SIX STEPS TO A SUCCESSFUL DOSE-REDUCTION STRATEGY

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ABSTRACT

The increased importance of demonstrating achievement of the ALARA principle has helped produce a proliferation of dose-reduction ideas. Across a company there may be many dose-reduction items being pursued in a variety of areas. However, companies have a limited amount of resource and, therefore, to ensure funding is directed to those items which will produce the most benefit and that all areas apply a common policy, requires the presence of a dose-reduction strategy.

Six steps were identified in formulating the dose-reduction strategy for Rolls-Royce and Associates (RRA):

1. collating the ideas,
2. quantitatively evaluating them on a common basis,
3. prioritising the ideas in terms of cost benefit,
4. implementation of the highest priority items,
5. monitoring their success,
6. periodically reviewing the strategy.

Inherent in producing the dose-reduction strategy has been a comprehensive dose database and the RRA-developed dose management computer code DOMAIN, which allows prediction of dose rates and dose. The database enabled high task dose items to be identified, assisted in evaluating dose benefits, and monitored dose trends once items had been implemented. The DOMAIN code was used both in quantifying some of the project dose benefits and its results, such as dose contours, used in some of the dose-reduction items themselves.

In all, over fifty dose-reduction items were evaluated in the strategy process and the items which will give greatest benefit are being implemented.

The strategy has been successful in giving renewed impetus and direction to dose-reduction management.

INTRODUCTION

Why have a dose-reduction strategy? Several years after the widespread implementation of ALARA, most major dose-reduction activities are being applied, and there is a plethora of proposals which will make smaller, but still significant, reductions in accrued dose. Although individual modifications or improvements to plants are assessed and an ALARA decision made, these may have knock-on effects to the dose benefit to be gained from proposals in other areas. There is the need to direct expenditure to those items which will produce the most overall benefit and to ensure a common policy across all areas of design, operation and maintenance. In addition, there is a need to take a long-term view on dose-reduction activities to ensure that dose will continue to be driven down in the future in order to meet the continuing downward trend on what is considered acceptable. This approach led to the formulation of a dose-reduction strategy at Rolls-Royce & Associates, consisting of a prioritised compilation of dose-reduction proposals across all areas with recommendations for implementation. Six steps were identified during the creation and implementation of the strategy and these are described below.

THE STRATEGY

Step 1 - Collating the Ideas

Creating a list of dose-reduction ideas to be considered for implementation was achieved by a variety of techniques. A literature search was carried out resulting in over 1,800 abstracts which were reviewed to identify, in particular, any dose-reduction items that had not previously been considered, as well as to confirm that all the major techniques were already being pursued. As a result of this work, some practices that had not previously been investigated, such as the injection of zinc ions into the reactor primary coolant and the anodic oxidation of the primary pipework (both of which may reduce cobalt deposition), were added to the ideas list.

The majority of the ideas came from various "brainstorming" sessions held between the staff involved such as operators, maintainers, designers, and Health Physics. These sessions took advantage of their experience and knowledge of the reactor plants and provided a forum for all ideas to be considered. The ideas ranged from detailed proposals such as greater use of mechanical couplings as opposed to welded, and relocation or redesign of various plant items to improve ease of maintenance, to more general suggestions such that workers should clean up as they go along.

In all, approximately 80 ideas were generated from the literature search, group sessions, and items previously proposed as part of the normal on-going improvement of the plants. The ideas were distilled down to 60 firm dose-reduction proposals. Group sessions were again used to segregate the list into three sections based on whether they were expected to produce a high, medium or low dose saving (unquantified at this stage).

Step 2 - Quantitatively Evaluate on a Common Basis

The dose-management system at Rolls-Royce & Associates incorporates a comprehensive database recording both measured doses from the various reactor plants as well as predicted doses generated by the ALARA engineers (see Figure 1). The information held on the database can be analysed and displayed to provide, for example, individual dose, task dose, worker group dose, comparisons of measured and predicted dose, etc. One of the predictive tools used is the RRA-developed computer code DOMAIN, which calculates dose rates and task doses from the reactor plant or indeed any physical structure containing gamma activity. DOMAIN can also be used to investigate the effect of various options such as installing extra shielding, draining components or decontaminating the activity.

From the database information the measured task or worker group dose related to each dose-reduction item was determined and used to estimate the potential dose saving resulting from its implementation. Some of the proposals will affect more than one task and, therefore, the dose savings from several tasks have to be combined, e.g., extending the use of metallic lagging on the primary plant will have a knock-on effect in reducing the time required for cleaning and inspection as well as reducing the dose for removing and replacing the conventional lagging.

For items involving a change in the actual dose rate environment (as opposed to a reduction in occupancy time, where simple calculations are generally adequate), the DOMAIN code was used to model the situation and calculate the dose with and without the change, e.g., it was used to calculate the effect on various maintenance tasks of adding temporary shielding around components.

For the majority of dose-reduction proposals, the cost penalty associated with implementation has been estimated from knowledge of the costs incurred with similar tasks. For those items with the greatest potential for dose saving, a more rigorous costing exercise was applied. Some items of relatively low dose saving were difficult to quantify in terms of cost and for these cases the value of unit dose, in UK terms the £/Sv value, was used to determine what cost could be reasonably justified against the estimated dose saving.

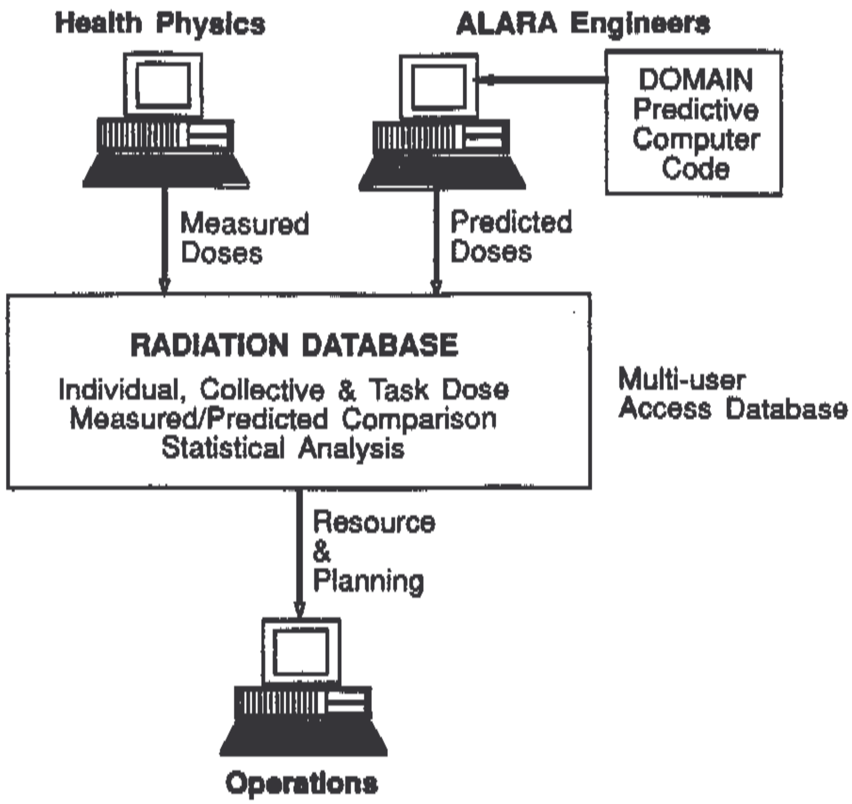

Figure 1. Dose Management System

Step 3 - Prioritise in Terms of Cost Benefit

Having determined dose savings and cost penalties, the proposals were ranked. The top ten items, listed in Table 1, were recommended for implementation during this first phase of the dose-reduction strategy.

Table 1. Top Ten Dose-Reduction Proposals

	Proposal	Dose Saving (man-Sv)	£000/Sv Value
1.	Extend application of metallic lagging	8	25
2.	Set dose targets for all tasks	5	6
3.	Revise painting requirements	2	10
4.	Install CCTV for inspection and general monitoring	2	40
5.	Reduce frequency of Health Physics manual inspections	1	10
6.	Reduce number and length of electrical maintenance procedures	0.6	35
7.	Provide permanent supports for erection of temporary shielding	0.5	200
8.	Extend application of automated equipment for NDE	0.5	200
9.	Label or color-code areas for dose	0.25	200
10.	Use computer simulated models as training aids	0.5	400

The latest recommended value of the £/Sv by the UK National Radiological Protection Board (NRPB) is that it would be reasonable to spend up to £50,000 per man-Sv of dose avoided based on the assumed health risk. If benefits from dose reduction such as worker reassurance, public perception and good public relations are taken into account, then expenditure of £100,000 per man-Sv avoided has been readily accepted previously at RRA. The positions of the dose proposals in Table 1 on a cost benefit vs dose saving graph are illustrated in Figure 2.

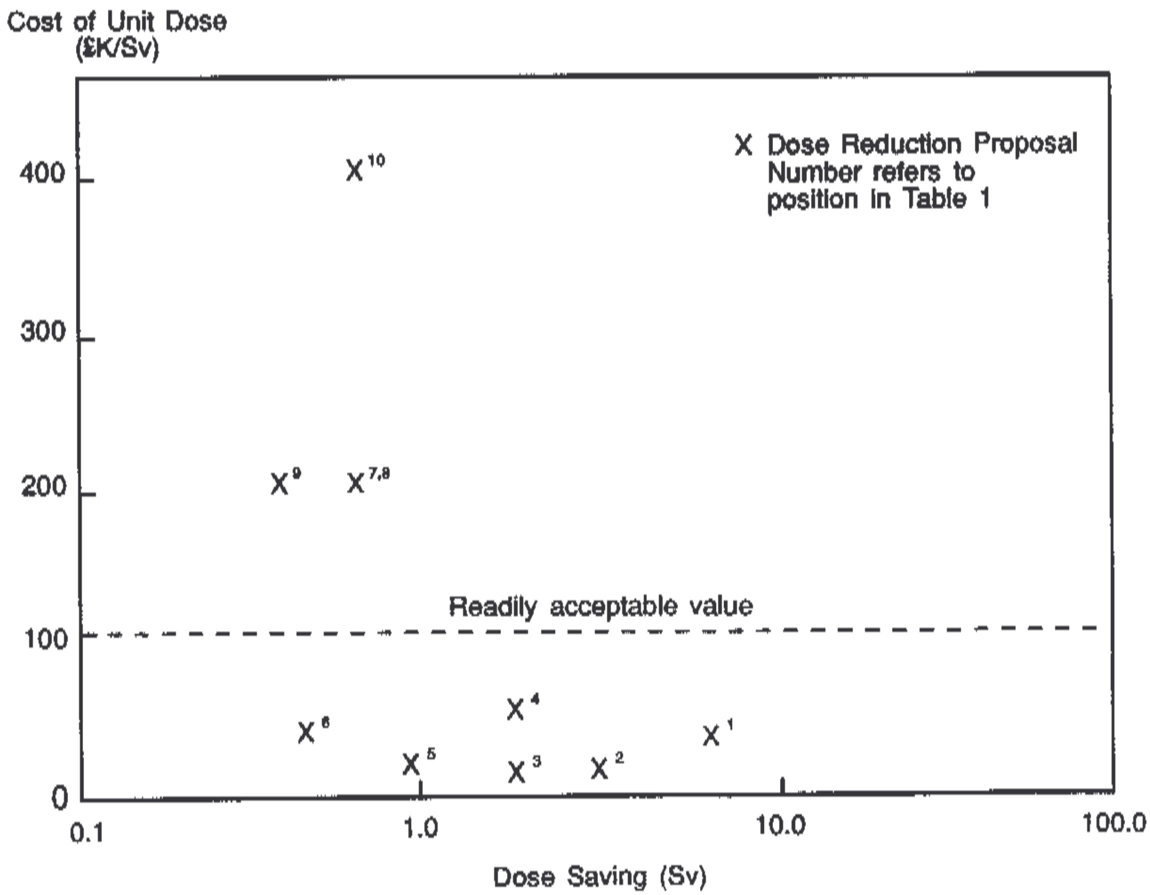

Figure 2. Location on top ten proposals in cost benefit terms

The figure shows that the top six items in terms of dose saving all lie below the £100K/Sv value. The four items above the "acceptable" £/Sv value, although producing a relatively low dose saving were either low cost items or were extensions to dose-reduction items that were common practice. For example, on item 7, temporary shielding is already being used extensively during maintenance and, therefore, the provision of permanent shielding supports was still judged worthwhile.

It is also noticeable that there are no high dose saving (>10 Sv) items on Figure 2. These would be measures such as decontamination which save several tens of Sv of dose and which are already in use. The implementation of these high dose saving measures has often had knock-on effects to other tasks (decontamination reduces the dose on nearly all tasks), and therefore, the available dose saving for future measures is reduced. The dose-reduction measures further down the priority list would all appear on the extreme left-hand side of the graph, with the majority of them some way above the £100K/Sv level. Careful consideration will need to be given as to whether their implementation can be justified.

Step 4 - Implementation of the Highest Priority Items

The dose-reduction strategy has been regarded as a single project as regards progress monitoring, even though the individual items are carried out by different areas, and this has ensured a high visibility as the overall strategy requires significant funding. The top ten items are currently in various states of implementation, e.g., new equipment is being tested that will carry out some electrical maintenance remotely (item 6); closed circuit television (CCTV - item 4) is being used for a variety of tasks such as general work area viewing, monitoring the performance of automated machinery and remotely reading instrumentation; and the use of automated equipment for painting is being investigated (item 2). Development of items 9 and 10 (color coding of areas and use of computer simulated models) has involved the use of the dose prediction code DOMAIN. From a set of measured dose rates around the reactor plant DOMAIN can calculate the source activity and hence determine dose rates anywhere around the plant. This capability is being used to generate dose rate contour maps both to identify low dose rate "awaiting" areas in the reactor plant during maintenance, and to combine with virtual reality models of the plant to enable display of the dose rate and accumulated dose during simulated walk-throughs of the plant for training purposes.

Step 5 - Monitoring Success

Just as important as the generation of ideas and their implementation, is to demonstrate how effective the measures are proving to be. This will give confidence in the strategy and help to provide realistic goals. One of the most useful techniques we have found to monitor dose reduction achievement is the "task learning curve." This involves compiling the measured dose from the radiological database for each task or worker group which has been subject to a dose-reduction measure, normalising this dose to account for different dose rate environments or other variations, and recording the data in chronological order in graphical form.

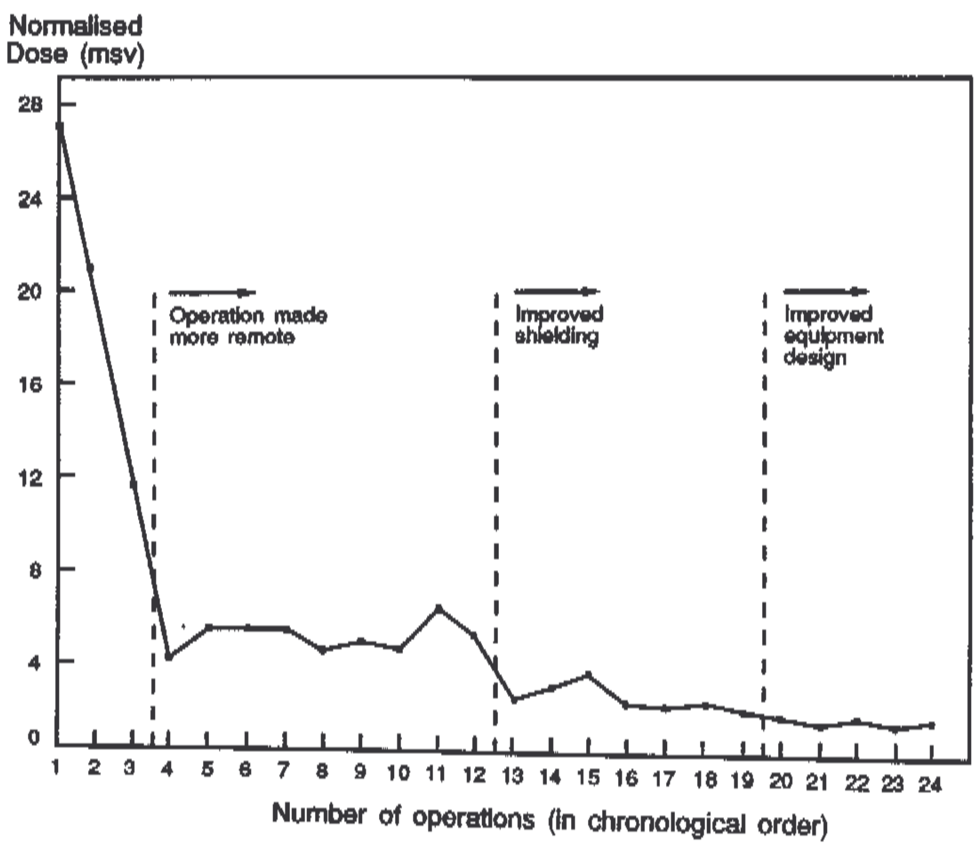

Figure 3. Task Learning Curve for a Non-destructive Examination Technique.

Figure 3 shows the task learning curve generated for the application of an ultrasonic examination technique on a primary plant component. This shows a large reduction in the task dose (normalised to an average primary plant working dose rate) when the technique was first carried out due to initial teething problems being solved and increased familiarity with the equipment. What is also noticeable is the apparent change in dose following the introduction of various dose-reduction measures:

i) greater use of CCTV leading to more remote operation, task dose fell to approximately 6mSv.

ii) increased use of temporary shielding giving greater overall coverage, task dose fell to an average of 3mSv.

iii) improved equipment design requiring less assembly in the radiation area, task dose fell to an average of 2mSv.

Dose-reduction strategy items are being monitored in this way, if applicable, to produce a quantifiable measure of the dose saving achieved. Other benefits arising from this type of approach is that any higher than expected doses will be readily apparent, and the curve can be used for predicting the dose for future applications. A quantifiable measure of effectiveness will be difficult to produce for some of the individual dose-reduction proposals, e.g., setting dose targets and color-coding areas, since they are aimed more at increasing the overall ALARA awareness. However, the overall effectiveness of the strategy will be able to be judged by the total dose to all employees since the strategy was introduced compared to previous years.

Step 6 - Periodically Reviewing the Strategy

Reviews of the dose-reduction strategy are required to summarise the progress of the strategy to date, to ensure that the strategy will meet its objectives and to recommend the next phase of proposals to be implemented. At Rolls-Royce & Associates the first review is being carried out and will recommend an additional further five to ten proposals from the original list be studied further, as well as investigating whether any new dose-reduction methods or ideas are worth examining.

CONCLUSION

The creation of a dose-reduction strategy to bring together and assess, as a unified project, dose-reduction proposals over all aspects of the reactor plant has worked well both in raising the profile of ALARA and in directing effort and resource in the most cost effective and beneficial way. Dose savings achieved as a result of the strategy will continue to be monitored and new proposals implemented in order to continue the downward trend in accrued dose.

Author Biography

Margaret Bennett is a Senior Engineer in the Health and Safety Department at Rolls-Royce & Associates (RRA), whose operations include design and support to the UK's nuclear submarine fleet. She is responsible for providing ALARA advice and developing the implementation of ALARA throughout the Company. She has worked for RRA for 14 years and, prior to her work in the ALARA field, has been involved in various aspects of PWR reactor design and radiation safety. She has a BSc in Physics from St. Andrews University, Scotland.

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