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MEMORANDUM

A report on progress towards new recommendations: A communication from the International Commission on Radiological Protection

International Commission on Radiological Protection¹

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Abstract

Throughout the hundred-year history of the uses of ionising radiation in medicine and industry there has been advice on the need to protect people from the hazards associated with exposure. Protection standards have evolved throughout this period to reflect both the scientific understanding of the biological effects of exposure and the social and ethical standards to be applied. The Main Commission of ICRP is now considering a revised, simpler approach that is based on an individual-oriented philosophy and represents a potential shift by the Commission from the past emphasis on societal-oriented criteria. The initial proposals were promulgated through IRPA and an open literature publication was published in the Journal of Radiological Protection in June 1999. On the basis of comments received and the observations presented at the IRPA-10 Congress in May 2000, the Commission is beginning to develop the next recommendations. This article describes the issues involved in the preparation of the next recommendations and indicates the process that the Commission proposes to follow. The Commission wishes there to be an ongoing debate with an iteration of ideas over the next few years.

1. Historical background

Roentgen discovered x-rays in 1895, and in 1896 Grubbé described x-ray dermatitis of hands in the first paper to appear reporting radiation damage to the skin of the hands and fingers of the early experimental investigators. On the 12 December 1896, the American journal *Western Electrician* contained a paper by Wolfram Fuchs giving the first protection advice. This was:

- make the exposure as short as possible;
- do not stand within 12 inches (30 cm) of the x-ray tube; and
- coat the skin with Vaseline and leave an extra layer on the area most exposed.

Becquerel's identification of the phenomenon of radioactivity, also in 1896, and the Curies' separation of radium in 1898 soon led to the use of radioactive substances, together with x-rays, for therapy. In the next ten years, many papers were published on the tissue damage caused by radiation.

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In 1913, the Deutsche Roentgen Gesellschaft issued radiological protection advice and in 1915 the British Roentgen Society recognised the hazards of x-rays in a warning statement. Several countries were actively reviewing standards for safety by the start of the First World War, but it was not until 1925 that the International Congress of Radiology was formed and first met to consider establishing protection standards. This Congress established the 'International X-ray and Radium Protection Committee' in 1928, which evolved into the present International Commission on Radiological Protection (ICRP) in 1950.

The early recommendations were concerned with avoiding threshold (*deterministic*) effects, initially in a qualitative manner. A system of measurement or dosimetry was needed before protection could be quantified and dose limits could be defined. In 1934, recommendations were made implying the concept of a safe threshold (ICRP 1934): 'Under satisfactory working conditions a person in normal health can tolerate exposure to x-rays to an extent of about 0.2 roentgens per day.' This would be about ten times the present annual dose limit. The tolerance idea continued for the next two decades so that in the 1950 recommendations (ICRP 1951) it is stated that 'the figure of 2 r per week seems very close to the probable threshold for adverse effects'. This led to a proposed limit of 0.3 r per week for low-LET radiation. In considering neutrons and alpha particles, it was stated that 'anaemia and bone damage appear to have a threshold at 1 μ Ci Ra-226'. In these 1950 recommendations, the Commission provided an impressive list of the health effects that should be kept under review:

- Superficial injuries.
- General effects on the body, particularly blood and blood-forming organs, e.g. production
 of anaemia and leukaemia.
- The induction of malignant tumours.
- Other deleterious effects including cataract (and other less likely examples).
- Genetic effects.

For the first 60 years after the discovery of ionising radiation, the ethical position was that of avoiding deterministic effects from occupational exposures and the principle of radiological protection was to keep *individual doses* below the relevant *thresholds*. Low doses of radiation were deemed beneficial, largely because the uses of radiation were for medical purposes, and radioactive consumer products abounded.

A change in philosophy was brought about by new biological information that began to emerge in the mid-1950s. There was the epidemiological evidence of excess malignancies amongst American radiologists and the first indication of an excess of leukaemia cases in the survivors of the atomic bombings at Hiroshima and Nagasaki. Previously there had been only deterministic effects, where the severity of the effect increases with the size of the dose, and above a certain threshold dose the effect is almost certain to appear. Now there were *stochastic effects* where the probability of the effect, not the severity, is proportional to the size of the dose.

The threshold was rejected. The problem had become one of limiting the probability of harm, and much of what has subsequently developed related to the estimation of that probability of harm and the decision on what level of implied risk is acceptable or, more importantly, unacceptable. In the 1955 recommendations, ICRP first began to address this question of acceptability (ICRP 1955). It was said that since no radiation level higher than the natural background level can be regarded as absolutely safe, the problem is to choose a practical level that, in the light of present knowledge, involves a negligible risk. Maximum permissible doses should be set so as to involve a risk which is small compared with other hazards in life. And: 'In view of the incomplete evidence on which the (risk) values are based

coupled with the knowledge that some effects are irreversible and cumulative ... it is strongly recommended that every effort be made to reduce exposure to all types of ionising radiation to the lowest possible level.'

There was then a prolonged debate over how to deal with the acceptability of the risks. In Publication 1 (ICRP 1959), the words 'lowest possible' were succeeded by 'as low as practicable' and by 1966 had become 'as low as is readily achievable' (ICRP 1966). The Commission used these words so as to include social and economic considerations. Other considerations, such as ethical ones, were not excluded by this wording; the Commission considered them included in the adjective 'social'. In Publication 22 (ICRP 1973), the adverb 'readily' was replaced by 'reasonably', because 'readily' seemed to be too permissive.

The 1977 recommendations (Publication 26) (ICRP 1977) set out the new system of dose limitation and introduced the three principles of protection in paragraph 12:

- No practice shall be adopted unless its introduction produces a positive net benefit.
- All exposures shall be kept as low as reasonably achievable [ALARA], economic and social factors being taken into account.
- The doses to individuals shall not exceed the limits recommended for the appropriate circumstances by the Commission.

These principles have since become known as *Justification of a Practice*, *Optimisation of Protection (or ALARA)* and *Individual Limits*.

The recommendations were much concerned with the bases for deciding what is reasonably achievable in dose reduction. The principles of justification and optimisation aim at doing more good than harm and at maximising the margin of good over harm for society as a whole. They therefore satisfy the *utilitarian principle of ethics*, whereby actions are judged by their overall consequences, usually by comparing in monetary terms the relevant benefits (e.g. statistical estimates of lives saved) obtained by a particular protective measure with the net cost of introducing that measure.

Paragraph 72 of Publication 26 suggests that the decision on what is ALARA depends on the answer to the question: is the collective dose sufficiently low that further reduction in dose would not justify the incremental cost required to accomplish it? Paragraph 75 then recommended the use of differential cost—benefit analysis where the independent variable is the collective dose, and recommended that there be assigned a monetary value to a unit of collective dose. This classical use of cost—benefit analysis addresses the question: how much does it cost and how many lives are saved?

In 1977, the establishment of the dose limits was of secondary concern to the cost-benefit analysis and use of collective dose. This can be seen in the wording used by ICRP in setting its dose limit for members of the public. Publication 26 states: 'The assumption of a total risk of the order of 10^{-2} Sv⁻¹ would imply restriction of the lifetime dose to the individual member of the public to 1 mSv per year. The Commission's recommended limit of 5 mSv in a year, as applied to critical groups, has been found to give this degree of safety and the Commission recommends its continued use.' In a similar manner the dose limit for workers was argued on a comparison of average doses and therefore risk in the workforce with average risks in industries that would be recognised as being 'safe', and not on maximum risks to be accepted.

Throughout this period of protection, the Commission was dealing with stochastic risks where the probability of harm was proportional to dose. The question had become one of acceptability of risk, since there was no threshold below which there was zero risk. This acceptability was determined by what was 'as low as reasonably achievable' and the utilitarian ethical approach was used. This approach provided insufficient protection for the individual and required the retention of the concept of the dose limit.

In 1989, the Commission issued the draft of a new set of recommendations to be issued in 1990. Several developments had led the Commission to revise its recommendations. The most powerful argument was the availability of new information suggesting higher values of the probability of stochastic effects of radiation. The dose limit for public exposure applied only in defined conditions, but many people regarded a limit as being absolute. The use of higher doses for emergencies and for radon in homes was seriously confusing. The Commission tried to clarify this by distinguishing between *practices* that added doses and *interventions* that subtracted doses in existing situations. The confusion was not eliminated. Other factors included the excessive formality of the use of differential cost—benefit analysis and the rigid interpretation of collective dose. A report on the specific topic of optimisation, Publication 55 (ICRP 1989), was issued to reduce this formality, but did not seem to have much influence.

2. The present situation

The 1990 recommendations were issued as Publication 60 (ICRP 1991a). They still adopted the same three principles, in the same order, but extended the explanations of the 1977 material into a 'system of radiological protection':

- No practice involving exposures to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes.
- In relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received should all be kept as low as reasonably achievable, economic and social factors being taken into account. This procedure should be *constrained by restrictions on the doses to individuals* (dose constraints), or on the risks to individuals in the case of potential exposures (risk constraints) so as to limit the inequity likely to result from the inherent economic and social judgements.
- The exposure of individuals resulting from the combination of all the relevant practices should be subject to dose limits, or to some control of risk in the case of potential exposures.
 These are aimed at ensuring that no individual is exposed to radiation risks that are judged to be unacceptable from these practices in any normal circumstances.

In the 1990 recommendations, the Commission continued to adopt implicitly a societal/ethical policy using a *utility-based criterion*, aimed at determining the optimum deployment of resources applied to optimise protection by the control of, or at, a source. Because of the emphasis on collective dose in the first two requirements, this order emphasised the protection of society over that of individuals. However, this emphasis does not necessarily provide sufficient protection for each individual. Classical cost–benefit analysis is unable to take this into account, so the Commission established an added restriction on the optimisation process. This addition modified the principle of optimisation by the introduction of the concept of a constraint. Optimisation is a source-related process while limits apply to the individual to ensure protection from all sources under control. The constraint is an *individual-related criterion*, applied to a single source in order to ensure that the most exposed individuals are not subjected to excessive risk, and to limit the inequity often introduced by cost–benefit analysis.

The definition of the dose limits was changed to indicate that the continued exposure just above the limits would result in additional risks that could reasonably be described as 'unacceptable in normal circumstances'. Much of Publication 60 was concerned with how the level of unacceptability should be established. It therefore included comprehensive annexes on dosimetric quantities, biological effects, and the bases for judging the significance of biological effects. It has however proved complex and, in parts, confusing. For example:

- The users of the recommendations confused justification and the optimisation of protection.
- The optimisation requirement had led to an overemphasis of the use of differential cost—benefit analysis and collective dose, thereby losing the emphasis on 'reasonably' in the phrase 'as low as reasonably achievable'.
- The use of collective dose, aggregated to include all levels of dose and all periods of time into a single value, distorted the process of optimisation of protection.
- The dosimetric quantities were not directly measurable and caused concern in relation to measurable quantities.

The Commission weakened the link to cost–benefit analysis and collective dose, initially in Publication 55 (ICRP 1989) and more firmly in Publication 77 (ICRP 1997), reflecting an overall shift of the ethical position from utilitarian values. However, the Commission concluded that it should begin the process to produce a new set of recommendations, at a date of about 2005. This will be 15 years after the adoption of Publication 60.

The Chairman of the Main Commission made proposals to the Commission for a possible simplification of the system of protection, which were accepted. The principal change was to emphasise the dose to an individual from a controllable source. There would still be requirements to keep the individual dose both below a defined action level and as low as reasonably practicable. The second requirement would not be linked to collective dose in its present form. The Commission invited its Chairman to publish the proposals (Clarke 1999) and the International Radiation Protection Association (IRPA) to arrange a discussion of the Chairman's paper amongst Constituent Societies and to make comments.

IRPA held a special session at its Congress, IRPA-10, in May 2000 where the principal views expressed can be summarised as follows. The majority of Societies indicated the following views:

- Essentially all Societies welcomed the Commission's initiative to open the debate.
- There was an overwhelming view that the principle of Justification must be addressed.
- The majority of Societies agreed with the use of natural background radiation in setting and explaining protection standards.
- The retention of limits was felt essential.
- There was thought to be some value in the use of collective dose for workers.

A minority of Societies argued for other views:

- There was a need for the retention of the unrestricted (infinite time, infinite space) collective dose.
- The system was not applicable in medical areas.
- Changes should be made only if there would be an improvement in protection.

The Commission has considered these opinions and has decided to proceed, taking account of views expressed, towards new recommendations. It wishes there to be an on-going debate with an iteration of ideas in the development process. This article describes the principal issues involved in the preparation of the next recommendations.

3. The development of the next recommendations

A great deal of work has still to be undertaken by the Commission and its Committees. A Task Group of the Main Commission has already been selected to co-ordinate the programme. The Committees will develop proposals for discussion by the Task Group which will develop

position papers on the many issues to be resolved before the Commission finalises any new recommendations. The material in this communication is therefore intended only to indicate the areas in which the Task Group will be expected to work.

3.1. The system of protection

It is the control of radiation doses that is important, no matter what the source, in protecting individuals from the harmful effects of ionising radiation. In most situations, the most effective controls are those applied at or near the source of radiation. In the first place, therefore, consideration should be given to the dose to an individual from a particular controllable source.

The term *controllable source* can be used when either the source or the resulting exposures are controllable by reasonable means. It may be more convenient to call a controllable source an *optional source* when the existence, or the nature, of the source is a matter of choice. The term *unavoidable source* might be used when neither the existence nor the nature of the source is a matter of choice, but the pathways to man are controllable.

The doses may be received as result of work (occupational exposure), in medical practice (medical exposure), in the environment (public exposure), due to artificial radionuclides, or to natural sources such as cosmic rays and long-lived radionuclides in the Earth's crust. The doses may have already been received, or will be received in the future, from the introduction of new sources or following an actual or potential accident.

For each previously justified, controllable source, the first consideration in the proposed system of protection is to restrict the dose to individuals by means of *Protective Action Levels*. The need for protective action is influenced by the individual dose, but not by the number of exposed individuals. At present, this criterion is provided by dose limits, constraints and action, or intervention, levels. The second consideration stems from the recognition that there is likely to be some risk to health, even at small doses. This introduces a moral requirement, for each controllable source, to take all reasonable steps to restrict both the individual doses to levels below the action level and the number of exposed individuals. At present, the Optimisation of Protection provides this criterion.

3.2. The justification of an endeavour

'Endeavour' might be a better description than the current term 'practice' which has proved difficult, partly because of its antithesis, 'theory'. The judgement that it would be justifiable to introduce or continue an endeavour involving exposure to ionising radiation is important, but is not usually taken by radiological protection authorities, although they should influence the decision. The responsibility for judging the justification of an endeavour usually falls on governments or government agencies.

The medical exposure of patients in a general sense should be justified, as is any other endeavour. In addition, a more detailed justification has to be introduced. The principal aim of medical exposures is to do more good than harm *to the patient*, subsidiary account being taken of the radiation detriment from the exposure of the radiological staff or of other patients. Provided that the necessary resources are available, the responsibility for the justification of the particular use of a particular procedure falls on the relevant medical practitioners.

The Commission's present recommendations for justification require that the endeavour should do more good than harm. This procedure implies a quantified balance of costs and benefits, but in practice, governments, physicians or individuals do not make decisions about courses of action in a predominantly quantitative way. A qualitative approach is more common and usually more appropriate. Nevertheless, a strict interpretation of the present system has

Table 1. Bands of concern about individual effective doses in a year.

Band of Concern	Description	Level of dose	
Band 6	Serious	>100× normal	
Band 5	High >10× normal		
Band 4	Normal	1–10 mSv	
		(Typical natural background)	
Band 3	Low	$>0.1 \times normal$	
Band 2	Trivial	$>0.01 \times normal$	
Band 1	Negligible	$<0.01 \times normal$	

often been taken to require an estimate of the total collective dose from the endeavour, over all levels of dose, all locations and all times.

The next recommendations will apply only to situations in which either the source is susceptible to control (by elimination or modification), or the pathways to individual dose are subject to control, or both. Furthermore, the current proposals for the new system of protection start from the justification of an endeavour. Until justification has been established in general terms, it is not considered appropriate to apply a system of protection to optional sources. The next recommendations as now proposed would therefore apply only to justified optional sources and to unavoidable sources.

3.3. Protective Action Levels

The proposed system of protection starts from a generalised structure of individual doses linked to recommended Protective Action Levels. These are levels of individual dose above which it is proposed that there is a requirement to take all feasible steps to reduce doses. They are influenced by the type of action and by the type of exposed individual. This necessitates a number of such levels. Protective Action Levels would be chosen on the assumption that the action is, or will be, effective.

A convenient starting point for the use of Protective Action Levels is a classification of levels of individual dose. A scale indicating the appropriate level of concern was suggested by the Commission (Clarke 1999). The aim was to specify a broad basis for defining bands of concern. It is desirable to avoid a rigid demarcation of the bands while avoiding ambiguity. Table 1 provides a similar classification into bands, each with a descriptive specification, and an indication of the level of dose compared with natural background.

The most effective action will be that applied at the design stage of a new endeavour. However, experience may show that the design precautions were inadequate, or accidents may occur. Existing precautions may sometimes have to be improved. If the source is not optional, additional protective action may have to be applied in the environmental pathways, or to individuals, previously known as intervention. Protective actions will be different for optional sources and unavoidable sources.

The bands of concern suggested in table 1 provide guidance about the ranges of action level relevant to common types of protective action and types of exposed individuals. Broad principles may be included in the next recommendations. Detailed guidance will probably be best provided in specialist publications of the Commission.

The magnitude of Protective Action Levels and the methods of application will have to be decided by the Commission at a later stage of the preparation of the next recommendations. Meanwhile, table 2 uses the bands of concern given in table 1 to provide guidance about the broad range of action required to meet relevant protective action levels. At exposures below the

Table 2. Typical protective actions for optional and unavoidable sources.

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Level of concern	Type of exposure	Typical protective actions for optional sources	Typical protective actions for unavoidable sources
Band 6 (Serious)	Public	Remove or greatly reduce	Relocate or temporarily
		the source	evacuate individuals
	Medical	Justify the exposure	Assess the consequences,
		(excluding therapy)	treat the individuals if necessary
	Occupational	Remove or greatly reduce	Assess the consequences,
		the source	treat the individuals if necessary
Band 5 (High)	Public	Reduce the source	Shelter in buildings.
			Administer stable iodine
	Medical (diagnosis)	Reconsider the diagnostic procedure	Assess the implications
	Occupational	Reduce the dose	Reduce the dose
Band 4 (Normal)	Public	Reduce the dose	Reduce the dose
	Medical (diagnosis)	Reconsider the diagnostic procedure	No protective action
	Occupational	Reconsider the working procedure	No protective action
Band 3 (Low)	Public	Reduce the dose	No protective action
	Medical (diagnosis)	No protective action	No protective action
	Occupational	No protective action	No protective action
Band 2 (Trivial)	Public	No protective action	No protective action
	Medical (diagnosis)	No protective action	No protective action
	Occupational	No protective action	No protective action
Band 1 (Negligible)	Any exposure	Exclude from the ICRP	Exclude from the ICRP
		system of protection	system of protection

action level, there would be a necessary, but less prescriptive, requirement to take all reasonable steps to achieve further reductions in doses. This is part of the process to keep exposures as low as is reasonably practicable (ALARP).

3.4. Optimisation of Protection

The process of taking all reasonable action to reduce exposures is still likely to be called the Optimisation of Protection. The initial proposals (Clarke 1999) suggested that the optimisation of protection as it is now usually understood should be replaced by a different requirement to ensure that the residual doses, after the application of the Protective Action Levels, should be kept 'as low as reasonably practicable' (ALARP). This requirement would apply both to individuals and to groups.

One procedure for judging that the doses are as low as is reasonably practicable would involve the comparison of a number of feasible protection plans. The comparison would aim at selecting the plan where the step to the plan next higher in stringency would result in an improvement insufficient to offset the increase in resources needed to take the step. The current plan could then be said to result in exposures that are as low as reasonably practicable. Since the requirement would apply to both individuals and groups, the choice would be dependent on judgement rather than on collective dose.

In addition to the protection of individuals, there is an additional need to protect groups, taking account of changes both in the level of dose and the number of individuals affected. The obvious quantity to use is the product of the size of the exposed group and the average dose to the group. The term collective dose has proved unsuitable for this product because it is widely used for the product over the world population and over all time. The Commission is considering the term *group dose*, where the definition of the exposed group is limited to individuals receiving specified ranges of dose over specified periods of time. The use of the group dose would be particularly useful when the group is a workforce. It might then be called the *workforce dose*.

The requirement to keep all doses as low as is reasonably practicable should also take account of the possible inequity of the distribution of individual doses. This inequity will be limited by the use of Protective Action Levels, but the formal use of *reference levels* will still be needed to express optimised protection. These have already been used for medical diagnostic procedures in the Euratom Patient Protection Directive of the European Community and also in the IAEA Basic Safety Standards as guidance levels.

4. Other issues

4.1. Health effects

In the 1990 recommendations (ICRP 1991a), the Commission included the following material: 'The probability of a cancer resulting from radiation usually increases with increments of dose, probably with no threshold, and in a way that is roughly proportional to dose, at least for doses well below the thresholds for deterministic effects. The severity of the cancer is not affected by the dose. This kind of effect is called 'stochastic', meaning 'of a random or statistical nature'. If the damage occurs in a cell whose function is to transmit genetic information to later generations, any resulting effects, which may be of many different kinds and severity, are expressed in the progeny of the exposed person. This type of stochastic effect is called 'hereditary'.'

The systems of protection in the 1990 recommendations and suggested in this article are based on these views. The Commission has initiated a comprehensive review of the biological and epidemiological information. If this review leads to a major change in these views, the Commission will have to judge whether the system now suggested, which will be effective and prudent, can be maintained. The introduction of a threshold for stochastic effects or a serious departure from linearity would be inconsistent with the use of average absorbed dose and with the independence of the assessment of the effects of individual sources. The whole conceptual basis of radiological protection would be changed. For the present, no such conceptual change is considered.

4.2. Dosimetric quantities

There have been some persistent differences of view about the definitions of the Commission's dosimetric quantities. In the next recommendations, the Commission hopes to remove these differences. The root of the conflict lies in the difference in objectives. Metrologists have correctly aimed at providing a definition of 'dose' that unequivocally defines the dose in an absorbing medium, without involving in the definition itself information about the type of radiation or the size, shape and composition of the medium.

This aim has led to the quantity *absorbed dose at a point*. Whatever the exposure situation, the absorbed dose can, in principle, be determined using only information available at the

point. For protection purposes, the aim is different. The dosimetric quantity should correlate reasonably well with the probability and severity of the consequent health effects. Clearly, this aim can never be fully achieved, and fairly crude relationships will always have to be accepted. Absorbed dose at a point is a good starting point, but the information at a point is unlikely to meet the protection aims. For protection purposes, the Commission uses the *average tissue dose*, sometimes weighted for the type of radiation and for the choice of tissue. The magnitude of the average tissue dose depends on the type of radiation and on the shape, size, composition and location of the tissue. None of this information is included in the definition, so it is always necessary to state, or to imply, the details of the models used. In the next recommendations, it will be necessary to clarify the difference between the quantities that can be specified at a point and the quantities that are averaged over tissue.

The radiation and tissue weighting factors are derived from biological data, but each numerical value draws on a wide range of situations. The values cannot be taken directly from the experimental data derived from particular studies. The sets of values currently in use do not reflect this generalisation and are more complex than can be justified. Consideration will be given to providing simpler sets of weighting factors in the next recommendations. The aims of the weighting factors are not likely to change and it may be possible to define equivalent dose and effective dose in terms that will not cause quantitative changes large enough to be significant for radiological protection purposes. In any event, it should be possible to separate the measurable quantities, which are subject to conventional metrology, and the protection quantities, which would be determined from the measurable quantities by conversion coefficients chosen by ICRP.

4.3. Medical applications

In Publication 73, 'Radiological Protection and Safety in Medicine' (ICRP 1996), the Commission explained the features of medical practice that influence the approach to radiological protection. The following paragraph is taken from Publication 73:

Several features of medical practice require an approach to radiological protection that is slightly different from that in other practices. In the first place, the exposure of patients is deliberate. Except in radiotherapy, it is not the aim to deliver a dose of radiation, but rather to use the radiation to provide diagnostic information or to conduct interventional radiology. Nevertheless, the dose is given deliberately and cannot be reduced indefinitely without prejudicing the intended outcome. Secondly, the patient needs a special relationship with the medical and nursing staff. For this reason, the system of protecting the staff from the source, e.g. shielding, should be designed to minimise any sense of isolation experienced by the patient. This is particularly relevant in nuclear medicine and brachytherapy, where the source is within the patient. Thirdly, in radiotherapy, the aim is to destroy the target tissue. Some deterministic damage to surrounding tissue and some risk of stochastic effects in remote non-target tissues are inevitable. Finally, hospitals and radiology facilities have to be reasonably accessible to the public, whose exposure is thus more difficult to control than it is in industrial premises.

Biomedical research includes the exposure of volunteers who do not necessarily obtain any benefit from the exposure. The associated problems were discussed in Publication 62, 'Radiological Protection in Biomedical Research' (ICRP 1991b). The Commission intends to retain these approaches in the next recommendations.

5. Conclusions

The discussions in this article indicate how it will be feasible to develop the next recommendations based on an individual-related philosophy using the concept of controllability of sources. For each previously justified, controllable source the first consideration in the proposed system of protection would be to restrict the dose to individuals by means of Protective Action Levels. There still remains an additional requirement to do all that can be done to make exposures as low as reasonably practicable (ALARP) from the source. Thus a major change from Publication 60 will be this re-ordering of the principles, to place that of optimisation after that of individual protective action. This is a development signalled in Publication 60 by the introduction of a constraint to the optimisation of protection.

A great deal of work has still to be undertaken by the Commission and its Committees. A Task Group of the Main Commission has already been selected to co-ordinate the programme and the Committees will be asked to develop position papers on the many issues to be resolved before the Commission finalises any new recommendations.

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