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PLOWSHARE RADIATION PROTECTION GUIDANCE

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ABSTRACT

The recommendations of the ICRP and the NCRP were developed primarily for occupational radiation exposures. They were later modified and applied to non-occupational exposures of populations. These, with appropriate interpretations, can be used to provide Plowshare radiation protection guidance.

Exposures from Plowshare operations will tend to be acute, arising from radionuclides of relatively short half-life, but will have some chronic aspects due to small amounts of long-lived radionuclides generated. In addition, the neutron activation process of Plowshare technology will produce radionuclides not commonly encountered in routine nuclear energy programs.

How these radionuclides contribute to personnel exposure is known for only a few situations that may not be representative of Plowshare exposure. Further complications arise from differences in radionuclide deposition and physiological sensitivity among individuals of different ages and states of health in the exposed population. All parameters necessary to evaluate such exposures are not available, even for good quantitative approximations, resulting in the need for interpretive experience.

INTRODUCTION

Nuclear energy has shown us its destructive forces in war, its harnessed powers in electrical generating facilities, its humane potentials in medicine, and most recently, its constructive capabilities in Plowshare programs. Are the radiation protection aspects of Plowshare applications ready to meet the needs of the rapidly developing programs? A look at the radiation protection guidance currently on hand says yes. The problem seems to be: What radiation protection guidance should be applied? A clear and unified policy relating to the application of radiation protection guidance to Plowshare needs to be established.

The development of nuclear energy programs was accompanied by effective radiation safety programs. An exceptionally good radiation safety record resulted. The constructive application of nuclear energy to Plowshare programs should be accomplished with a similar radiation safety performance record. Well-balanced plans to assure radiation safety for all Plowshare programs are a necessity.

As with any safety program, the commonly undiscussed balance between the benefits to be gained and the risks to be incurred needs to be made so that the appropriate radiation protection guidance can be used. The difficult questions for selecting radiation protection guidance for Plowshare are: Who will make the benefits versus risks balance? And then once made, who will accept the balance? It is too much to anticipate a balance that will be accepted by everyone. What, then is the reasonable course of action?

It would appear that only professional authoritative groups, such as the NCRP, FRC, or the ICRP, are in a position adequately divorced from the controls and influences of government, trade unions, and the public to provide the necessary benefit-risk balance, and hence, the selection of the appropriate radiation protection guidance. To provide guidance is not to be confused with determining performance. The AEC and the Public Health Service both have major roles in assessing and evaluating environmental conditions resulting from Plowshare activities. They both have the important role of determining just how well Plowshare programs meet the prescribed radiation protection guidance.

DISCUSSIONS

Presently available radiation protection guides include the publications of the NCRP, ICRP, FRC and the IAEA. All of these recommendations are based on limiting and controlling the radiation dose to the individual, be he a radiation worker or a member of the general public. All concentration limits that are derived are ultimately based on controlling radionuclide intake and depositions so as not to exceed some prescribed dose limit.

One or more of the NCRP or FRC guides may be translated into recommendations for Plowshare radiation protection guidance. For example, some may suggest the prescribed guides for the public exposee or for the general public can yield recommendations directly applicable to Plowshare radiation protection. Others may advocate the use of the dose limits for the radiation workers as Plowshare control limits. A few may advocate dose limits even higher than the annual limits recommended for radiation workers because of the relatively short durations of the Plowshare radiation exposures. I would suggest that only the guidance for the public exposee and for the general public can be unequivocally identified as applicable for Plowshare radiation protection guidance.

Several factors need to be considered in selecting the proper radiation protection guidance for Plowshare. The principal factors of concern are the size of the group to be exposed by a Plowshare program and the extent to which

the group can be monitored and moved to control its exposure. These factors may not always be the same for each Plowshare program. This is perhaps the most troublesome and often least appreciated aspect of some current deliberations on this subject. By accepting the concept of different guidance for different Plowshare programs, the risk versus benefit balance can be made more justly. Before developing the potential of this approach, a short review of the basis for the various radiation protection guidance for the workers, the public exposee, and the general public may be helpful.

For the radiation worker, dose limits were established such that a lifetime of occupational exposure within the dose limits would not result in deleterious effects that would be objectionable to the individual or to his physician. The public exposee is identified as the maximum exposed individual of the general public. His exposure is limited to 0.5 rems per year primarily to avoid exposure of the fetus, although his general state of health and age are important factors also. For the general public, the radiation dose guidance is based on genetic mutation considerations.

Guidance for the occupational exposure to radiation is given by the Equation, $Dose = 5(N-18)$, where the dose is in rems and N is the age of the individual. This expression determines the acceptable occupational dose that may be delivered in a well distributed pattern of both low dose and low dose rate to the whole body. The critical organs, in determining the whole body limit, are the gonads and the red bone marrow. It is important to remember that the pattern of exposure needs to be relatively uniform with no short periods of high exposure followed by long periods of little or no exposure.

The exposure controls for the non-radiation worker are defined in two ways. The public exposee, or individual, should have his radiation exposure limited to 0.5 rems per year; however, the general public as a whole should receive exposure at a rate not exceeding 5 rems in 30 years, or about 0.17 rems per year. The rate of accumulation of this exposure should be relatively uniform. It would not be a good practice to exceed the 0.17 rems/yr rate.

A more detailed review of these dose limits indicate that there are three categories of occupational limits: 1) the critical organ, 2) the limiting organ, and 3) definable special cases. The $5(N-18)$ dose guidance is applied to the critical organs. A dose of 15 rems per year is defined as the maximum permissible for the limiting organs. Special definable cases are treated individually. Two cases of common interest are potentially pregnant women, whose dose is to be limited to 0.5 rem per year, and the fingers of the hands and the forearm. The fingers may receive up to 75 rems per year; while the transition area, the forearm, is permitted up to 30 rems per year.

Now, to return to the concept of different guidance for different Plowshare programs. If a small group of individuals will be involved in a Plowshare program and if this group can be totally monitored and their dose controlled by actions taken after the Plowshare event, should this become necessary, then control of exposures to near the public exposee limit of

0.5 rems per year seems appropriate. By individual monitoring, their actual radiation exposure from all sources is known. If a large group of individuals will be involved, such that individual monitoring or subsequent control is not feasible or possible for any reason, then the general public guidance should be used and their exposure should be limited to 5 rems per 30 years, or about 0.17 rems per year.

Some may advance the concept that the short duration of the exposure for Plowshare detonations provides increased latitude and tends to permit higher doses than those normally recommended for the general public. Such an approach is not to be recommended because even short-term radiation levels, equal to or approaching those established as acceptable for radiation workers, may not be without some deleterious effect to special groups within the general population, particularly those in early pregnancy.

The very wide variations between the makeup of a worker population and a general population support the appropriateness of the public exposure or the general public limit guidance. Not many would advocate the exposure of pregnant women, children, the elderly, sick or chronically ill to doses comparable to those permitted safely to a select group of radiation workers or to a group whose exposure was monitored and was controllable to a reasonable extent.

The ability to monitor and control the radiation dose to the population involved should be realistically determined to decide if the public exposure or the general population guidance should be used. The radionuclides to be encountered and their exposure path to and in the body should be determined so that the allowable dose for each radionuclide can be established. The environmental pathways and dietary habits of the population can be used to determine the permissible rates of intake for each radionuclide. Dilution factors and radiation control practices appropriate to the specific needs of the Plowshare program can be defined—all within the radiation protection guidance currently available. One really needs to practice the old cliché, "Expect the Unexpected," in each step of this calculation.

What about considerations arising from possible multiple sources of exposure? Others have recommended reduction factors for the general population limits of 10 or 100 to 0.5 rems per year or 0.005 rems per year in the assignment of acceptable dose accumulation rates to particular radionuclides to make allowance for multiple radiation source contributions. Let's think about such calculations. They do not affect the basic dose guidance for Plowshare. They are a type of "allowance factor" to be applied in calculating doses to be permitted from particular radioisotopes. If, for a given Plowshare program, three radionuclides were present for ingestion and each of these had the whole body as the critical organ, then allowing 1/3 of 0.5 rems per year or 1/3 of 0.17 rems per year for each radionuclide would be in order, however, the basic guidance has not changed. If some other unrelated source of exposure could be identified, then an appropriate allowance also should be made for it. However, a practical analysis of the recommendations to use reduction factors of 10 or 100 arbitrarily for all Plowshare programs immediately runs into difficulty. While keeping radiation exposure at the lowest practical level is our prime

and absolute objective, it is, however, not appropriate to prescribe mandatory control limits with unneeded conservatism. One should consider multiple radiation sources exposures of the general public only as they become identified. It is not necessary to develop Plowshare protection guidance from such a restrictive position.

One can always consider the likelihood that a Plowshare population will also be in a position to receive substantial multiple source exposures from unknown activities. With the limited current Plowshare program and the diverse locations where future programs may be conducted, the potential for exceeding the population control limits from multiple sources exposures unknowingly seems remote. To impose the more restrictive controls at this time is to apply an unjust, improper benefit-risk burden on the developing Plowshare program.

Guidance at 5 rems per 30 years or less also seems advisable when considering the use of Plowshare products by the general public. Consider the tritium contamination in Plowshare-assisted natural gas wells. The distribution of this natural gas and its small amount of tritium to homes over very wide parts of the country can lead to the exposure of a very large population under unmonitored conditions. This is clearly a general population exposure in its fullest sense.

One might consider the benefit-risk balance made by a family with respect to natural gas associated with Plowshare programs. I dare speculate that many a family would make the benefit-risk balance at a higher cost of gas and the absence or near-absence of tritium. Similar considerations enforce and support actions to very seriously keep radiation exposures as low as practical. There is more in the benefit-risk balance than company profits and technical safety. Each family will have its own criteria for measuring benefits and risks and hence, the general acceptability of Plowshare-linked products. One should be reluctant to break with the long standing guidance on exposure of the general population in any Plowshare program. It would seem prudent to advise exposure control limits no more restrictive and no more liberal than those used for some time now. Any change would call for a complete review of the technical basis for change by the NCRP or FRC.

We cannot arbitrarily decide what cost will be attributed to Plowshare radiation protection activities due to the selected radiation protection guidance or what cost can be devoted to ecological studies to support dose estimations. Each situation may be unique, and adequate information needs to be collected before, during and after each program to demonstrate that a completely safe program within the dose guidance is attained. The conditions of each Plowshare program will determine the cost required to provide total adequate, but not excessive, radiation protection.

Two questions of thoughtful concern: What are the international legal aspects of programs on foreign soils? What recourse might occur if improper programs were planned or actually performed? The treaties authorizing U.S. Plowshare programs on foreign soils will undoubtedly determine the levels of exposure that will be anticipated.

Some international authoritative review body would seem to have a role to play in providing assurances that necessary and adequate precautions and care were taken in planning and executing each test. Perhaps an arm of the IAEA could provide this help. It will be a challenging task. It needs to be performed soundly, but on a very timely basis. An overseer--not a roadblock--is needed.

SUMMARY

It appears appropriate to evaluate each Plowshare program individually, providing the necessary studies and population considerations, so that one may use the correct dose limit guidance for determining acceptable conditions. The AEC and the Public Health Service need to give careful attention to collecting and analyzing environmental exposures and dose data so that we may learn from experiences and assure safe conditions. We need to maintain the good record of the nuclear energy program by not making unsafe errors in estimating the consequences of any Plowshare programs.

Plowshare can be performed safely. To do so requires good judgment, sound application of existing radiation protection guidance, and sufficient funding to meet the needs of practical safety programs. A safe approach using the public exposee or the general population dose control limits, as the situation may demand, is necessary to help assure the rapid development of Plowshare programs. A high priority should be assigned to developing methods to apply the existing radiation protection guidance so that Plowshare programs may proceed safely.

There seems to be no doubt but that the peaceful applications of nuclear energy in Plowshare programs will develop as rapidly as funding and commercial opportunities present themselves. The safe history of the nuclear industry, the long-term potential benefits, and the varied applications for developing Plowshare technology may be at stake if authoritative and sound radiation protection methods are not incorporated in all Plowshare applications. If Plowshare does not get off with a safe, well accepted record of radiation management and control, then its potential benefits will be doubly difficult to develop. It would be a long and difficult task for Plowshare to attain a right finish after making a wrong start.

QUESTION FOR HERBERT M. PARKER

I. From R. Duff:

Will you comment more quantitatively about the non-linear effects of low level radiation exposure recently discovered?

ANSWER:

Most radiation protectionists are generalists who have some competence in reviewing the work of others. It has taken three decades, remember, to get some sense into this despite the fact that the very best radiobiologists in the world have been working on it. I think it would be very imprudent of me to comment at great lengths. I would refer the questioner to the genetic case which is the one, I think that socially is the most troublesome. I say that partly on the grounds that it's not too bad if we louse up this generation, but if we louse up the next hundred generations, that's a different issue. Work in the area of genetics is essentially done through the outstanding findings of Russell and Russell at Oak Ridge. Those of you who were at the other symposium I addressed about a month ago heard a superb review by Dr. Russell in terms that those of us who are not geneticists, like myself, could really understand and I believe that is going to be published by Lawrence Radiation Laboratory. I wouldn't know a finer quick reference to what really has been found out about effects of low dose rate and low dosage both, in this case of course in the mouse and carried over inferentially to the human case. Male and female cases are very different and there may be some experts in the room who would volunteer to fill this in more fully. I would rather not.

SESSION V - EXISTING AND REQUIRED RESEARCH FOR DEVELOPMENT OF
RADIATION PROTECTION GUIDANCE FOR PLOWSHARE

Chairman: Mr. Charles L. Weaver
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