DOSE REDUCTION AND CONTROL AT THE WINFRITH REACTOR

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1 INTRODUCTION

The Winfrith Reactor is a 100 MW(e) heavy water moderated, light water cooled, pressure tube reactor. It was designed and built in the 1960s as a prototype, using the best technology available at the time. Coolant chemistry problems initially caused fuel failures and due to material specification, significant quantities of activated corrosion products and minor quantities of fission products are transported into working areas. For several years the Reactor has been the focus of a major dose reduction programme with the emphasis on reducing individual doses. The options available in a dose reduction programme are straightforward. Remove or reduce the source and then apply the usual "distance, shielding and time". Source reduction depends upon the replacement of dose contributing alloys (eg Cobalt-rich stellite) where practicable, the refinement of chemical control of the coolant to minimise pick-up, transport and plate-out of the active species together with chemical cleaning of the circuit before major maintenance work starts in the primary containment. Gains can also be made by arranging rapid removal of active waste.

Distance usually means relocating active plant items requiring maintenance from high dose areas to low. Identification of such items is greatly facilitated by the collection of dose records specific to work areas and jobs. The costs of plant relocation are often high and in Cost Benefit terms unattractive (see 5). For an existing plant, shielding may be portable - eg lead wool blankets - or permanent, and may be cheaper than relocation. Permanent shielding need not necessarily be of sophisticated design; for example a high density concrete brick wall, erected by relatively unskilled staff, produced a dose rate reduction of about x10 in an area of high occupancy. Of all the available methods, working time reduction and dose sharing potentially offer the most cost effective option but their successful application is crucially dependent on sophisticated dose recording and analysis techniques. It is with these techniques that this paper is chiefly concerned.

2 ANALYSIS OF PERSONAL DOSE

2.1 Data Collection. Effective control of individual doses in situations where significant doses can be incurred very rapidly, requires a system which works very closely to real time. The system developed involves the issue of personal indicating dosemeters (PIDs) on entry to potentially high dose, barriered, work areas in addition to routine issue TLD badges. These PIDs are read out by Health Physics Barrier Controllers and the data transferred to the local Dose Control Computer. The flow diagram of the system is shown in Fig 1. Although careful sensitivity checks have been made between the PIDs and the (legal) TLDs, for staff approaching local dose limits, the TLD badge read out is available within 30 minutes.

2.2 Dose to Different Work Groups. To target dose reduction measures most productively, the reactor work force was split up into about 40 different groups and the dose received by each group measured. As with most water reactors the highest dose groups were those associated with mechanical maintenance work. An example of a dose reduction measure for these groups is to use labour from other, lower dose, groups to erect temporary shielding rather than mechanics themselves. Individual doses in groups were also looked at and where wide variations were apparent, supervisors were requested to investigate the situation to share the dose more evenly.

2.3 Dose for Different Tasks. Of the several hundred planned tasks carried out during a maintenance shutdown, analysis showed that about 20 produced 60 to 70% of the total dose. Most of these high dose tasks are foreseeable and special provisions to reduce doses made, eg special tools, training, mock-ups and local shielding; however some of these jobs encounter unforeseen problems and it is essential to review task doses daily to allow remedial actions to be taken. Some initial effort was required to motivate staff to provide correct task numbers to the Barrier Controllers but the accuracy of dose allocation has steadily improved and with the issue of task number tags to personnel, has probably ensured a 90 to 95% accuracy - more than adequate for planning purposes. Further analysis highlighted the high proportion of dose incurred on some high dose tasks by those carrying out preparatory work such as scaffolding installation and removal and replacement of thermal lagging. More permanent scaffolding and demountable lagging panels are now provided.

2.4 Presentation of Dose Information. It is essential that the supervisors organising and allocating work are provided with regular, frequent and clear information on individual doses. During the annual maintenance shutdown the work force is enhanced by contractors and staff from other buildings and AEA sites and many people have different dose limits ascribed to them by their home base. A simple alphabetical list of "best estimate" doses is therefore inadequate. During the night, Health Physics shift staff produce a dose list of each supervisor's team and as well as listing "best estimate" monthly, quarterly and annual doses, a final column lists "dose to go to lowest limit". Supervisors usually use data in this last column as a basis for work allocation. Individual and task dose data also go to senior supervisors and Health Physicists.

3 SIMVIDOSE

The system is fully described elsewhere (Ref 1) and its operational use at the reactor will be illustrated here. One job involving a potentially high dose was the replacement of a reactor pressure tube. The TV camera and lights were therefore erected in an area where dose rates of up to tens of mSv hr^{-1} were possible and the dose incurred had to be offset against potential dose savings. In the event the task was carried out for about 50/60% of the original dose estimate. Some of this saving was due to training and equipment improvements on the mock-up but SIMVIDOSE contributed the following:

(a) Supervisors were able to monitor work from low dose rate areas and act appropriately.

(b) Support staff viewed the work on TV and needed a minimum of takeover briefing.

(c) The person wearing the dosemeter effectively carried out an area radiation survey and this allowed "hot spots" to be identified and shielded. The video tape of the operation is also a useful training aid.

4 TRAINING

4.1 Training Techniques. When providing training for numerous staff the use of a video or slide/tape presentation is often preferred. However some form of personal contact must be established perhaps via a question and answer session at the end, and by highlighting special factors applicable to the particular audience. (The classic methods of dose reduction by "Time, Distance and Shielding" should be physically demonstrated.)

4.2 Refresher Training. It has been found that initial training has to be supplemented by other techniques to maintain individual interest in dose reduction measures. These other techniques involve the repeating of initial training, preferably with some variations to maintain interest, personal contact when specific tasks involving high doses are proposed or carried out or high individual doses incurred, and financial incentives, such as staff suggestion schemes, for dose saving ideas. The provision of eye catching notices highlighting areas of high dose rate and low dose rate have proved useful but are soon taken for granted and need to be revised regularly to maintain an impact.

5 COST BENEFIT ANALYSIS - CBA

CBA, as part of the ALARP (As Low As Reasonably Practicable) process, has been helpful in the selection of viable schemes but much depends upon the skill, familiarity with the plant and its history and appreciation of the future programme possessed by the practitioner. Usually however the "social" factors of ALARP outweigh the "economic", and expenditure on dose saving is frequently greater than the approximate £25K per man Sv indicated by the NRPB proposals (Ref 2). The expenditure justified by CBA is often exceeded by custom and practice in the industry.

6 ASSESSMENT OF DOSE REDUCTION PROGRAMME EFFECTIVENESS

Measurement of dose savings from the various actions described is hampered by the interaction of plant modifications and changes in work requirements or operating regimes. The general picture of dose rates in working areas can be measured by fixed point instruments (40 are used in the reactor containment) but even here the results are confused by the effects of local plant changes. Two assessment methods are therefore used:

(a) Standard tasks carried out during each annual shutdown, chosen for their independence of other work and their total dose penalty measured.

(b) The total daily personnel dose is measured for operational and shutdown periods. Table 1 shows the rapid initial improvements but the increasing difficulty in maintaining the annual reductions, which progressively need greater effort to achieve.

7 CONCLUSIONS

The dose reduction programme has been very successful with the total annual collective dose halved over 5 years but further improvements are increasingly hard to achieve. The use of comprehensive computerised data analysis has been a major factor both in targeting action areas and the operational control of dose uptake. Finally, a co-operative climate of commitment to the programme both amongst workforce and management is essential both during training and operation.

Fig 1 SYSTEM FLOW DIAGRAM

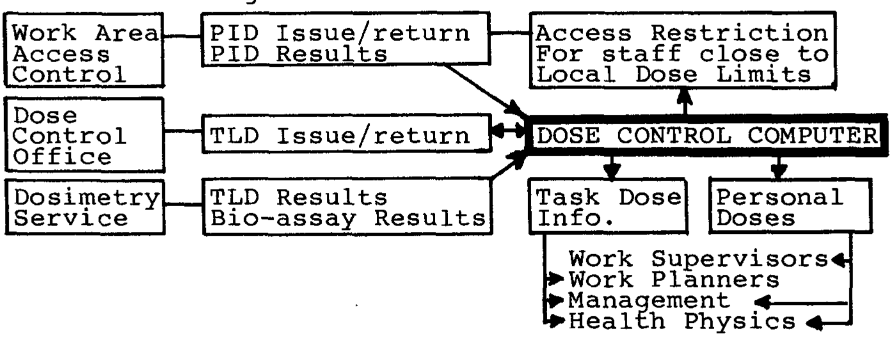

Table 1 NORMALISED SHUTDOWN AND OPERATIONAL EXTERNAL DOSE RATE

	1981	1982	1983	1984	1985	1986
Average Shutdown Dose per day	1.00	0.81	0.69	0.66	0.63	0.63
Average Operational Dose per day	1.00	0.87	0.70	0.67	0.59	0.61

Ref 1 GC Meggitt Reduction in Occupational Doses Using the UKAEA SIMVIDOSE System (Paper 292 IRPA-7).

Ref 2 National Radiological Protection Board - ASP.9.