose and dose rates associated with the work,
Lessons learnt from previous work of a similar nature, and
Actions to be taken to keep dose ALARP.

From Policy to Practice

Hunterston and Hinkley routine outages

BEG formed an approved strategy with a single contractor to tackle the inspection and repair activities of in reactor vessel boilers at both Hunterston and Hinkley during 1999 and 2000. This comprises the routine outages for all four reactors including both planned inspection and repair work (where the dose can be predetermined) and some emergent work (where the degree of work and dose is indeterminate). The basic approach to planning, training, deploying and managing a large and diverse team across 2 sites was considered sound. Decisions on the extent of emergent work is dictated by factors such as defect severity, location, repair techniques, programme, manpower, safety case implication and commercial risk.

In 1999 the BEG outage team focused their thinking on the planned work. However, there was a need to react to emergent work discovered by the in-vessel inspections. This resulted in a combined in-vessel collective dose of 880 man-mSv, where 18 vessel entrants exceeded the project target individual dose of 10 mSv but not the CDRL at that time being 15 mSv. As a consequence, for the year 2000 outages the team decided to plan for both planned and possible emergent work resulting from the inspection campaign. Due to the nature of the work, and the environmental conditions under which it is conducted, the available resource is limited. It was considered that the scale of both the planned and emergent work would make it extremely difficult to remain compliant with the BEG CDRL.

As a contingency, the contractor in conjunction with the outage management team provided a dose management document for the work. This predicted a collective dose of 1053 man-mSv and a number of staff could be expected to exceed the CDRL. Additionally a mechanism was needed to address the impact of the Hunterston outage on the subsequent Hinkley outage, to be conducted by the same team and the possible issues arising from restrictions to employing contractor staff at BEG sites during the remainder of the year.

On the basis of the predicted dose from the above-mentioned document, HSED made a forecast, that the BEG Company collective dose would be 2.9 man-Sv (see figure 3). The BEG Company dose target for the year being 0.2 man-Sv per reactor (aggregate of 3 man-Sv).

HSED then performed a review comparing and scrutinising both the dose predictions and the strategy for various options of defect repair techniques. This review found the predictions to be pessimistic when compared to realistic and historic information. HSED suggested a total collective dose target of 650 man-mSv (cf. 1053) and indicated that the maximum dose to an individual should be imposed well under the CDRL. The foremost reason being a realistic assumption of average dose per entry to the vessel. HSED considered, based upon past outages and history of previously found defects on these reactors, that it was

unlikely that there would be a need to exceed the CDRL for planned and emergent work in both the intended outages for year 2000.

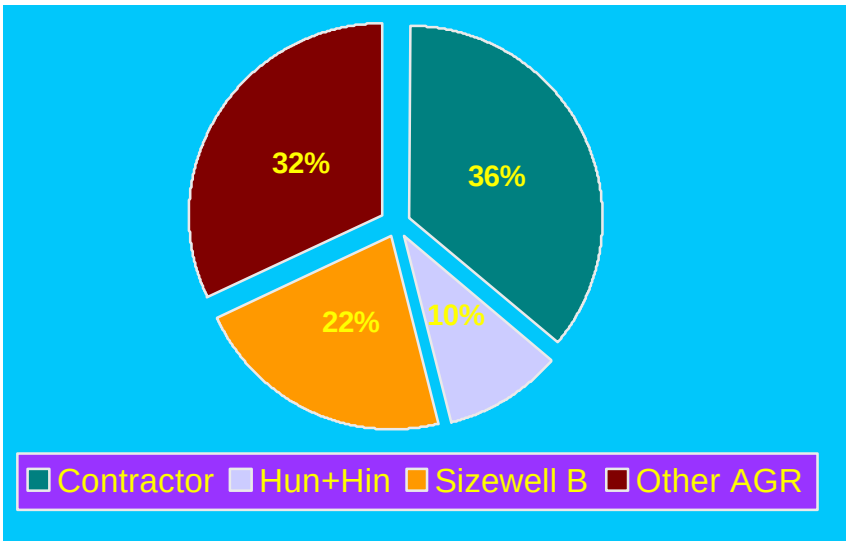


Fig 3. Dose Forecast 2000

As required under BEG Safety Rules, both Hunterston and Hinkley prepared pre-work ALARP assessments reports that underwent the required review by HSED prior to work commencing. Both sites were required to prepare review reports following outage completion. Following the Hunterston outage, Hinkley confirmed that, provided there was not a large degree of emergent work, they should not need to make a request to exceed the CDRL. Table 3 compares planned verses actual dose performance.

Table 3: Comparison of outage dose targets against actual for year 2000.

Station	Planned * collective dose constraint **man-mSv**	Actual collective dose **man-mSv**	Planned individual dose constraint **mSv**	Actual maximum individual dose **mSv**
Hunterston	400	286	8	5.1
Hinkley Point	270	375	8	8.5
Sizewell	550	419	8	3.7

* Note that Hunterston and Hinkley only provided information for **planned** work, as they could not predict the extent of any emergent work, which is included within the **actual** totals.

Additionally as part of BEG self-regulation of practices, independent evaluations of the outage were performed by HSED at both sites and Sizewell B in year 2000. These evaluations identified good practices and possible areas for improvement; Together with local site reviews many of these were accepted as actions to improve for subsequent in-vessel and dose management campaigns.

The outcome (661 man-mSv) in table 3 closely agrees with that suggested earlier by HSED (650 man-mSv) and was a significant improvement on 1999 collective (880 man-mSv) and individual doses. Credit for this result is due both to the BEG sites and the contractor for learning from previous experience and for applying diligent dose management programmes. At the end of the programmed outage work in year 2000 doses were adequately planned and maintained below the CDRL.

Plant Failures

In May 2000 the non-outage reactor at Hunterston B experienced a failure of a boiler tube and was returned to service at reduced output as a consequence. In November, after the BEG statutory outages were complete, the reactor was taken out of service to repair the tube and any other tubes exhibiting indications of wear. Contingency plans were made for limited inspection and to repair up to 10 tubes, dose estimates were made beforehand that predicted this work should be completed within the CDRL.

Before the return to service in May, BEG had assured the regulator that a programme of inspections to assess the full extent of the damage and effect repair to the tubes would be undertaken at the earliest practicable opportunity. The principle justification for the then planned vessel entry was therefore a requirement to return the reactor to full compliance with the safety case. Secondary justifications for vessel entry was the requirement to demonstrate compliance with the gaseous discharge authorisation, requiring "best practicable means" to be used to minimise discharges. A significant proportion of a discharge limit (S^{35}) was released in May as a result to protect reactor internal components and another similar discharge would be undesirable. Also it would be an opportunity to recover boiler surface area by repairs to economiser swage pieces and superheater bifurcation for continuous operation.

Inspections revealed that the number of tubes requiring repair was greater than anticipated, in excess of 80 tubes required replacement and early dose estimates of 2.5 man-Sv were estimated to complete the task. The available specialist manpower for in-vessel work was finite and could not be increased as it was not possible to train the necessary additional resource, especially in the time scale required to complete repairs without BEG forfeiting a significant commercial loss. It was decided to use the same contractor to perform the work. This contractor offered the benefit of having relevant recent experience and proven good improvement in dose management. The disadvantage was clearly that many of them, due to this special circumstance, would evidently exceed the CDRL for year 2000. The HSED Director was subsequently requested to authorise individual exposure above the CDRL with the agreement of the contractor. This was provided following consultation with the Company RPA and by issuing specific conditions.

The work programme would extend well into year 2001 covering four identified phases of work, supported by ALARP assessment documents all furnished to the HSED Director for review. The normal (vessel) top entry for all the work would increase the dose to nearly 3 man-Sv and a decision was made to perform bottom vessel entry by removal of a gas circulator to reduce the overall dose further. Benefits include improved safety to staff and their psychological well being, greater flexibility in staff selection and team composition, better quality control and reduced training requirements. These arrangements conserve individual dose by improved flexibility in dose sharing. In this case the risks to personnel from the work were considered to be acceptable when compared with the safety and financial benefits to society that were expected. The precautions taken and benefits expected more than comply with guidance [3] on the monetary value of dose.

Radiation protection specialists from the regulator and HSED undertook inspections to confirm that the work was indeed justified and ALARP. Specific meetings were held with the regulator, safety committees and contractor representatives to explain the work programme and assure staff that safety was fundamental.

Hunterston B Economiser outage

This work was divided into four phases; phases 1-3 were undertaken in 2000/1 with a total dose of 474 man-mSv. Phase 4, undertaken in 2001 resulted in 833 man-mSv additional dose; the highest individual dose was 8.6 mSv where only 3 exceeded the very challenging individual dose constraint of 7.5 mSv, all notably below the CDRL. The alternative access route to the vessel through a gas circulator casing resulted in a saving exceeding 500 man-mSv than by top entries in 'hot suits'. It provided additional improvements in productivity and reduced rework and for responding to emergent work. Alternative work management methodologies operated by the contractor also resulted in substantially reduced time and dose. The substantial difference between predicted and actual dose (2500 cf. 1307 man-mSv) was due to the work being performed noticeably quicker in much lower than expected dose rates at the sub-annulus.

Hinkley mini outage

The Hinkley non-outage reactor underwent a mini-outage vessel entry programme in December 2000 to allow inspection of its economiser boiler tubes. Also, additional work included the repair of a tube leak that occurred during the shutdown, plus repairs to recover defective boiler tubes and subheaders. In order to support the design safety case limits and return the station to nominal design output again, it was necessary to utilise individuals that had already exceeded and others who were near to exceeding the CDRL. The

requirement to exceed the CDRL was subject to prior sanction from the Director, HSED. Although the predicted collective dose was 93 man-mSv the actual collective dose was 86 man-mSv.

BEG dose performance in years:	**1999**	**2000**	**2001**
Hunterston B collective dose man-mSv	446	788	961
Hinkley Point B collective dose man-mSv	675	638	103
Sizewell B collective dose man-mSv	786	499	271
BEG Company collective dose man-mSv	2876	2659	1781

It transpired that in the year 2000 a **total** of **39** contract staff (from an overall 130 who participated in vessel entries) **exceeded the BEG CDRL**, 33 of these exceeded the level whilst working at Hunterston and the remaining 6 whilst at Hinkley. The highest individual (site) dose at Hunterston was 11.9 mSv and 13.8 mSv at Hinkley for the year. The highest individual dose at Hunterston in 2001 was 8.6 mSv.

As required in the BEG safety rules an investigation report has been provided for all contractor individuals who exceeded the CDRL (even though their employer's investigation level is 15 mSv) and this report drew upon the pre-work ALARP assessment reports and post outage reviews.

Lessons learned from the CDRL sanctioning process

The introduction of a CDRL in a self-regulated organisation has been effective in reducing both collective and individual dose, coupled with sanction by the Organisations' Executive Director of Health & Safety, who is supported by a unit that undertakes independent review and evaluation.

The benefit of having a CDRL of 10 mSv provided motivation for enhanced dose reduction practices that resulted in minimising both individual and collective dose. The prominence of the CDRL produced a greater awareness for effectual dose management across both BEG and contractor staff alike. Post task and outage ALARP reviews have been invaluable in identifying areas and actions necessary for the improvement of dose reduction practices.

Preceding systems for the monitoring of radiation dose records for CDRL performance across BEG placed a sizeable burden on site Health Physics services staff. Recent changes to adopting the Electronic Personal Dosemeter as the legal dosemeter and consolidating approved dosimetry services has now improved matters and is essential to the process.

It has been a common practice to plan the engineering programme and subsequently perform the ALARP assessment. At this point the work programme is often fixed and difficult to change. Some important ALARP considerations are required for management decision before possible revisions to the work programme. Hence, ALARP assessments are now integrated into the overall project plan and highlighted early on whilst tendering and co-operating with our contractors in outage projects.

In view of the plant problems experienced and the anticipated increase in dose rates with continued operation of the reactors, the strategy for future in-vessel inspection and repairs and the impact of the Company Dose Restriction Level needs has been reviewed. One important initiative at Hinkley Point is for enhanced vessel inspection in outage year's 2002/3 to enable a case to be made to the Inspector for remote in vessel inspection in subsequent years.

References

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