RECOVERY OPERATIONS AFTER THE CHERNOBYL ACCIDENT: THE USSR'S NCRP INTERVENTION CRITERIA

(Summary of an informal meeting arranged by the IAEA Secretariat on 12 May 1989)

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ABSTRACT

An informal meeting was arranged by the Secretariat of the International Atomic Energy Agency to discuss the policy on intervention criteria recommended by the National Commission on Radiation Protection (NCRP) of the USSR. The paper presents a summary of the criteria presented and the discussions and conclusions during the meeting. The meeting took place in Vienna on 12 May 1989 and was attended by nearly 100 experts from 20 countries. Many of the experts were participating in the meeting of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) being held the same week.

The meeting dealt with possible problems arising from long-term contamination by radioactive substances after major radiation accidents in general, with particular consideration of the post-Chernobyl situation. The NCRP Chairman informed the participants of the contamination situation after the Chernobyl accident, of the remedial actions which have been taken, and of the intervention criteria that have been used and recommended for the future.

Special attention was given to the problems remaining after the first years during which the remedial actions were consistent with a globally accepted policy. There was little previous experience, however, of the long-term effects of a nuclear accident causing large contamination. The policy proposed by NCRP is to limit the total dose received from the accident by individuals in the critical groups in the USSR to 350 mSv over their lifetimes; such a level met with general acceptance by the participants. It was agreed, however, that the dose limitation for such purposes would have to be decided by national authorities, because it would depend on the local situation and on the severity of the accident.

1. PURPOSE

The purpose of this paper is to present a summary overview of an informal meeting arranged by the Secretariat of the International Atomic Energy Agency to discuss the post-Chernobyl intervention criteria recommended by the National Commission on Radiation Protection (NCRP) of the Ministry of Health of the USSR. The meeting took place in Vienna on 12 May 1989 and was attended by nearly 100 experts from 20 countries. Many were participating at the meeting of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) being held the same week. The informal meeting was chaired by Professor Bo Lindell. The NCRP criteria were extensively described by the NCRP's Chairman, Dr.L.A. Il'in, and substantiated in the document "The Policy of the USSR National Commission on Radiation Protection on the Substantiation of Temporary Annual Dose Limits for Public Exposure due to the Chernobyl Accident". A limited distribution of this document, coded UNSCEAR/XXXVIII/10 (8 May 1989), was made at the 38th Session of UNSCEAR held in Vienna from 8 - 12 May 1989(1).

The accident at Unit 4 of the Chernobyl Nuclear Power Plant in 1986 is unique in the history of the peaceful use of nuclear energy in its scope, character and potential effects on people and the environment. Radiation protection specialists have learned and will continue to learn many lessons from the Chernobyl accident. The accident has shown that, although a very sophisticated system of radiation protection standards and recommendations has been established for dealing with anticipatable, planned situations for which it is assumed that radiation exposure will be delivered with certainty, only very limited guidance was available for unanticipated, unplanned, de facto situations such as the long-term contamination resulting from an accidental release of radioactive materials into the environment. The most applicable guidance would be that relating to the problem of high levels of radon in existing dwellings; this guidance, however, is also very limited.

After a radiation accident a typical problem is how to deal with contaminated areas where the radiation level has been found to be higher than 'normal' and what criteria to use for deciding whether people in such areas must be evacuated or not, or for permitting evacuees to re-enter the areas. Several international bodies, including the International Atomic Energy Agency (IAEA), are working at this moment to fill the vacuum of international guidance for dealing with this problem.

The NCRP experts had to deal with a unique de facto situation: the unprecedented post-Chernobyl contamination. They have been quite successful, particularly at the earlier stage for which there was some applicable international guidance and for which there was also preparedness in the USSR. But, in the longer run, there appeared to be problems which no national or international competent body had really anticipated well enough to prepare a policy for. The Soviet authorities had to face (and they are still facing) the problem in reality and as a result they have gained a great deal of experience that they are willing to share. The ultimate purpose of the informal meeting organized by the IAEA Secretariat was to foster information exchange among specialists in order to make full benefit of such unique experience.

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(1) Further information can be found in the report "Ecological Patterns and Biomedical Consequences of the Accident at the Chernobyl Nuclear Power Station" by L.A. Il'in, M.I. Balonov, L.A. Buldakov, V.N. Bur'yak, K.I. Gordeev, S.I. Demet'ev, I.G. Zhakov, G.A. Zubovsky, A.I. Kondrusev, Y.O. Konstantinov, I.I. Linge, I.A. Likhtarev, A.M. Lyaginskaya, V.A. Matyuhin, O.A. Pavlosvsky, A.I. Potapov, A.E. Prysyazhnyuk, P.V. Ramsaev, A.E. Romanenko, M.N. Savkin, N.T. Starkova, N.D. Tron'ko, A.F. Tsyb; this report was submitted to the General Assembly of the Academy of Medical Sciences of the USSR on 21-23 March 1989 and reproduced by the World Health Organization under the code PEP/89.20 (with limited distribution).

Additionally, there were two main impetuses for the meeting: the first being a sincere wish from the NCRP to share their first-hand and extremely important experience; and the second was the NCRP's wish to hear the experts' views on its approach, bearing in mind that as the Chernobyl accident developed the NCRP found itself faced with many problems which had previously never been contemplated.

The meeting intended to discuss only the purely scientific aspects of the matter, but it should be emphasized that the political, economic and, particularly, the socio-psychological aspects of the Chernobyl accident have played such a significant part in the NCRP's work that it was impossible to exclude them from the discussion.

2. THE NCRP INTERVENTION CRITERIA (as presented at the meeting)

2.1 The Early Stage

Immediately after the Chernobyl accident the NCRP had to face a radiological situation without precedent in the history of radiation protection. In dealing with it, the NCRP's main objectives were to avoid public exposures which might cause acute radiation injury and to keep as low as reasonably achievable the possible late detrimental effects on those present in contaminated areas and their progeny. In fact, in the first hours following the accident the NCRP's first and main problem was that of protecting the staff and general public from the possible non-stochastic effects of irradiation.

Long before the Chernobyl accident the Soviet Union had, like other countries, prepared decision-aiding criteria for use in the event of an accident involving a nuclear reactor: the "Criteria for Decision-Making on Measures to Protect the Population in the Event of a Reactor Accident", which were established by the USSR Ministry of Health in 1983 (2). The criteria specify countermeasures to be taken at the so-called first, early stage of an accident. They provided for the implementation of a series of measures aimed at protecting the public. A dose range of 250-750 mSv for a short period of time - literally a matter of a few days following an accident - was recommended for decisions on extreme radiation protection measures, such as the evacuation of the general public. The level at which evacuation became compulsory was a forecast total radiation dose of 750 mSv and above.

The early stage is assumed to last from the beginning of the accident (initial release and plume formation) until the occurrence of ground

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(2) The basis of this criteria had already been discussed internationally at the IAEA Symposium on Handling of Radiation Accidents which was held in Vienna from 19 to 23 May, 1969 (see: Dibobes, I.K.; Il'in, L.A.; Kozlov, V.M.; Moiseev, A.A.; Konstantinov, Yh.O.; Tarasov, S.I.; and Shamov, V.P.; "The Adoption of Urgent Measures to Protect the Population in the Event of an Accidental Release of Radioactivity into the Environment"; in the Proceedings of the Symposium; IAEA-SM-119/48); IAEA, Vienna, 1969.

deposition of radioactive material from the plume. However, the Chernobyl accident overturned all earlier ideas concerning the time factor and the dynamics of accident development: in the space of few days the exposed reactor core and the graphite cladding fire resulted in the release into the environment of an unprecedent amount of radioactive materials. At Chernobyl the length of the first stage was about 10 days.

Besides preventing acute somatic effects, a secondary objective in the early stage was to reduce public exposures as much as possible by applying prompt and sometimes simple measures such as sheltering, respiratory protection, administration of stable iodine and evacuation. (At this early stage, the problem of limiting the late stochastic effects, including radiation-induced cancers and hereditary defects, was of lesser importance). The compulsory action levels corresponded to doses which could cause either acute radiation sickness or functional disturbance of specific organs, primarily of the thyroid. The criteria used for evacuation at the early stage of the accident are shown in Table 1 in comparison with criteria recommended by international organizations and adopted in some countries.

Table 1

Dose criteria for the evacuation of the population at the early stage of an accident
(mGy)

Country or international agency	Projected dose for first week: Whole body	Projected dose for first week: Separate organs	Year adopted
ICRP	50-500	500-5000	1984
IAEA	50-500	500-5000	1985
WHO	50-500	500-5000	1985
CEC	100-500	300-1500 a/	1982
United Kingdom	100-500	300-1500 a/	1981
Netherlands	50-500	250-1500 b/	
Federal Republic of Germany	100-500	300-1500	
USSR	250-750	300-2500 b/	1983

a/ Skin value 1000-5000
b/ Thyroid only

2.2 The Intermediate Stage

The main radiation protection requirement during the second, intermediate stage of the accident was to keep the stochastic effects as low as reasonbly achievable. This was effected by the introduction of what were termed "temporary annual dose limits" (TADLs) for public exposures. This intermediate stage was initially assumed to last no longer than a year, but in practice has been extended until 1989.

The TADLs were applied to the whole Soviet territory contaminated by the accident. Their enforcement was assisted by protective measures, such as: withholding and bans on foodstuffs and drinking water contaminated in excess of temporary permissible levels derived from the TADLs; decontamination of buildings, roads, household articles, transport facilities and other environmental objects; and a number of agrotechnical measures, such as switching of the dairy cattle to stored fodder and deep ploughing of agricultural lands. It should be noted that unless the above measures could ensure compliance with the TADL in any particular population centre, the population was relocated to areas where the constraints could be observed.

The IAEA and the International Commission on Radiological Protection (ICRP) recommend that decisions on action levels for introducing countermeasures at the intermediate stage should be based on the principle of optimization of protection. This principle may be implemented by using cost-benefit analysis or any other appropriate decision-aiding techniques. However, at least two problems made the use of quantitative optimization techniques difficult in the aftermath of the Chernobyl accident:

(a) The use of quantitative optimization techniques is facilitated by dealing with objective radiation detriments alone. However, as experience from the Three Mile Island accident had already shown, psychological factors, such as radiophobia and stress, played a governing role in the post-accident decision-making processes.

(b) The inaccuracies in factors in the implementation of optimization in practice, such as the value assigned to the unit collective dose, may lead to undesirable decisions. In the literature this value has been reported to range from US$ 1,000 to 100,000 per manSv approximately. In the USSR such a monetary value had not been officially established and had never been used in practice.

Thus, taking into account the scope and character of the Chernobyl accident and the uncertainties in the radiological conditions the NCRP decided to follow ad hoc assessments of experts for setting TADL values.

The following TADL were established for the population within the accident zone: 100 mSv in the first year after the accident, 30 mSv in the year 1987 and 25 mSv per year for 1988-1989. The observance of these dose constraints, which were approved by the USSR Ministry of Health, is verified by assessing the average dose to the critical groups in every population centre of the accident zone.

The scale of the Chernobyl accident was such that a number of Soviet districts, with a total population of some 273.000 people, had to be included within the so-called areas of strict control (ASC). In these territories (a total of 789 population centres) major restrictions had to be introduced in order to comply with the TADL of 100 mSv in 1986-87, after which the NCRP recommended the new TADLs for the following years up to 1 January 1990.

Table 2 presents the TADL for relocation adopted by the NCRP for the first year on the basis of experts' ad hoc evaluation, in comparison with other national and international criteria.

Table 2

Dose criteria to decide upon the relocation at the intermediate stage
(mSv/a)

Country or international agency	Projected dose for the first year	Year adopted
ICRP	50-500	1984
IAEA	50-500	1985
WHO	50-500	1985
Federal Republic of Germany	50-250	
USSR	100	

As indicated, in the second year the NCRP introduced a TADL of 30 mSv for people living not in these areas only, but throughout the contaminated territory. The TADL was reduced to 25 mSv in each of the following two years. Thus, over the entire intermediate stage period, the conclusion of which can be tentatively estimated as 1990, the cumulative permitted exposure of the public is expected to be around 170 mSv.

As the NCRP had to take extensive measures in order to remain below the established levels, the result has been that the normal pattern of human life in the affected areas has been disturbed, among other reasons, because the consumption of locally produced food products had to be banned. The inhabitants continue to receive food products imported into the area, principally milk, since contaminated milk is a main path for caesium intake. The consumption of milk on private farms was also forbidden, which means in effect that normal life has been considerably disrupted.

The large number of strict sanitary measures caused great changes of practices in the social and economic structure. One of the primary measures for controlling internal contamination was the adoption of derived intervention levels (DILs) for drinking water and food. During the first three months after the accident, iodine radioisotopes present in drinking water and food were the most important internal dose contributors. Table 3 presents DILs for ^{131}I adopted in the USSR and other countries and those recommended by international organizations.

Table 3

Summary of derived intervention levels for iodine-131
(Bq/L or Bq/kg)

Country	Pathway: Drinking water	Milk/ dairy products	Vegetables	Meat	Other	Date adopted
Austria		370	185			2 May 1986
Norway		1000	1000	1000		
Finland	2000	2000				2 May 1986
Sweden		2000	300; 50000	300		2 May 1986
Italy		560	560	560		1971
Greece		125	90			26 May 1986 (CEC)
Netherlands		500	1000			2 May 1986
Luxembourg		500	250			
Germany Fed.Rep.		500	250			
United Kingdom	11000	2000	110000		160000	March 1986 (NRPB-DL10)
Belgium		500	1000			2 May 1986
Japan	110	220	7400			
United States of America	1.5	560			1850	1982 (forage)
Canada	10	10;40	70	70	70	May 1986 (all but water)
Spain		125	90		90	26 May 86 (CEC)
Portugal		125	90		90	26 May 86 (CEC)
USSR	3700 a/	3700 - 370000 a/	370000 a/			6 May 1986
			370-3700	370		16 May 1986

a/ Permissible level of iodine-131 ten times less in food supplied to children's homes.

Later, caesium radioisotopes became the important radiation source. Table 4 shows the established DILs for contamination with caesium-134 plus caesium-137 radiocaesium in drinking water and food.

Table 4

Summary of derived intervention levels for total caesium (caesium-137 plus ceasium-134)
(Bq/L or Bq/kg)

Country	Pathway					Date
	Drinking water	Milk/ dairy products	Vegetables	Meat	Other adopted	
Austria		185;300	110;175	185;300		
Norway		370	600	600;6000	370	20 June 86
Finland		1000		1000	1000	22 May 1986
Sweden		300	300;10000	300	300	15 May 1986
Switzerland		370	600	600	600	8 Sep 1986
Italy		250;370	250;600	250;600		31 May 1986 CEC 1971
Germany, Fed.Rep.		370	600	600		31 May 1986 CEC
Greece		370	600	600		31 May 1986 CEC
Ireland		370	600	600		31 May 1986 CEC
Luxembourg		370	600	600		31 May 1986 CEC
Netherlands		370	600	600		31 May 1986 CEC
France		370	600	600		31 May 1986 CEC
Denmark		370	600	600		31 May 1986 CEC
United Kingdom	51000	3600;370	190000;600	1000; 600	280000	March 1986 DERL 31 May 1986 CEC
Belgium		370	600	600		31 May 1986 CEC
Turkey		370	600	600		31 May 1986
United States of America	90	8900				(milk) 1982
Canada	50	50;100	300	300	300	May 1986 (except water)
Spain		370	600	600		31 May 1986 CEC
Portugal		370	600	600		31 May 1986 CEC
Australia		100	100	100	100	May 1986
USSR	18.5	370	740	1850- 2960	370 (diet of children)	6 Oct 1986

The wide range of DILs in Tables 3 and 4 may be the result of differences in the local situation, including national differences in administrative and public health systems. Thus, in spite of similarity in the common principles forming the basis for remedial measures taken in various countries, DILs differed even in countries with similar contamination levels and social and economic structures. These differences caused concern and anxiety among the public, perplexity among experts and difficulties on the official level, including loss of public credibility.

The Nuclear Energy Agency of OECD, in its report on The Radiological Impact of the Chernobyl Accident in OECD Countries (OECD, Paris, 1987), singled out the following reasons for countries' different responses to the Chernobyl contamination:

"- the large emphasis given to non-radiological, non-objective criteria in the deicision-making process;
- differing levels of uncertainty on impacts;
- the use of different methodologies in assessing the potential impact; and
- the use of different assumptions and values of parameters related to environmental transfer modelling, dosimetry modelling and characteristics of the affected population groups."

2.3 The Long-Term Stage

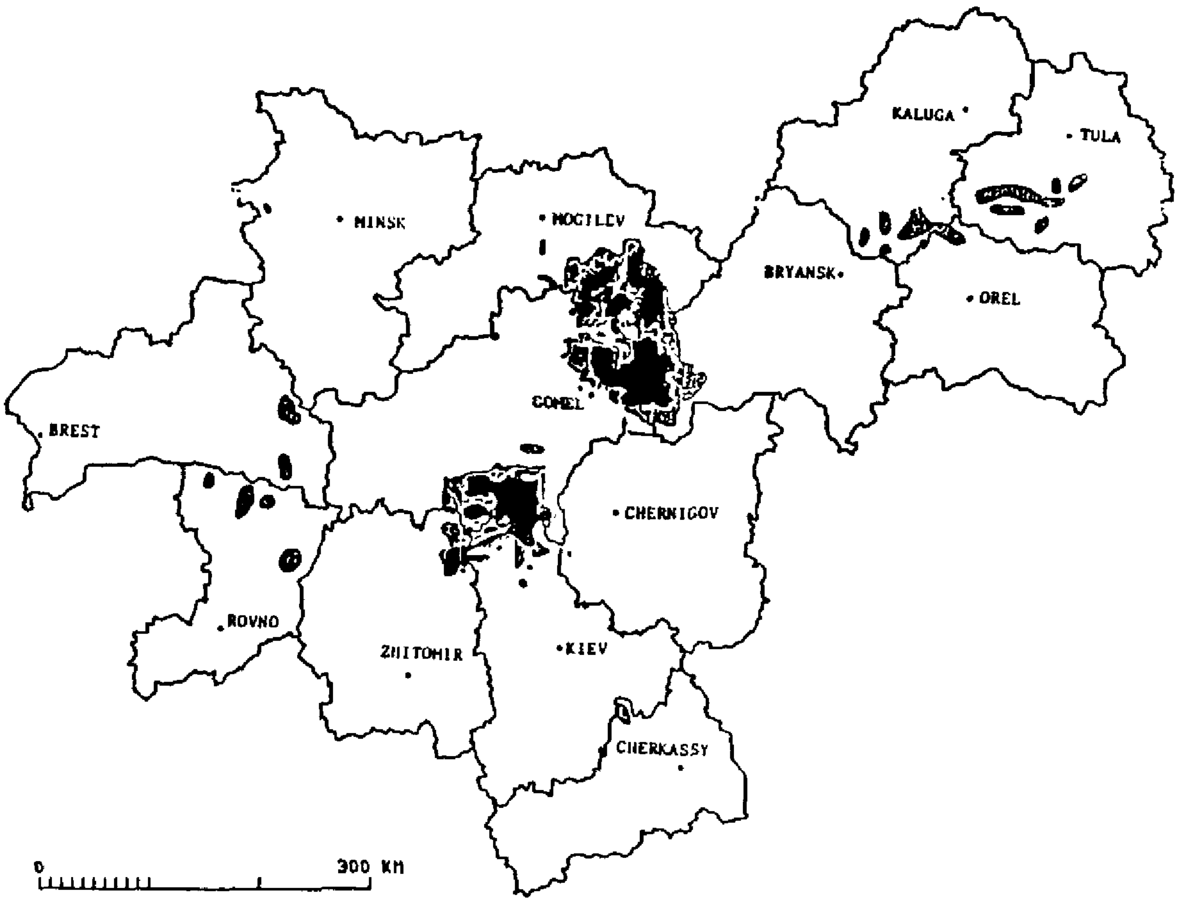
Before the Chernobyl accident there had been no accident in the world that had resulted in heavy, long-term contamination of rural areas populated with hundreds of thousands of people. Not surprisingly, there was no available international guidance on radiation protection criteria for dealing with such a situation. The only available guidance was limited to criteria for the protection of the population in the initial and, eventually, intermediate phases of an accident, including time restrictions for outdoor residence, provision of iodine prophylaxis and evacuation. Precedents for solutions were lacking for dealing with the protracted lifetime exposures due to the contamination of large areas with long lived radionuclides. Thus, the competent bodies of the USSR, particularly the NCRP, found themselves faced with a lack of relevant international guidance and the immensely critical responsibility of deciding the fate of thousands of people living in the affected regions.

The NCRP's approach was to introduce a radically new standard which was called a "lifetime dose limit" (LDL). Provided the LDLs were not exceeded, all restrictive measures, including the ban on the consumption of certain products and on their substitution for imported products, could be removed. In parallel extensive measures would be taken to decontaminate these areas and improve radiological conditions in the population centres.

Figure 1 shows a map, which was produced jointly by the USSR's Ministry of Public Health and the State Committees on Meteorology and Agroindustrial Complex, which shows the so-called "caesium spots" in the contaminated areas. The total area of ^{137}Cs contamination amounts to 10.000 km^2 for radioactive contamination in excess of 5.55 10^5 Bq/m^2 (15 Ci/km^2); the areas with a contamination higher than 1.85 10^5 Bq/m^2 (5 Ci/km^2) total 21.000 km^2. Furthermore, in the north of Rovenskaya province and the south of Brestskaya province, and in zones of Kaluga and

Tula, radioactive spots of a lower density, from 0.74 to 1.85 105 Bq/m2 (2 to 5 Ci per km2), were detected, in soils characterized by an extremely low content of humus substances, with the result that the rates of caesium migration through the food chain are fairly high.

Figure 1



^{137}Cs contamination on the territory of the RSFSR, Ukrainian SSR and Byelorussian SSR:

- in excess of 5 Ci/km^2

- in excess of 15 Ci/km^2

Breakdown: RSFSR - 2000 km^2

Byelorussian SSR - 7000 km^2

Ukrainian SSR - 1000 km^2

Table 5 gives specific data relating to the Bryanskaya, Kievskaya, Zhitomirskaya, Mogilevskaya and Gomel'skaya provinces, with a total of 26 districts, including the number of population centres in each district and the total number of people living in areas of strict control (ASC).

Table 5

The population size and the number of settlements in the areas of strict control (ASC)

Region	District (# of ASC Settlements)	Total Population 10^3	ASC Population 10^3	Percentage of Total Population in ASCs	# of settlements
Bryansk	Gordeyevsky (55) Klimovsky (1) Klintsovsky (41) Krasnogorsky (46) Novozybkovsky (131)	153.6	111.8	72.7	274
Kiev	Polessky	35.8	20.8	58.0	28
Zhitomir	Luginsky (3) Narodichesky (37) Obruchsky (5)	107.8	31.2	28.9	45
Mogilyov	Bykhovsky (1) Klimovischsky (17) Kostyukovichsky (46) Krasnopolsky (76) Slavgorodsky (28) Cherikovsky (25)	135.4	23.3	17.2	193
Gomel	Braginsky (7) Budakoshelevsky (21) Vetkovsky (69) Dobrushsky (22) Yelsky (2) Lelchitsky (1) Loyevsky (1) Kormyansky (27) Narovlyansky (22) Khoyniksky (26) Chechersky (48)	339.5	85.7	25.2	246
Total	26 Districts	772.1	272.8	35.3	786

Table 6 presents data prepared by NCRP and based on information from measurements of external irradiation doses, in vivo measurements, and data relating to caesium concentrations in milk and throughout the entire chain. It includes the distribution of individual doses received by the public from 26 April 1986 to 1 January 1990 inclusive (in the case of the year 1990, forecast data are given). It is estimated that, whereas the 'permitted' dose (sum of the relevant TADL) was in the order of 170 mSv, the actual average exposure of the public in these areas amounted to 60 mSv. It could therefore be concluded that the whole complex of measures that were put into effect "saved" approximately 65% of the permissible dose laid down by the NCRP. There were, however, a total of six population centres, with a combined population of some 800 inhabitants, in which these dose levels were exceeded. The NCRP found that the people concerned were on the whole elderly foresters who neglected the NCRP's rules and requirements and ignored all recommended protective measures, and for example, continued to drink the milk from their cows.

Table 6

Exposure level distribution for the population of settlements under strict control for the period from 26 April 1986 to 1 January 1990

Dose Range cSv	No.of Settlements	Population 103	Cumulative percentage of persons with doses below top of range	Collective dose by 1990 103 man.Sv
1 - 2	49	16.4	6.0	0.24
2 - 3	91	13.5	11.0	0.35
3 - 4	188	105.7	50.0	3.88
4 - 5	103	33.7	62.0	1.56
5 - 6	101	31.0	73.4	1.67
6 - 7	89	24.9	82.5	1.62
7 - 8	39	6.8	85.0	0.51
8 - 10	60	29.0	95.6	2.49
10 - 12.5	30	6.0	97.9	0.67
12.5-15	17	2.4	98.8	0.32
15 - 17.3	13	2.6	99.7	0.41
> 17.3	6	0.8	100.0	0.18
Total	786	272.8	100.0	13.90

On the basis of the data thus far presented and also of corresponding theoretical data, the following tables will present the prognostic assessments of the lifetime radiation doses in the population centres, which were carried out on the basis of the withdrawal of all restrictions from 1 January 1990. Table 7 shows that for 216.000 members of the public living in these areas, the radiation dose will not exceed a lifetime value of 0.35 Sv. However, the public living in certain population centres will, in the scenario in which all restrictions are removed, receive radiation doses in the range 0.35 to 0.50 Sv, while the public in the third group of population centres - some 18.000 individuals in all - could, according to the prognosis, receive radiation doses in excess of 0.5 Sv over 70 years.

Table 7

The distribution of the population of areas under strict control according to projected lifetime doses (if all restrictions on consumption of foodstuffs produced by individual farms are lifted from 1 January 1990)

Region	Projected dose: Below 35 rem		35-50 rem		Above 50 rem	
	Population 103	No.of settlements	Population 103	No.of settlements	Population 103	No.of settlements
Bryansk	90.22	170	14.32	70	7.34	34
Kiev	8.05	22	11.90	2	0.80	4
Zhitomir	27.37	30	1.46	5	2.40	10
Mogilyov	14.82	132	5.09	31	3.33	30
Gomel	76.04	190	5.66	31	4.03	25
Total	216.50	544	38.43	139	17.90	103

This is how the NCRP arrived at the concept of the Lifetime Dose Limit (LDL), the level of which was recommended to be 350 mSv over 70 years of uninterrupted residence in these areas. The NCRP recommendation refers to the accumulated internal and external dose during 70 years of life and includes doses to which the population has been exposed since 26 April, 1986 and excludes exposure to natural background radiation and medical exposures. The observation of the LDL would be regulated by the mean individual dose equivalent to the critical group of each populated area.

In the Soviet Union the permissible radiation dose for the public living in the vicinity of nuclear power plants and other nuclear installations is 5 mSv/a. This dose limit could serve as a reference for putting the LDL in proper perspective. In practice, by introducing an LDL of 350 mSv, what the NCRP actually ends up with after 70 years is the equivalent of the pre-accident standard of some 5 mSv/a for members of the public living in the vicinity of nuclear power installations, on the understanding that the annual dose during the initial stage (i.e. in the first years following the accident) has been up to around 200 times higher, and that it will subsequently level off. During the first years after introducing the LDL, the actual annual dose rate may be 3-4 times higher than the annual dose limits.

Another reference point is the internationally recommended limits for other de facto situations. According to ICRP Publication 39, the action levels for existing buildings with radon contamination reaches 20 mSv/a, while for the purposes of planning new buildings this publication recommends a figure of up to 10 mSv/a. Such figures pertain in many countries and do not cause any distress to the public .

Thus, an LDL of 350 mSv was suggested as the criterion for the maintenance or cancellation of countermeasures in certain populated areas and also for further official decisions on relocation from those sites where it could not be ensured that the standard would not be exceeded.

Since, as mentioned before, several areas will exceed the 350 mSv criterion, the NCRP recommended the Soviet Government to take measures to ensure that if this concept was put into practice, very meticulously planned operations to resettle the population from some of the population centres in these areas would be undertaken, since any decontamination or prohibitive measures there would in practice fail to have the desired effect.

It must be emphasized that the NCRP abides by the principle of keeping doses as low as reasonably achievable, taking into account social and economic factors. The principle will be particularly applied to restrain the forecasted radiation exposure of the critical population group of children. It should also be noted that the levels of caesium incorporation in children are assessed according to a 90 % quantile of the actual concentration of caesium in milk in these areas, which provides certain safety margins in the assessments. Moreover, the metabolism constants for caesium in a child's organism are calculated on the basis of the parameters used for adults and the calculations are based on an uninterrupted period of residence of 70 years in these areas.

The recommended LDL is to be introduced as of 1 January 1990 and is expected to give rise to a whole series of problems. A main concern refers to the question of the fundamental validity of the criteria. The NCRP came to the conclusion that the introduction of the LDL will not result in negative consequences for the state of health of the population. In fact, the NCRP prognoses indicate that the levels of presumed additional cancer, genetic effects and congenital development abnormalities will be from 0.5 to 2.0% above the corresponding spontaneous levels.

The following tables present specific information relating to predicted effects taking three nosological forms: malignant neoplasms, teratogenic effects and genetic effects.

Table 8 shows the levels of anticipated effects in the population of the constantly controlled areas in terms of leukaemia, other forms of cancer arising from in utero exposure, and leukaemia and other forms of malignant neoplasm, excluding tumours of the thyroid gland, if the LDL of 350 mSv were to be introduced. The table also shows the extent to which these figures exceed the spontaneous incidence levels, i.e. 1.5% in the case of leukaemia and 0.5% for all other forms of cancer.

Table 9 has the same format as Table 8, and relates to the delayed effects on the population - some 15 million in all - living in the provinces referred to before. The corresponding figures for leukaemia and cancers in excess of the spontaneous level are 0.12% and 0.04%.

Table 8

Estimated potential late effects for the population of areas under continued control in the case of setting a lifetime dose limit of 35 cSv

Soviet Republic	Region	Population, 10^3	Collective dose: 10^4 man Sv	Excess lifetime mortality, (expected cases): In the population exposed 'in utero'		Excess lifetime mortality, (expected cases): In the exposed population		Total (except thyroid)	Spontaneous lifetime mortality (expected cases)		Excess over spontaneous level, (%)	
				Leukaemia	Other cancers	Leukaemia	Other cancers		Leukaemia	All cancers	Leukaemia	All cancers
Ukraine	Zhitomir	31.2	0.77	1	1	2	26	29	127	4428	2.1	0.7
	Kiev	20.8	0.42	0	0	1	14	16	67	2954	2.2	0.5
	Total	52.0	1.19	1	1	3	40	45	194	7383	2.2	0.6
Byelorussia	Gomel	85.7	1.76	1	1	5	59	66	372	12172	1.7	0.5
	Mogilyov	23.3	0.48	0	0	1	16	18	72	3312	2.4	0.5
	Total	109.0	2.24	2	2	6	75	84	444	15484	1.8	0.5
RSFSR	Bryansk	111.8	1.97	1	1	6	66	74	603	15879	1.2	0.5
Total		272.8	5.39	4	4	15	180	203	1240	38746	1.5	0.5

Table 9

Estimated potential late effects for the population of the regions of the Ukraine, Byelorussia and RSFSR most heavily contaminated due to the Chernobyl accident

Soviet Republic	Region	Population, 10^3	Collective dose, 10^4 man Sv	Excess lifetime mortality (expected cases): In the population exposed 'in utero': Leukaemia	Excess lifetime mortality (expected cases): In the population exposed 'in utero': Other cancers	Excess lifetime mortality (expected cases): In the exposed population: Leukaemia	Excess lifetime mortality (expected cases): In the exposed population: Other cancers	Excess lifetime mortality (expected cases): Total (except thyroid)	Spontaneous lifetime mortality (expected cases: 10^3): Leukaemia	Spontaneous lifetime mortality (expected cases: 10^3): All cancers	Excess over spontaneous level, (%): Leukaemia	Excess over spontaneous level, (%): All cancers
Ukraine	Zhitomir	1547	2.6	2	2	7	86	96	6.3	220	0.14	0.04
	Kiev	4446	4.7	3	3	13	157	177	14.3	631	0.11	0.03
	Chernigov	1428	0.9	1	1	3	30	34	4.6	203	0.07	0.02
	Total	7421	8.2	6	6	23	273	307	25.2	1054	0.11	0.03
Byelorussia	Gomel	1678	6.7	5	5	19	224	253	7.3	238	0.33	0.11
	Mogilyov	1282	1.8	1	1	5	60	68	5.6	182	0.11	0.04
	Total	2960	8.5	6	6	24	284	321	12.8	420	0.24	0.08
RSFSR	Bryansk	1472	5.0	4	4	14	167	188	7.9	209	0.22	0.09
	Tula	1865	1.3	1	1	4	43	49	10.1	265	0.04	0.02
	Oryol	864	0.2	0	0	1	7	7	4.7	123	0.01	0.01
	Kaluga	1035	0.6	0	0	2	20	23	5.6	147	0.04	0.02
	Total	5236	7.1	5	5	20	237	267	28.2	744	0.09	0.04
Total		15617	23.8	17	17	67	794	894	66.3	2218	0.13	0.04

Table 10 relates to the possible delayed effects in the strict control areas (i.e. the same areas as in Table 8, but with the removal of all restrictions, including those on the level of irradiation). Whereas in Table 4 the rises above the spontaneous level of incidence are 1.5% and 0.5%, in Table 10 they are 2.1% and 0.7% respectively.

Table 11 describes the delayed effects for the central areas of the European part of the Soviet Union, where there are some 75 million inhabitants. It shows the anticipated occurrences of malignant neoplasms and leukaemia over and above the corresponding spontaneous levels.

Table 12 shows similar calculated data, this time relating to congenital development abnormalities for the population centres under strict control. It takes account of both the scenarios mentioned before, i.e. for removal and maintenance of the restrictions, and presents these data in relation to the number of children born in the first year, the first three years, the thirty years and the seventy years following the accident.

Table 13 contains data on the genetic effects in the first two generations of the population. The calculations take into account various types of hereditary effects, including lethal effects.

Table 10

Potential late effects of total exposure for the population of areas under continued control in the case of removing a lifetime dose limit of 35 cSv

Soviet Republic	Region	Population, 10^3	Collective dose: 10^4 man Sv	Excess lifetime mortality, man: Exposed in utero: Leukaemia	Excess lifetime mortality, man: Exposed in utero: Other cancers	Excess lifetime mortality, man: Exposed population: Leukaemia	Excess lifetime mortality, man: Exposed population: Other cancers	Excess lifetime mortality, man: Total except thyroid	Spontaneous lifetime mortality, (expected cases): Leukaemia	Spontaneous lifetime mortality, (expected cases): All cancers	Excess over spontaneous level, (%): Leukaemia	Excess over spontaneous level, (%): All cancers
Ukraine	Zhitomir	31.2	0.93	1	1	3	31	35	127	4428	2.6	0.8
	Kiev	20.8	0.72	1	1	2	24	27	67	2954	3.8	0.9
	Total	52.0	1.65	1	1	5	55	62	194	7383	3.0	0.8
Byelorussia	Gomel	85.7	2.11	2	2	6	70	80	372	12172	2.0	0.7
	Mogilyov	23.3	0.79	1	1	2	26	30	72	3312	3.9	0.9
	Total	109.0	2.90	2	2	8	97	109	444	15484	2.3	0.7
RSFSR	Bryansk	111.8	2.71	2	2	8	91	102	603	15879	1.6	0.6
Total		272.8	7.26	5	5	21	243	274	1240	38746	2.1	0.7

Table 11

Potential late effects of total exposure for the population of the central areas of the European part of the USSR following the Chernobyl accident

Soviet Republic	Region	Population, 10^6	Collective dose: 10^4 man Sv	Excess lifetime mortality, man: Exposed in utero: Leukaemia	Exposed in utero: Other cancers	Exposed population: Leukaemia	Exposed population: Other cancers	Total except thyroid	Spontaneous lifetime mortality, (expected cases: 10^3): Leukaemia	Spontaneous: All cancers	Excess over spontaneous level, (%): Leukaemia	Excess over spontaneous: All cancers
Ukraine	Central	13.60	9.2	6	6	26	307	345	44	1931	0.073	0.018
	Western	8.32	0.8	1	1	2	25	28	27	1182	0.010	0.002
	Eastern	14.47	1.5	1	1	4	49	55	47	2055	0.011	0.003
	Southern	14.60	0.9	1	1	2	28	32	47	2073	0.006	0.002
	Total	50.98	12.3	8	8	34	409	460	164	7241	0.026	0.006
Byelorussia	South-Eastern	2.96	8.5	6	6	24	284	321	13	420	0.236	0.076
	North-Western	7.05	1.9	1	1	5	63	71	31	1001	0.022	0.007
	Total	10.01	10.4	8	8	29	347	392	43	1422	0.085	0.027
RSFSR	Central	9.78	8.0	5	5	22	267	300	53	1388	0.052	0.022
Moldavia		4.14	0.4	0	0	1	14	16	13	589	0.012	0.003
Total		74.91	31.1	22	22	87	1037	1168	274	10640	0.040	0.011

Table 12

Estimated potential congenital anomalies (CA) and mental retardation (MR) following in utero exposure

Exposure conditions	Pathology	Children born in the year of accident (4500 children)			Children born over 3 years after the accident (13500 children)			Children born over 30 years after the accident (135000 children)			Children born over 70 years after the accident (315000 children)		
		Induced anomalies	Spontaneous anomalies	% of spontaneous	Induced anomalies	Spontaneous anomalies	% of spontaneous	Induced anomalies	Spontaneous anomalies	% of spontaneous	Induced anomalies	Spontaneous anomalies	% of spontaneous
Lifetime dose unlimited	CA	5.22	270	1.9	12.3	810	1.5	32.5	8100	0.4	35.7	18900	0.19
	MR	0.013	34	0.038	0.031	102	0.030	0.081	1020	0.008	0.089	2380	0.004
Lifetime dose limit of no more than 35 cSv	CA	5.22	270	1.9	12.3	810	1.5	25.6	8100	0.32	27.7	18900	0.15
	MR	0.013	34	0.038	0.031	102	0.030	0.064	1020	0.006	0.069	2380	0.003

Tabel 13

Estimated hereditary effects in the population of settlements under continued control

Exposure Conditions	No. of generations	Total hereditary effects			Severe hereditary effects			Lethal hereditary effects		
		Induced	Spontaneous	% of Spontaneous	Induced	Spontaneous	% of Spontaneous	Induced	Spontaneous	% of Spontaneous
Lifetime dose unlimited	First two	182	18900	0.96	0.36	1575	0.023	0.34	54338	0.00063
	10	728	81000	0.90	1.44	6750	0.021	1.36	232875	0.00058
Lifetime dose limit of no more than 35 cSv	First two	135	18900	0.71	0.27	1575	0.017	0.25	54338	0.00046
	10	540	81000	0.67	1.07	6750	0.061	1.00	232875	0.00043

Table 14 shows specific estimates of the frequency of development abnormalities in the Gomel'skaya and Mogilevskaya provinces using the Vitebskaya province (which suffered no contamination) for the purposes of comparison, and relating everything back to 1985. The data failed to indicate any difference over the years 1985 to 1988, either by comparison or in real terms.

Table 14

Ratio of congenital anomalies to births for 1985-1988 in the Gomel, Mogilyov and Vitebsk regions with reference to the year 1985

Region	1985	1986	1987	1988
Gomel	1.00 ± 0.6	0.87 ± 0.2	1.19 ± 0.2	1.19 ± 0.3
Mogilyov	1.00 ± 0.2	0.93 ± 0.2	1.00 ± 0.3	1.15 ± 0.2
Mean	1.00 ± 0.3	0.89 ± 0.2	1.09 ± 0.2	1.18 ± 0.2
Vitebsk (control)	1.00 ± 0.3	1.21 ± 0.2	1.36 ± 0.2	1.29 ± 0.2

Half width of the confidence interval is given, using a 95% confidence probability.

In summary, therefore, as the NCRP proposal is to introduce the LDL of 350 mSv from 1 January of next year in conjunction with the withdrawal of all restrictions for the population living in these areas, it was of interest for the NCRP to hear the reaction of experts attending the meeting and, eventually, to receive their support in respect both of the NCRP approach and of the value recommended for the LDL.

In this regard it should be noted that in the Soviet Union radiophobia and the commotion being made in the media in the aftermath of the Chernobyl accident are still important factors. The scientists dealing with the radiation protection aspects of the accident are constantly having to defend themselves against attacks on their integrity in the media, and find it very difficult to persuade the public of the scientific validity of the radiation protection standards they recommend. As an extreme example of this problem it was recounted at the meeting that when, against a background of scientific information, a photograph of a calf with only one eye was shown by sensationalistic media, the public, as might be expected, reacted in undue panic and fear.

3. DISCUSSION

(Summary of opinions of experts attending the meeting)

On the terminology:

The NCRP has introduced what it has termed a "lifetime dose limit" for dealing with the particular situation of the long-term contamination caused by the Chernobyl accident. However, it is not a real lifetime dose limit, but rather a limit on the dose committed from decisions on intervention following an unanticipatable, de facto situation: the post-Chernobyl contamination. The decisions to be made include whether to evacuate a contaminated area or not, whether to let people enter an area or not, or whether to ban a contaminated food or not. These various decisions are usually made on the basis of intervention levels resulting from a balance between the negative consequences of the decision and the dose commitment avoided by the decision, rather than on the basis of dose limits.

It is more coincidentally the relation between the recommended intervention level of 350 mSv and the normal dose limit of 5 mSv per year, because there is no expectation of a reduced margin of doses from other sources. In fact, the adoption of the recommended levels will not mean that people will be prevented from incurring other exposures to radiation, which they usually would be permitted to incur within the dose limit.

The term of dose limit is therefore preferred for anticipatable, normal conditions of exposure rather than for this de facto situation. The so called limit is really either an action level or a non-action level, i.e., an intervention level. The key concept should be that people should not be put in a worse situation as a result of an intervention and, if normal limits are used for deciding on intervention after an accident, the intervention might put people in a worse situation.

On the approach of the ICRP:

In particular, the ICRP would not term a limit what is in fact an intervention level, because the ICRP reserves the term "limit" for situations in which there is planning to use a radiation source, or to set up an installation, or to perform an operation. Thus, the ICRP limits are really a part of the system that would constrain the doses in such planned situations. If the control of the source is lost and the only control possible is either to apply a remedial action or not, the ICRP does not use the term limit for the levels set for deciding on action; rather the ICRP would term such levels "intervention levels" or "action levels". But aside from the terminological differences, there are no conceptual differences between the NCRP LDLs and the ICRP intervention and action levels.

In deciding on intervention in such cases of long-term contamination, a common question is whether to let people stay in or enter the area, or whether to evacuate people and not allow them to enter the contaminated area. In the case of the Chernobyl accident, and following the NCRP criteria, if the decision is that they could stay or they could enter, it would mean that the critical group should receive at most a dose of 350 mSv. The dose level would be the total dose that the worst irradiated person would receive due to the decision, which would be somebody living his or her whole life in that place; such persons would constitute the "critical group"; everyone who was already older would receive a lower dose. It seems that the level of 350 mSv, by coincidence, was calculated multiplying a dose limit of 5 mSv per year by 70 years.

But, following ICRP criteria, the annual dose limit for planned situations and the intervention levels for post-accident situations belong to different accounts, since for a normal situation, e.g., for a planned new Chernobyl reactor or even for the other units at Chernobyl operating today, the 5 mSv per year limit would still apply and radiation doses would be delivered (and allowed) independent of whether the 350 mSv dose was incurred or not. So as these quantities relate to different accounts, the intervention level should not really be compared with an annual dose limit (either 5 mSv per annum or any other). Nevertheless, the comparison could be a way of justifying the 350 mSv value by conveying the feeling that the related risk is very small.

The ICRP procedure for deciding the intervention level would be to decide whether the intervention is justified and (if it is justified) to optimize radiation protection by optimizing the intervention level. For post-accident situations, it would imply assessing the advantages and disadvantages of deciding on a specific intervention (e.g., allowing re-entry or not allowing re-entry) and making the decision on the basis that the countermeasure should do more good than harm. Opimization can be performed by intuition, with ad hoc expert advice, or by any available quantitative technique such as cost-benefit analysis.

On the basis of cost-benefit analysis, some decisions have been planned to allow re-entry when the maximum annual dose is around 50 mSv per year and some optimization studies resulted in optimum levels for relocation of people as high as 10 mSv per month. For the case of contamination with caesium which is absorbed into the ground and has a mean half-life of about fifteen years, a level of 50 mSv per year would imply an overall dose commitment (from that decision of allowing re-entry) of 750 mSv in a lifetime. This value is higher than the value recommended by NCRP but it is readily acceptable because it results from optimizing the level of protection.

On the same grounds it would be interesting to evaluate the cost of the evacuation per person and per year. Using this quote, it is almost sure that optimum intervention level would lead to a dose commitment over a whole lifetime that would be in the range indicated. Thus, if it were a saving of efforts caused by the intervention, it could be shown (e.g. on the basis of differential cost-benefit optimization) that it is quite likely that the optimum value of the action level would be much higher than 350 mSv. Although 350 mSv is a prudent action level, a higher level - if optimum - would be perfectly acceptable as well.

There was some concern, though, that NCRP felt that its approach of taking non-objective factors into account in some way is in conflict with the ICRP recommendations on optimization. After all, even such ad hoc approaches represent some kind of optimization, although the factors are not easy to express in cost-benefit terms. The ICRP optimization surely should introduce all of the inconveniences of evacuation and relocation.

On the perspectives given by natural background exposure:

In areas contaminated by Chernobyl there is a similar situation to that in areas with different background radiation. For instance, in China, in the Quantung province there are two populations near Taijuan: around one million people incur a normal level of natural radiation exposure, of around 2 mSv per year, and a similar number of people incur three times this level. There is a significant number of people, with about the same differences between the normal background and with the NCRP derived average level of 5 mSv per year, and this case could be used for providing an appropriate perspective to the NCRP levels.

Moreover, rather than the normal range of natural background radiation for comparison, the range in the Soviet Union could be used. In such a large country there must be very great differences between the natural levels in different places, not only in the remote places where the density of population is very low, but also in the densely populated parts of the Soviet Union.

On the criteria used in other countries:

Apart from the terminology in question, the principles used by the NCRP are very similar to the principles used in other countries to control radon exposures. The first principle is to do anything reasonable to prevent non-stochastic effects. The second, overriding other principles, is to justify the intervention and to optimize protection as far as possible. By "justification" and "optimization" it is meant that the situation should not be made worse for people by application of countermeasures and that the level of intervention should be the best under the prevailing circumstances.

In the case of radon, studies have shown that older people tend not to worry so much about radon and they tend not to take expensive countermeasures against radon. That is perfectly natural and there should not be any intention at all to evict old people from their dwellings even if they incur doses of 100 mSv per year because the disruption would be very bad for them.

A somewhat similar example to radon control relates to the control of the Chernobyl consequences themselves. With respect to food restrictions it has been said that it is possible, without many consequences, to keep doses below 1 mSv per year. (This corresponds to a long-term average, so it would mean 70 mSv in a 70 year lifetime). It has also been said that special consideration should be given to children and to pregnant women. So for those groups doses above 1 mSv per year should certainly be avoided. But there might be other groups for whom the consequences might be quite significant if individuals are forced to stay below these 1 mSv per year. For instance, the whole culture of reindeer breeders in Nordic countries might be threatened if they were to change their lifestyle as dramatically as would be necessary to limit their doses to below 1 mSv per year. It might also be fishermen and other people who would suffer quite severe consequences from changing their lifestyles to keep doses below 1 mSv per year. In these cases there were decisions not to take any further countermeasures as long as these groups stayed below 10 mSv per year, which means 700 mSv in a 70 year long life. The countermeasure which will be taken if it is noticed that critical groups will exceed 10 mSv per year will only be increased follow-up and increased information. But their life will not be disrupted to keep their doses below

10 mSv per year. They should, however, be properly informed to what extent their risk is increased if they incur doses of 10 mSv per year over a long period.

On the universality of intervention levels:

Although the NCRP recommended intervention level seems to be appropriate, it would be difficult to recommend a universal number for deciding intervention. It is going to vary from country to country and it must depend on the extent of the contamination. Its selection comes into part of the consideration of where to spend efforts and wealth. It seems clear that the whole of a country's gross national product should not be expended on cleaning up an area of a major accident. The intervention level has to be a compromise. The sort of number that would be used could be in a range of doses probably in the first year or two (the dose per year and a lifetime dose) which spans the NCRP range. From below to above the NCRP range would be the sort of numbers that could be used.

On people's attitudes:

Different people are going to have different attitudes towards intervention. Old people usually don't want to evacuate their homes. Conversely some younger people will say, "we'll not go there, ever - and we'll keep away". People's attitudes vary and to face them is a difficult problem. The NCRP figure is not very different from the lifetime dose due to natural background radiation and, therefore, it might be expected that people would not be concerned about doubling their exposure to natural background radiation since this does not seem terribly alarming.

The selection of an average value of 5 mSv per year over 70 years for everyone may have advantages for the co-operation of the media, of the people and of the authorities. But it may be easier to follow the ICRP approach which is more flexible and permits the level to be adapted in relation to the local situation (and may be convenient to have differences between certain local situations). The disadvantages are the differences between the dose incurred by various people which are difficult to understand. If these differences are in the ranges of the natural background (and this is the case), it would be more understandable to the media or the authorities. But, in fact, with the system of simple optimization (not a very sophisticated optimization) it is possible to have more flexibility and to adapt the countermeasure to the situation in the local area. There is the possibility for different intervention levels depending on the de facto situation in the different areas.

It is assumed that an individual incurring a dose of 350 mSv over a lifetime will have a chance of around 1% of incurring cancer, which is a very small increase over the natural chance. Thus, the 350 mSv level may seem a sensible number for people to end up with, but on the basis of comparing it to doses due to natural background radiation and the possibility of incurring cancer rather than to annual dose limits.

On the media reaction:

On a news programme by a television station in a western country, a film from the Soviet Union was presented which discussed the problem of intervention levels. The film was done in the region of Chernobyl. It showed two groups of Soviet citizens. One group complained about not being permitted to go back and the other group complained about having to go back. And a question was asked: "How would [that country's] radiation protection authorities react to a similar type of incident?". The answer given made a comparison with the natural background radiation: it explained that in that country there are regions where the background level is six times as high as in other regions. However, no one has ever suggested that such regions should be evacuated. Moreover, in that country, there are native inhabitants who live almost entirely on caribou meat which has been contaminated over the years with caesium. And it has been accepted that a 5 mSv per year extra dose was warranted in return for the better nutrition and the fact that their whole culture and way of life is dependent on hunting these caribou.

On risk perception:

There is a tendency that the safer the country, the more worried people are about risks. People in generally safe countries are extremely worried about various risks and use to perform studies on risk perception. There is one observation which it is important to keep in mind about these studies: when people talk about risk perception they really mean that other people do not rank acceptance of the risks as they do. This is a mistake. For example, if various sources of risk are ranked according to the actual scientifically estimated risk, it would be logically concluded that the acceptance of risk would follow the same ranking. But there is no reason for that: people continue to smoke yet they may object very much to some other risk from a source that they do not like - even if that risk is very small in comparison with the risks of smoking. So, the acceptance of risk depends on many other things than the level of risk. And that is not unreasonable. There is a reason for it because people are very much influenced by whether they enjoy taking certain risks or not.

4. CONCLUSION

The accident at Chernobyl resulted in the release into the environment of an unprecendently large amount of radioactive radionuclides and in the contamination of areas whose size and the number of people affected were unprecedented. This situation presented new problems that necessitated new approaches to radiation protection, particularly in the formulation of principles for setting-up criteria for dealing with long-term contamination in post-accident situations.

The informal meeting organized by the IAEA Secretariat to discuss the NCRP criteria for intervention was very useful for sharing information in this field. The NCRP Chairman informed the participants on the contamination situation and on the remedial actions and action levels, both decided and proposed. The meeting, which dealt with problems arising from long-term contamination by radioactive substances after major radiation accidents in general with particular consideration of the post-Chernobyl situation, provided members of UNSCEAR, radiation protection experts attending meetings at the IAEA and officers from the Agency Secretariat a forum and an opportunity for exchanging opinions on this very important matter.

The intervention criteria used by the NCRP in the early and intermediate stages after the accident were very useful for the organization of radiation protection of the public in the aftermath of the accident in the area affected where countermeasures have to be taken under difficult conditions and in a short period of time. The initial remedial actions and action levels were consistent with international policy. There was little previous international experience, however, of how to deal with the long-term effects of a nuclear accident causing widespread contamination.

There is no universal solution to a de facto situation like the post-Chernobyl long-term contamination; it must differ from country to country and depend upon the seriousness of the situation. Therefore, the dose limitation criteria in such situations would have to be decided by national authorities; it would depend on the local situation and on the severity of the accident. In particular, the setting of the action levels for major countermeasures, such as relocation of people, either in terms of an annual dose or for lifetime dose, should always be within the competence of national authorities. The case of Chernobyl was clearly under the competence of the USSR authorities which - in setting the levels for intervention - had to take into account the medical and biological consequence of the dose averted and economical and social factors influenced by the countermeasures.

On the basis of the above-mentioned considerations, a 'lifetime dose limit' or action level of 350 mSv was set by the Ministry of Public Health of the USSR for the total lifetime dose received due to the accident by individuals in the critical groups of the areas contaminated as a result of the Chernobyl accident. Apart from a terminological question (radiation protection experts prefer to reserve the term 'limit' for dose limitation in anticipatable, planned situations, and to use the term 'level' for the doses which may trigger protective actions in existing situations), the 350 mSv level met with general support by the participants. From the discussion it was clear that for one reason or another, perhaps for many reasons, the number is lower than, or in the range of, the levels that the experts might well have proposed had they been responsible in similar situations.

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