COMMISSION OF THE EUROPEAN COMMUNITIES

LIMITS USED IN THE CONTROL OF RADIOACTIVE EFFLUENTS FROM NUCLEAR INSTALLATIONS

A REVIEW AND ANALYSIS

MARCH 1978

DIRECTORATE-GENERAL EMPLOYMENT AND SOCIAL AFFAIRS

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N O T E S

1) Where the term "dose equivalent" (rem) would be more correct, nonetheless, for brevity, the expression "dose" is used throughout.

2) The term "Dose Limit" (with capital letters as shown) refers to limitation of the exposure of members of the public as recommended by ICRP.

3) The use of the units "rem" and "curie" in lieu of the new units "sievert" and "becquerel" respectively arrises from the fact that the documentation to which this report refers uses the former units.

P R E F A C E

In october 1974, the Commission of the European Communities organized a meeting of representatives of competent authorities and the nuclear power plant operators (UNIPEDE) on the methods used to determine limits for the discharge of effluents from nuclear power plants in Member States. At this meeting, the discussion concentrated mainly on discharge authorization procedures and, to a lesser extent, on actual discharge limits.

In april 1977, the Commission*) organized a further meeting, this time with representatives of the competent authorities and of the Group of Experts appointed under Article 37 of the Euratom Treaty (see Appendix), on the generally applicable limits for effluent control and operational discharge limits applied in Member States to nuclear installations. The aim of the meeting was to create a better mutual understanding in this field with a view ultimately to harmonizing the different approaches used in the various countries to implement the ICRP principle of "as low as reasonably achievable".

Part 1 of this report surveys and compares the generally applicable limits for effluent control in Member States of the European Communities, in the USA, and in some other countries. These limits can be expressed either as dose limits, representing a small fraction of the ICRP Dose Limits, or as activity discharge limits, valid for a particular category of nuclear installations. This part of the report was prepared by the National Radiological Protection Board (U.K.) and was amended slightly as a result of the 1977 meeting.

Part 2 summarizes the information resulting from this meeting, as subsequently revised by the participants, as to how operational limits applying directly to particular plants are derived from the aforesaid general limits and implemented. Finally some conclusions are drawn.

It is hoped that the report will serve as a possible step towards the stated object of ultimate harmonization.

*) DG V, Health and Safety Directorate in collaboration with DG XII, Directorate for Research, Development and Nuclear Policy.

Contents

1. General limits applied to the control of radioactive effluents from nuclear installations

1.1. Introduction

The revised Basic Safety Standards for the health protection of the general public and workers against the dangers of ionizing radiation, issued under the Council Directive of 1 June 1976 (1) which is required to be implemented by all Member States of the European Communities, require that, for controllable sources of exposure of members of the public, the exposure and the number of persons exposed to ionizing radiation must be kept as low as is reasonably practicable and that the doses received must not, in any event, exceed stated dose limits. No attempt is made in the Directive, however, nor indeed in the current recommendations of the International Commission on Radiological Protection (ICRP), which form the basis of the Directive, to allocate any fraction of the dose limits to a particular practice, although the Directive, in line with ICRP recommendations, does lay down a more restrictive limit for the genetic dose, from all sources, to the population* and ICRP stress that no single type of population exposure should take up a disproportionate share of the total. /ICRP in its Publication 9 (2) state that "the way in which this is done will depend upon circumstances which may vary from country to country, and will be determined by national, economic and social considerations"./

In several European countries, and in the USA, generally applicable numerical limits are being used, or will shortly be introduced to control the exposure of individuals and, in some cases, populations, arising from discharges of radioactive materials from nuclear installations. This part of the report surveys and compares the general standards presently applied or proposed for the control of effluents, in the Member States of the European Community and in some other countries.

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* The genetic dose to the population is defined in the Directive as "the dose which, if it were received by each person from conception to the mean age of childbearing, would result in the same genetic burden to the whole population as do the actual doses received by the individuals of the population".

1.2. Radiological protection standards

Recommendations on basic standards for radiological protection are made by ICRP. Their currently recommended system of dose limitation is based on three fundamental principles:

1. JUSTIFICATION of activities which involve human radiation exposure
2. OPTIMIZATION of radiological protection arrangements, ie, maintaining exposures as low as is reasonably achievable, economic and social considerations being taken into account
3. COMPLIANCE with appropriate dose limits

In considering the recommendations of ICRP, national authorities, or perhaps the authorities from a group of countries, as in the case of the European Communities, decide, taking into account political, economic, social and scientific factors, whether the system of dose limitation and the numerical values recommanded by ICRP are appropriate to their individual circumstances.

In the case of exposure of the general public, ICRP in its Publication 9 (2) state that the genetic dose to the population should certainly not exceed 5 rem over a period of 30 years (approx. 170 mrem/a) from all sources other than natural background and medical irradiation. In addition, Dose Limits for individual members of the public are specified as follows:

Whole body, gonads, red bone-marrow;	0.5 rem/a
Skin, bone, adult thyroid;	3 rem/a
Child thyroid (less than 16 years of age);	1.5 rem/a
Hands, forearms, feet, ankles;	7.5 rem/a
Other organs;	1.5 rem/a

It should perhaps be pointed out that the concept attached to these Dose Limits by ICRP permits the limits to be applied to the mean dose to members of an established critical group and not necessarily to the most exposed individual. This implies that some members of the critical group may receive doses exceeding the Limits.

It should be mentioned, however, that in its recent Publication 26 (2), the ICRP recommendations have been changed substantially. For organs for which non-stochastic effects are limiting, a Dose Limit of 5 rem/a* is recommended for members of the public. For stochastic effects, the risks should be equalized for uniform and non-uniform irradiation of the body. Weighting factors have, therefore, been assigned to the various individual organs, relative to the whole body. These weighting factors are to be applied to the doses calculated for each individual organ; the sum of the weighted doses must not exceed the whole body Dose Limit of 0.5 rem/a for members of the public. For the genetic exposure of the population there are no longer any limits proposed.

It will be some time before these new recommendations will be incorporated in the Basic Safety Standards and subsequently appear in the national legislations. The implications of these changes are not, therefore, of any immediate significance to the present report, the more so since discharge limits in general imply significantly lower doses than the limits recommended by ICRP.

1.3. Radiological limitations for effluent control in the countries considered

In addition to the nine Member States of the European Communities, the countries considered in this report are Switzerland, the United States, and collectively those countries, which along with Denmark, form the Nordic group, viz. Finland, Iceland, Norway and Sweden.

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* exceptionally 3 rem/a for the lens of the eye.

The systems of radiological limitation used, or currently proposed, for the control of effluents vary significantly from country to country and are not in most cases directly comparable. Some countries have adopted or will adopt the systems used by other countries with a wider experience of nuclear operations. In the following sub-sections, a brief outline is given of the current or proposed system of radiological limitation applied to effluent releases in each of the countries, or group of countries, considered. Where they could be extracted from the references cited, details are provided concerning the philosophy of the approach used and, in the case of countries applying general numerical limits, the justification for the limits chosen.

For ease of comparison of the systems incorporating generally applicable limits, the numerical values of these limits, and the conditions relating to their application, are presented in Table 1.

1.3.1. Belgium

At the meeting on 15th December, 1975, the "Commission spéciale en matière de radiations ionisantes" (the nuclear safety committee in Belgium) imposed, for the next four nuclear power stations to be built in Belgium, the rules published or adopted by the United States Nuclear Regulatory Commission (USNRC). (See Section 1.3.11 and Table 1.1.) Nevertheless, requirements additional to or deviating from NRC practice can be accepted or imposed by the Belgian authorities.

1.3.2. Denmark*

The recommended "basic principles and standards for the limitation of releases of radioactive substances from nuclear power stations" in the Nordic countries have been stated in

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* also Finland, Iceland, Norway, Sweden

a recent publication (3) issued jointly by the radiation protection institutes of all the countries in the group. The statement represents the present views of the institutes and although there is no obligation for national authorities to incorporate the recommendations into legislation the statement is intended to serve as a basis for more formal rules and regulations which may be drawn up within each country.

The statement recommends that in addition to complying with ICRP requirements on justification and optimisation, the release of radioactive substances from nuclear power stations should be subject to the following requirements:

a) The doses to a critical group, as defined by ICRP, shall not exceed a stipulated fraction of the general Dose Limits for individual members of the public; and

b) The global population average dose in any one year shall be small and remain acceptably small in the future. In order to ensure that this will be so the time integral of the world average dose rate over a period equal to that over which nuclear power is expected to be used shall not exceed a stipulated value, related to the installed nuclear generating capacity.

The recommended "dose" limits (Table 1.1.) apply to the relevant dose commitments over the applicable periods of time rather than to current doses, eg, annual doses. /For example, if the operative annual dose limit is'd'mrem, it is the dose commitment of one year's practice that must not exceed'd' mrem./

1.3.2.1. Doses to critical group

The justification behind requirement (a) above is to make it most unlikely under normal operating conditions that any individual in the neighbourhood of a nuclear power station will receive a total radiation dose from all relevant sources, exceeding the Dose Limit that ICRP has recommended.

Although critical group dose limits as specified (see Table 1.1) will be applied, the statement claims that the controls implied by requirement (b) are likely to be limiting, certainly in the cases of releases to atmosphere.

1.3.2.2. Collective dose to world population

In laying down requirement (b) above, the statement points out that global contamination by long-lived radionuclides cannot be controlled by merely controlling the exposure of critical groups for each contributing source and concludes that an additional limitation of the global per caput dose is needed.

A limit of 10 mrem is recommended for the future annual global per caput dose from all nuclear power operations and the justification is based on the corresponding risk being insignificant to any one individual. It is pointed out that the suggested limit is 10% or less of the annual dose from natural background radiation and is also commonly less than differences in background radiation from place to place, a feature not usually taken into consideration when, for example, choosing a residence. The statement also points out that such a limit is well within ICRP recommendations (2) concerning population exposure.

Making assumptions regarding maximum conceivable requirements for nuclear generated electrical power (10 kWe per caput) and the maximum likely period over which electricity will be generated by nuclear means (500 years), recommended limits (see Table 1.3) are expressed in terms of global collective dose commitment for releases from both power stations alone and from complete fuel cycle operations.

Since the purpose of the limitation of the collective dose is to limit the future average dose at a time when the number of reactors is much larger than now, the statement

adds that "the requirement may be applied with some relaxation and flexibility during the initial period and, in particular, that it would also be permissible to average collective dose commitments and time integrals of collective dose rates over longer periods than one year, eg, over a ten-year period". The statement goes on to say, however, that this flexibility should not be used to justify planning of less restrictive operations purely for economic reasons.

1.3.3. France

Limitations for the control of radioactive discharges from nuclear installations are established either on a case-by-case basis or according to type of installation (7) (8) so as to comply with dose limits laid down (6) for individual members of the public and for the population as a whole. The limits are contrived on the basis of studies made by the operator, required under the Decrees of 6th November, 1974 (4) (relating to atmospheric discharges) and 31st December, 1974 (5) (relating to liquid discharges) for the purposes of authorization. The report must include all factors necessary to allow the competent authorities to carry out an assessment of doses to members of the public arising from the planned discharges.

Other regulations (9) (10), recently promulgated under these Decrees, specify generally applicable maximum discharge values (see Table 1.2) for power stations equiped with light water reactors; discharges authorised on a case-by-case basis for individual power stations, will, therefore, necessarily be less than these general limits.

1.3.4. Federal Republic of Germany

A comprehensive new Radiation Protection Ordinance (11) was promulgated on 13th October, 1976 and came into force on 1st April, 1977.

As well as requiring that radioactive effluent releases from all nuclear installation be maintained "as low as possible", the Ordinance specifies dose limits for individual members of the public, in unrestricted areas, arising from the releases (see Table 1.1).

The limits apply to the most adverse conditions of exposure for normal operations, summing all pathways, including food chains, hypothetical or otherwise, irrespective of whether the potential exposure locations are populated or used for agricultural purposes.

If other plant or installations on the same or other sites can contribute to the radiation exposure at these positions, the competent authorities are required to ensure that the radiological limits specified are not exceeded overall.

In recommendations made by the German Committee on Radiological Protection in 1975 (12), limits for releases of krypton-85 from fuel reprocessing were proposed (see Table 1.3). The purpose of the recommended limits is to reduce skin dose to the local population living in the vicinity of reprocessing facilities, and the doses to the world population arising from the releases. [To ensure that limits are not exceeded, it is recommended, for design purposes, that separation techniques to be employed should reduce releases of krypton-85 by a factor of at least 100.]

1.3.5. Ireland

A statement obtained recently from the Nuclear Energy Board (13) indicated that radiological limitation applied to effluent control from any nuclear power plant which may be constructed in Ireland will be based on generally applicable radiological limits (see Table 1.1).

An earlier statement (14) made at a CEC meeting in 1974 indicates that in fixing discharge limits, the ICRP principle of keeping releases "as low as reasonably achievable" will be applied. It was also stated that the limits are likely to be related to the exposure of individual members of the public rather than populations and that limitations would probably apply to releases from a site as well as from individual units on the site.

1.3.6. Italy

The system of limitation currently used in drawing up discharge authorizations for effluents from all nuclear installations considers each site on a case-by-case basis.

Taking into account the actual discharge needs of the plant being considered, the radiological capacity of the environment concerned, and the releases of existing or future installations into the same environment, discharge limits are defined in the form of discharge formulae which take into account the differing radiological impacts of the various nuclides to be emitted. In this context the radiological capacity of the environment is to be taken as the rate of releaseof activity into the particular environment that would give rise to an average dose to the individuals in the critical group not higher than the ICRP Dose Limit.

The authorities have no official guide levels for allocating a fixed fraction of the limiting radiological capacity. It is understood, however, that for design purposes the policy of the authorizing departments is to limit doses to the critical group, arising from the discharges, to about 5 to 10 mrem/a in the case of whole body exposure and corresponding values for other organs. Moreover, it is expected that generally applicable radiological reference levels will shortly be introduced.

1.3.7. Luxembourg

The system of generally applicable radiological limits recently promulgated in the Radiation Protection Ordinance (11) in the Federal Republic of Germany (See Section 1.3.4. and Table 1.1) is applied to nuclear installations in Luxembourg.

1.3.8. Netherlands

The Recommendations of the Health Council in a report (15) issued by the Ministry of Public and Environmental Health in 1975 state that licensing regulations associated with the operation of any nuclear installation should, as a minimum, guarantee that no individual living in the vicinity of the installation receives an annual dose in excess of that recommended.(See Table 1.1)

The basis of the recommended limit is the variations which might be expected in natural background radiation associated with a change of residence or mode of living.

The Council claim that, if the recommendation is complied with, only a few individuals within the critical group will approach the limit each year and it is likely that the average dose to an individual in the critical group will be at least a factor of ten lower. They add,however, that the recommendation must not be used as a basis for discharge criteria without qualification and that authorized discharges from particular installations must be kept as much below the recommended limit as is reasonably achievable on technical and economic grounds.

According to the Reactor Safety Commission, (15 b) operational releases from nuclear power stations (LWR) can be limited so that no individual living in their vicinity will receive an annual dose exceeding the values as given in Table 1.1. The Reactor Safety Commission is also of the opinion that releases of a 1 000 MWe LWR can be limited to the values given in Table 1.2.

These dose and discharge values will undoubtedly be observed in the licensing procedures for future power stations in the Netherlands.

1.3.9. United Kingdom

The established practice is to set controls on a case-by-case basis so that each situation can be judged on its own merits. By acting in this way it is considered that controls can fairly reflect the real needs of individual sites, while at the same time, the cumulative effects of all sources can be kept to a minimum.

The basic objectives of the current United Kingdom policy in relation to radioactive wastes are stated in a Government White Paper* (16). They are:

1. To ensure compliance, irrespective of cost, with the ICRP-recommended Dose Limits for members of the general public;

2. To ensure, irrespective of cost, that the whole population of the country shall not receive an average dose of more than 1 rem per person in 30 years; and

3. To do what is reasonably practicable, having regard to cost, convenience and the national importance of this subject, to reduce the doses far below these levels.

Legally enforceable authorisations for effluent discharges are drawn up to ensure that the above policy objectives are complied with and limits may be specified within authorisations for quantity, type and rate of release of activity.

The approaches to control of gaseous and liquid waste disposals differ considerably and are discussed separaly.

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* The contents of this white paper are currently being reviewed.

1.3.9.1. Discharges of gaseous waste

Authorisations for gaseous emissions from nuclear installations do not include specific limits for the nuclides discharged. Instead the authorisations contain conditions requiring the operator to use approved "best practicable means" to

(i) minimise the radioactivity of the waste discharged; and

(ii) ensure that the radioactivity of such waste does not exceed any limit which may for the time being be specified by the responsible Ministers.

Re (ii) above, such limits may be applied by means of a letter of intent addressed by the operator to the competent authority acknowledging the operator's obligation to adhere to such additional specific limits.

The word "practicable" as used above implies consideration of (amongst other things) the local conditions and circumstances, the financial implications and the current state of technical knowledge.

In the technical assessment of discharge proposals the authorities are, of course, fully concerned to meet each of the policy objectives stated above, although in practice it is usually that objective requiring exposure to be minimised which determines the acceptable levels.

It must be mentioned, however, that, following the recommendation of the Royal Commission on Environmental Pollution in its report on Nuclear Power and the Environment (16 b), the Government has agreed in principle that nuclear sites should have clear standards for airborne

emissions to which to work and that the possible additive effects of discharges should be taken into account in setting such standards (16 c)

1.3.9.2. Discharges of liquid waste

Unlike the authorisations which permit disposal of gaseous wastes, those for liquid wastes usually include numerical limits for specific radionuclides or groups of radionuclides, although the operator is still under an obligation to minimise discharges, avoiding unnecessary disposal.

In deciding on the limits to be attached to authorizations, the normal practice is, as in Italy, to compare the operator's proposals with the radiological capacity of the environment. The impact of the proposal can then be assessed in terms of the doses to members of the public; this ensures that the first and second policy objectives will be met. The operator is required to justify his proposed discharge which must not exceed the environmental capacity, and in line with the third objective, disposals are permitted only when there are proven needs. As a result of these procedures, authorised limits are usually very much less than the environmental capacity.

1.3.10. Switzerland

Limits (See Table 1.2) for liquid and atmospheric effluent releases are specified in the Federal Council's Ordinance on Radiation Protection of 30th June, 1976, (17) which came into force on 1st August, 1976. Within these limits the Ordinance requires that radioactive effluents be kept to a minimum and that permissible releases be specified in the authorizations for individual establishments. The limits apply generally to all establishments from which radioacitve materials are released to the environment.

The guidelines of the Federal Commission on Safety of Nuclear Installations (18) state that the exposure of critical groups of the population as a result of effluent releases from any one nuclear power station site should not exceed 20 mrem per year whole body dose weighted in accordance with ICRP Publication 26 (2 b). However, the authorised operational discharge limits should be kept as far below the values derived from this dose limit as is readily achievable.

1.3.11. United States

The Nuclear Regulatory Commission (NRC) announced in the Federal Register on 5th May, 1975, its decision concerning numerical guides for design objectives and limiting conditions of operation to meet the criterion "as low as reasonably achievable" for effluents from light water reactors.

The design objectives laid down (19) (Table 1.1) are intended to ensure that doses to individuals are kept below specific levels and that the dose to the population is kept as low as reasonably achievable with demonstrated technology.

It must be emphasised that the radiological levels specified are not "limits" incorporated into legislation. They merely represent exposure levels deemed by the licensing authority to represent compliance with the requirement of "as low as reasonably achievable". If an applicant can convince the authorities that higher doses proposed by him still comply with the criterion, then these may be accepted for licensing purposes.

The limiting conditions of operation, i.e. action levels as specified in the guidelines (19), stipulate dose levels which, if exceeded, oblige the licensee to investigate the causes of such release rates, to define and initiate a programme of corrective action and to report these actions to the NRC within 30 days of the end of the three month period in which the release(s) occurred.

The issuing of guidelines in this form reflects currently demonstrated levels of achievement in effluent control from

a wide experience of light water reactor operation in the United States. It is not expected (20) that guides of a similar nature will be issued in the foreseeable future for other steps in the fuel cycle.

Legally enforceable environmental standards (21), in the form of generally applicable radiological limits, have recently been promulgated by the Environmental Protection Agency (EPA) and they apply to almost the whole of the uranium fuel cycle.

Two types of limits are proposed. The first (Table 1.1) which is expressed in terms of maximum dose to any real individual, is designed to provide protection of the individual and to ensure that the exposure of nearby populations to short-lived radioactive materials will not exceed levels that can be achieved using cost-effective means of effluent control. The second type of limit (Table 1.3) is designed to limit the accumulation of long-lived radioactive materials in the environment. The Agency considers this second type of limit to be extremely important since it believes that these long-lived materials represent the largest source of potential exposure of human populations from fuel cycle operations.

Standards concerning this second type of limit are presently restricted to krypton-85, iodine-129, and alpha-emitting transuranics having half-lives greater than 1 year, but possible limitation of releases of tritium and carbon-14, the other isotopes of importance in this respect, will be considered when further knowledge is available on both the environmental impact of these nuclides and the cost-effectiveness of control.

Both the NRC numerical guides for LWRs and the EPA environmental standards contain variance provisions which may be exercised by NRC under temporary and unusual operating conditions when continued operation, compatible with considerations of health and safety, is deemed necessary to protect the overall public interest.

1.4. Discussion

1.4.1. Approach to radiological control

All the countries considered in the present study have systems of radiological control which ensure that doses to members of the public, arising from releases of radioactive materials from nuclear installations, are kept well below the Dose Limits specified in Section 1.2. In some cases, additional limitations have been introduced, or are being considered, to reduce the exposure of the world population arising from the global circulation of long-lived radionuclides released.

The basic difference between countries lies for the most part in their approach to radiological control:

- whether radiological control is exercised on a case-by-case basis, and with what end point in mind;
- or whether generally applicable numerical limits are applied, and what the limits represent.

Most of the Member States of the European Communities now employ, or have announced their intention to introduce, generally applicable limits for at least part of their system of control to limit exposures arising from the release of radioactive materials from nuclear installations. France, Italy and the United Kingdom presently base their radiological control entirely on a case-by-case approach, while the Nordic Group (in its latest proposal (3)) restricts the application of general limits to power generation.

In the United Kingdom no numerical limits are cited in authorizations for discharges to atmosphere; these specify instead that approved "best practicable means" be employed to limit the discharges.

1.4.2. Generally applicable limits

1.4.2.1. Scope

Of the general numerical limits applied, or proposed, in the countries considered in this report, in only one case, that of the NRC guides for effluents from LWRs,

is there a specific implication that the limits represent releases which are "as low as reasonably achievable". In all other cases, the limits appear to represent a maximum level of radiological exposure allocated to nuclear power and in particular to effluent releases, and within which efforts are expected to be made to minimise exposures in line with the ICRP criteria.

The limits have been arrived at on the basis of various radiological and technological considerations. Three countries or groups, viz. Switzerland, the Netherlands, and the Nordic Group, refer in the case of exposure of any one individual to the insignificance of doses lying within the variations in natural background radiation levels from place to place, and it appears to have been this radiological criterion together with a knowledge of currently achieved levels of operational control that have determined the limits used or proposed in those countries. Only in the case of the EPA standards are the limits clearly claimed to have been arrived at on the basis of detailed cost-benefit assessments.

1.4.2.2. Status

In most of the countries using generally applicable limits, the limits have been incorporated into legislation. In the other countries, the limits are laid down, for the present at least, in the form of recommendations or guidelines and it is not known to what extent the recommendations are implemented in practice and how they are administered.

1.4.2.3. Form

Most of the countries specify their limits in terms of dose equivalent (rem) per year to one or more body sites although in the case of the Nordic recommendations the limits are specified as the dose equivalent commitment, integrated over 500 years, arising from one year's practice. Only in the French and Swiss legislation are the limits expressed in the form of discharge limits (Table 1.2) Swiss legislation provides maximum concentration values based

on the maximum permissible concentrations in air and water recommended by ICRP for occupational exposure; these cannot be related directly to dose levels, since not all exposure pathways are considered.

1.4.2.4. Applicability

Significant differences exist in the conditions of applicability associated with the limits used by the various countries. In the case of limits designed to control the exposure of the local population (Table 1.1) the limits can relate to the average exposure of members of the critical group, to the most exposed individual (in "real" circumstances) or to a hypothetical person at the position of maximum exposure. Other differences of applicability relate to the fuel cycle step(s) involved, the pathways of exposure to be condidered and the extent of the installations considered. In the latter case, for example, limits are variously applied to single reactors of a specified type, to all reactors or other installations on the same site, or to all installations which contribute to the exposure at a given location.

It is not clear in most cases whether the limits relate to design specifications or to operational achievement.

1.4.2.5. Magnitude

Because of the significant differences of applicability attached to the limits used or proposed by the various countries considered, it is not possible to make direct comparisons between them, nor indeed to ascertain their relative severity. Nevertheless, considering the cases where effluent limits have been expressed in the form of dose limitation to the local population (Table 1.1) it is interesting to note that the limits applied to doses arising from combined atmospheric and liquid releases amount in all cases to not more than 10% of the ICRP/Euratom Directive overall Dose Limits for members of the public.(Section 1.2)

1.4.2.6. Limitation of global exposure

Only three of the countries or groups considered specify limits related directly to the exposure of the world population arising from the accumulation of long-lived radionuclides in the biosphere. These are Germany, the Nordic Group and the United States. All the limits (Table 1.3) are expressed differently, however, and as in the case of the limits for exposure of the local population they are not readily comparable. The nuclides currently being considered in this respect are carbon-14, krypton-85, iodine-129, tritium and the long-lived transuranics, including plutonium. In the case of krypton-85, the EPA standards (21) provisionally require their stated limits (see Table 1) to be put into effect by 1983, while recommendations for controlling releases of this nuclide have also been made in Germany (12). EPA have also specified release limits for iodine-129 (1983) and the transuranics (1979) and are to give further consideration to carbon-14 and tritium. The Nordic recommendations aim to ensure that the annual global per caput dose commitment will never exceed a value of 10 mrem from all steps in the nuclear fuel cycle.

1.4.3. Compliance with limits

Since the introduction (or proposal) of generally applicable numerical limits in the various countries is, for the most part, of very recent date, the ability of operators of nuclear installations to comply with the limits will, in some cases at least, need to be demonstrated. In many of the countries, the limits are restricted to releases from power generation alone and mostly relate to the operation of LWRs for which a wealth of operating experience exists and where much is known about the levels of radiological exposure achievable with currently demonstrated technology. (This is effectively true also in the case of countries who have specified limits applicable to all steps of the nuclear fuel cycle but who presently operate reactors.) The largest effluent releases will normally be associated with fuel reprocessing operations and it should be noted that only

France and the United Kingdom of the countries considered here presently operate facilities of this type on a commercial scale. In both these countries the radiological control of effluents from these operations is administered under authorizations drawn up on a "specific site" basis.

2. Operational discharge limits

2.1. Introduction

Operational discharge limits are the limits specified in the individual discharge authorisations by the competent authorities. While they meet the general limits outlined in the previous chapter, they may differ both in the units used to express these limits and in the releases permitted.

On the basis of the information received from the different delegations at or subsequent to the 1977 meeting, a survey is given in this part of the report of how operational discharge limits are derived, expressed and implemented in the Member States and in some other countries.

In order to facilitate the comparison of methods and approaches used, the information is presented for each country under the following headings:

(a) Methods of deriving operational limits
(b) Revision of limits
(c) Units used to express operational limits
(d) Limitations on short-term releases
(e) Flexibility permitted in relation to discharge limits
(f) Controls exercised to ensure compliance with the authorisation
(g) Procedures and/or actions following a breach of the authorisation

2.2. Belgium

a) Methods of deriving operational limits

In the case of the power stations currently in operation (Doel I and II, Tihange I), consultants acting on behalf of the operators proposed discharge limits to the authorities supported by an assessment of the radiological consequences corresponding to the maximum discharges thus envisaged.

For gaseous effluent the radiological consequences were calculated for a number of different atmospheric conditions.

For liquid effluent, the consequences were calculated on the basis of the maximum permissible concentrations in drinking water both for individual members of the public and for the public as a whole.

In both cases the authorities gave their consent on the basis of the safety margins between the discharge limits and

- in the case of air, the official dose limits
- in the case of water, the statutory concentration limits for drinking water,

but with the proviso that subsequent radioecological studies demonstrate that the population exposure by the various possible pathways for the nuclides discharged represent only a small fraction of the official dose limits.

As regards the four projected power stations on which work has already started or a decision has been taken (Doel III and IV, Tihange II and III), the NRC regulatory guidelines will be applied (see 1.3.1.). The basic guidelines with regard to radioactive effluent are set out in References 19 and 23 - 28.

The discharges limits will be fixed in the light of the results of the studies previously carried out on radiological impact at these sites but adapted to correspond to the total nuclear capacity now envisaged. The competent

authority will lay down the discharge limits on the basis of the impact thus estimated, the experience gained in operation of the first power stations and the expected performance of the effluent treatment plant. These limits ought to ensure that the exposure of any individual in an unrestricted area remains below the dose values adopted in the NRC guidelines. (Table 1.1.)

b) Revision of limits

The discharge authorizations contain no limitation as to their period of validity; the competent authority can modify the conditions at any time. A decision to this effect could be taken, for example, following the publication of new, significant, data on technology, ecology or radiological protection. In such cases there will be prior consultation between the operator, the authority and the appointed supervisory body.

c) Units used to express operational limits

For the existing nuclear power stations the applicable limits were set out in Annexe 2 to the minutes of the meeting of 21st and 22nd October, 1974 (14). The values adopted for the limits cover various individual radionuclides and groups of radionuclides in both gaseous and liquid effluent.

The limits for gaseous discharges are expressed in curies (Ci per period of 12 consecutive months).

The limits for liquid effluent are expressed in curies-equivalent (Ci-eq per period of 12 consecutive months); 1 Ci-eq corresponds to the radioactivity in drinking water with a radiotoxicity equal to that of 1 curie of a hypothetical radionuclide having an MPC in drinking water of 3×10^{-5} Ci/m^3 for occupationally exposed persons. The Ci-eq value of a nuclide 'i' is thus obtained by multiplying the number of actual curies by the factor $3 \times 10^{-5}/MPC_i$.

For the projected power stations, there will be for gaseous effluents specific limits on discharges of noble gases, iodine-131, aerosols and tritium. The limits for liquid

effluent will no longer be expressed in curies-equivalent but in actual curies. They will be defined in such a way as to fulfil two aims:

- compliance with annual and quarterly limits on activity discharged by means of a straighforward measurement,
- compliance with dose limits (Table 1.1) by means of specific nuclide analyses.

There will be limits for the total activity discharged (excluding tritium and occluded gases), for tritium and for occluded gases.

d) Limitation on short-term releases

For the existing power stations, gaseous releases are subject to annual discharge limits (12 consecutive months) and in addition concentration limits (maximum "instantaneous" concentration; maximum weekly and hourly average concentrations of iodine-131) and hourly limits (for discharges from the steam generators and start-up air ejectors); for liquid effluent there are both weekly limits and limits on "instantaneous" concentrations in the effluent and in the river.

For the projected stations no short-term limitations have yet been fixed.

e) Flexibility permitted in relation to discharge limits

Some limits (14) applicable to atmospheric and liquid effluent releases from the existing power stations may be exceeded if special permission has been granted; in each case there is a second, absolute limit which must never be exceeded.

For the projected stations the possibilities have still to be explored.

f) Controls exercised to ensure compliance with the authorisation

The control of gaseous and liquid effluent release is the responsibility of the plant operators.

The supervisory body checks periodically the calibration of the monitoring equipment.

The plant operator reports monthly to the competent authorities the activities discharged.

For the projected stations the authorities envisage independent checks of an unscheduled nature on samples taken from the liquid effluent holding tanks before discharge.

g) Procedure and/or actions following a breach of the authorization

In the event of a breach of an authorized discharge limit, the measures to be taken are the same as those laid down by the NRC for U.S. power stations. The role of the NRC will probably be entrusted to the "Institut d'Hygiène et d'Epidémiologie"and to the appointed body responsible for surveillance of the power station during operation.

If for 13 consecutive weeks the gaseous or liquid releases exceed predetermined values, or if operating conditions indicate that the annual limits are likely to be exceeded, there is provision for a system of consultation between the operator, the appointed supervisory body and the authorities. Permission may be granted for temporary discharge levels.

2.3. Denmark

To date no nuclear power plants exist or are under construction in Denmark; methods for deriving operational limits for gaseous and liquid effluent discharges have yet to be fixed.

2.4. France

a) Methods of deriving operational limits

Operational limits for radioactive effluent released from nuclear facilities are determined case by case on the basis of a preliminary study carried out by the operator (See 1.3.3) and evaluated by the competent authorities.

This study takes account of all ecological and demographic factors relating to the site and the foreseeable evolution of these factors during the operating life of the facility. The operator proposes limits and the authorities decide on the levels to be adopted, with reference in particular to the estimated doses calculated by the competent health authorities.

As regards nuclear power stations, discharge limits for individual cases must be within the overall limits laid down in the regulations (See Table 1.2).

b) Revision of limits

The conditions laid down in the discharge authorization apply for a period of three years; they continue in force thereafter unless specifically amended; such amendments may be made at any time by interministerial decree, subject to one year's notice.

c) Units used to express operational limits

Operational limits are defined in terms of cumulative annual radioactivity for the calendar year (Ci/a) and may be appropriately expressed in terms of:

- activity for various individual radionuclides present in the effluent,
- overall equivalent activity (a weighting formula is used to take account of the radiotoxicity of the individual nuclides).
- total activity, having regard to the composition of the effluent.

For releases from nuclear power stations with light-water reactors, the only distinctions drawn in the general regulations are:

- for gaseous effluent : - noble gases,
  - halogens plus aerosols,
- for liquid effluent : - tritium
  - other nuclides (excluding K-40 and Ra).

d) Limitations on short-term releases

Releases must be spread out with a view to maximum dilution. No short-term discharge limit is specified for activity per se, but for power stations with light-water reactors maximum average concentration levels (See Table 1.2) are laid down for the following periods:

- weekly for gaseous effluent,
- daily for liquid effluent,
- quarterly for the river basin.

These maximum concentration levels are values relating to the receiving environment and are ascertained by calculation, assuming uniform dilution.

Requirements additional to those for nuclear power stations can be imposed by virtue of the decrees relating to the general regulations applicable to fixing limits and discharge arrangements for nuclear facilities in general (7,8). Under these decrees, for certain types of facility the arrangements for releases - and in particular their distribution in time - can be adapted to take account of environmental parameters.

e) Flexibility permitted in relation to discharge limits

Flexibility relates only to the discharge arrangements and not the cumulative annual limits laid down for each facility within the overall limits mentioned above. These arrangements themselves, however, must take account of the average concentration limits - with the exception of releases into rivers from nuclear power stations with light-water reactors. In the latter case the average concentration

calculated on the basis of the authorized cumulative annual discharges may be multiplied by 10 for a cumulative period not exceeding 30 days per calendar year, subject to the prior consent of the Service Central de Protection contre les Rayonnements Ionisants (SCPRI), which has the responsibility for co-ordination in cases where a number of power stations lie in one river basin.

f) Controls exercised to ensure compliance with the authorization

Measurements and analyses must be carried out on gaseous radioactive effluent and on each batch of liquid radioactive effluent prior to discharge. Details are laid down in the respective authorizations for each facility.

Monitoring takes the following forms:

- measurement by the operator of activity in the storage tanks for gaseous and liquid effluent prior to discharge and in the stack during discharge, and of levels of activity in the environment.
- parallel measurements by the SCPRI which can also, apart from being carried out on a systematic basis, be of an unscheduled nature;
- daily recording of amounts discharged, recording the results of environmental measurements, recording of the maintenance and calibration of monitoring equipment; a copy of these records has to be transmitted monthly to the SCPRI.

The procedures and techniques for radioanalysis and the measurement of radioactivity to be employed by the operator of a nuclear power station are laid down for each particular case by the SCPRI, which supplies the necessary calibration standards to ensure that the measuring apparatus functions correctly.

g) Procedures and/or actions following a breach of the authorization

The procedures to be followed or actions to be taken in the event of the authorized limits being exceeded are laid down as follows:

- for gaseous effluent in Article 12 of the Decree of 6th November, 1974 (4),
- for liquid effluent in Article 13 of the Decree of 31st December, 1974 (5).

Under the terms of these two Articles, the SCRPI, if it finds that certain provisions of the discharge authorization have not been complied with, informs the authorities concerned. In particular it reports immediately to the Minister of Health, who contacts the Minister for Industry and Research with a view to possible application of the provisions of Article 13 of the Decree of 11th December, 1963, as amended (suspension of the facility's activities, if necessary by placing it under seal).

2.5. Federal Republic of Germany

a) Methods of deriving operational limits

In the Federal Republic the plant operator proposes discharge limits based on experience with similar facilities and providing the necessary margin in case of maloperation and malfunction. The licensing authority then calls for an independent radio-ecological assessment in the light of the levels applied for.

The assessment takes account of the actual meteorological parameters, but allows for the least favourable local possible conditions with regard to the ecological and demographic situation, this to take account of possible changes over the assumed life-time of the plant *).

The exposure of the critical population group via the relevant exposure pathways is calculated for each radionuclide and the resulting doses are added together to give the total exposure. Unless specific local living patterns are known, pessimistic assumptions are made **).

In calculating the exposure from radioactive effluents the activity already present in the dispersing medium is taken into account; i.e. all sources of radioactive effluents (e.g. of medical, industrial, scientific or nuclear origin) which can contribute to the exposure of the critical population group at the points of interest are included in the radio-ecological assessment. If this assessment indicates that the radiological limits (see Table 1.1.) would be exceeded, the levels applied for cannot be authorized. Either the operator then reduces the levels in his application or the licensing authority grants a licence specifying suitably reduced limits.

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*) In the basic assumptions used to evaluate the environmental radiological impact of nuclear power plants, the life-time of the plant is now supposed to be 50 years (31).

**) For further details see Refs. 31 and 32

However, even where the results from the assessment comply with the radiological limits, in the recent past the licensing authority has, where technologically and economically feasible, laid down limits less than those sought, in view of the "as low as practicable" principle.

The above method of fixing operational limits is applied to all types of nuclear installations including nuclear fuel reprocessing plants but in the latter case supplementary restrictions can be imposed to limit the collective dose to the population from long living nuclides. To date however, no generally valid criteria exist for this purpose.

b) Revision of limits

Discharge limits can be revised at any time when it would appear that a danger might exist for the population near a plant. Changes will also occur when new regulations (e.g. changes in the Radiation Protection Ordinance, or new statutory orders) are issued. This would also apply in the event that effluent treatment techniques were to be considerably improved. The change in discharge limits can be implemented by the competent authorities by amending a condition of the license or by issuing a supplementary condition.

c) Units used to express operational limits

In accordance with the Radiation Protection Ordinance (11) annual discharge limits are expressed in curies (Ci/a) It is customary to have separate limits:

for gaseous effluents: - noble gases
- iodine-131
  (with additional restrictions during the grazing season)
- long-lived aerosols ($T_{\frac{1}{2}} \geqslant 8$ d)

for liquid effluents: - tritium
- all other artificial radioactive materials.

d) Limitations on short term releases

Gaseous effluents

It has recently become normal practice to impose limits on short-term atmospheric discharges. These are designed to ensure that the relationship between discharge and exposure calculated using long-term dispersion factors remains valid under all foreseeable operational conditions.

The following short-term limits are currently recommended for nuclear power stations in the Federal Republic of Germany:

1) The hourly discharge-rate must not deviate by more than a factor of 2, in general, from the permitted average (i.e. the authorised annual discharge, Q Ci, divided by 8 760 hours)while any upwards deviations from Q/(8 760) must not occur systematically at particuliar times of the day or in particular weather conditions.

2) The hourly discharge-rate may deviate by a factor of up to 20 from the permitted average if the following conditions are met:

   a) The activity discharged per day (i.e. in 24-hour periods) is not greater than 1/100 th of the yearly authorised discharge Q;

   b) Discharges in excess of the permitted average do not occur systematically at the same time of the day, but are approximately equally distributed throughout the day;

   c) in any half-year period 50% of the permissible yearly discharge(0.5 Q)is not exceeded.

If these conditions are not met, a special calculation of the "short-term" exposure must be carried out. (See also (g) below)

Liquid effluents

Limitations on short-term discharges of radioactive substances into surface waters have not been issued to date.

e) Flexibility permitted in relation to discharge limits

No flexibility is permitted in relation to the annual discharge limits, as they incorporate a margin sufficient to allow for some malfunction and maloperation in the plant.

f) Controls exercised to ensure compliance with the authorization

Gaseous discharges

Atmospheric discharges are monitored and recorded by instruments which are the responsibility of the plant operator. These instruments are checked and calibrated by officially appointed specialists before the facility is commissioned and subsequently at regular intervals - e.g. yearly.

Random checks are carried out by the supervisory authority on the recordings made by these instruments in order to verify the data furnished by the plant operator.

Liquid discharges

Liquid radioactive effluent is collected in holding tanks. Prior to discharge into the receiving water body representative samples are taken in order to allow a decision to discharge, determine the types and quantities of radionuclides present in the effluent and provide supporting evidence. Measurements providing the basis for decisions to discharge are carried out by the plant operator. In addition, continuously operating detectors and sampling devices are installed in the discharge line.

The continuous measuring and recording devices are subject to commissioning tests, calibration tests and subsequent checks at intervals by independent specialists on behalf of the competent regional authority.

In addition to routine monitoring on behalf of the authorities, the gaseous and liquid discharges from all nuclear power stations in the Federal Republic of Germany have been regulary monitored by the Federal Health Office (Bundesgesundheitsamt) as part of a research contract. As a result of this research guidelines for the monitoring of discharges have been drawn up, and the State Committee for Nuclear Energy (Länderausschuss für Atomenergie) has made these guidelines binding on the operators of nuclear power stations (28,29).

The plant operator has to report the results of effluent monitoring to the competent authorities at least once a year but for certain measurements, at least once every three or six months.

g) Procedures and/or actions following a breach of the authorization

Whenever, the authorised discharge levels are exceeded, the plant operator must inform the competent authorities immediately by telephone, and confirm in writing. The channels of communication and the measures to be taken are fixed on a case by case basis in the licence for a particular plant. These measures will depend on the seriousness of the incident and can extend to the temporary closure of the facility and the imposition of a fine.

2.6. Ireland

a) Methods of deriving operational limits

Since to date no limitation system to effluent control has been introduced, only the general philosophy to be followed can be given.

Discharge limits will be based on the fundamental principle that all discharges of radioactive effluents to the environment and exposures of members of the public should be maintained as low as reasonably achievable.

The operational discharge limits will be derived from detailed consideration of meteorological, ecological, demographic and other data relevant to the site.

It is quite possible that design targets may be established for the safety assessment of nuclear power stations. Such targets would of course be lower than authorised limits.

b) Revision of limits

It is probable that authorisations will be issued for a specific period and renewed at the end of that period. In any case the regulatory authority can amend authorisations at any time.

c) Units used to express operational limits

The expression of operational discharge limits in curies is preferred to the use of curies-equivalent or discharge formulae. Specific limits will certainly be placed on iodine releases in gaseous effluent. The necessity for specific release limits for other radionuclides will be determined by the characteristics of the plant and the site.

d) Limitations on short term releases

In discharge authorisations provision is likely to be made for short term discharge rates.

e) Flexibility permitted in relation to discharge limits

No policy has been determined on permitting flexibility in discharge limits. It is probable, however, that a small variation in discharge rates may be permitted to allow for minor operational flexibility. Such flexibility will be defined in the authorisation.

f) Controls exercised to ensure compliance with the authorization

The controls applied to ensure that actual discharges are within authorized limits will be similar to those normally applied to the control of nuclear power stations elsewhere.

g) Procedures and/or actions following a breach of the authorization

Procedures and actions to be taken following a breach of an authorization have yet to be determined.

2.7. Italy

a) Methods of deriving operational limits

The operational discharge limits constitute part of the Technical Specifications, imposed by the competent authorities on a licensee as part of the operating licence. These limits are set for each individual plant on the basis of the results of two analyses:

- the safety analysis of the installation (nuclear power stations and others), its safety systems and the effluent treatment plant, taking into account the state of the art as regards the last mentioned (application of the principle "as low as readily achievable");

- analysis of the radiological consequences of radioactive discharges in the given environment, taking into account as far as possible potential changes over the lifetime of the plant.

In the latter analysis, an evaluation of the meteorological, ecological and demographic data (especially the diets and living habits of the population), permits determination of, for the principal nuclides discharged, a site's "environmental capacity".(See Section 1.3.6)

The discharge limits are then set on the basis of the discharge needs of the plant and the assessed environmental capacity. A check is made to ensure that the resulting dose commitment will correspond only to an "acceptable" fraction (normally 1-10%) of the environmental capacity.

b) Revision of Limits

The discharge limits are valid for two years, after which they are reviewed in the light of updated information on the environment and the operation of the installation (see (f) below).

c) Units used to express operational limits

The discharge limits are expressed by means of a discharge formula giving the maximum activity that can be discharged in one year taking into account the different radionuclides present in the effluent *).

The principal nuclides discharged are specified in this formula, which also incorporates terms for the total α, $\beta\gamma$ and activities of the nuclides which are not included individually.

For light water reactors the nuclides which are included in the discharge formulae are:

- liquid effluent: H-3, Sr-90, Co-60, I-131, Cs-137, total $\beta\gamma$ and α. ($\beta\gamma$ activity is usually expressed in terms of Co-60 and Cs-137 equivalent while α activity is normally expressed in terms of Pu-239 equivalent **).
- gaseous effluent: noble gases, I-131, $\beta\gamma$ particulates and α particulates ($\beta\gamma$ activity is usually expressed in terms of Sr-90 equivalent while α activity is normally expressed in terms of Pu-239 equivalent **).

d) Limitations on short term releases

There are restrictions for short-term discharge of gaseous and liquid effluents. In particular:

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*) For example for Garigliano power station (liquid effluent):

$$\frac{\text{H-3}}{5\times10^3} + \frac{\beta}{1} + \frac{\text{Cs-137 + Co-60 + 2(I-131)}}{25} + \frac{\beta\gamma}{2} + \frac{\alpha}{1} \leq 1 \text{ Ci/a}$$

**) The operator of each installation is supplied with a a list of equivalence factors so that the activity of each radionuclide can be related to the activity of the reference nuclide.

a) for discharges over a 13-week period the limit is equal to 50% of the annual limit;

b) for discharges over a 24-hour period the limit is equal to 10% of the annual limit.

In particular cases, e.g. where effluents are discharged into watercourses with a fluctuating flow rate, there are limits linked to the flow rate.

e) Flexibility permitted in relation to discharge limits

The flexibility which is permitted with regard to discharge limits appears from (d) above. If, in exceptional circumstances (e.g. malfunction or other unforeseen event), it is perforce anticipated that one of the discharge limits set for an installation may be exceeded, the operator must inform the regulatory body, which will investigate the reasons and the need for the discharge and check that its radiological consequences are acceptable. This body may then authorize an "exceptional discharge" arrange some kind of additional survey and request the elimination of the causes of the exceptional discharge.

ENEL (National Electricity Board), the only operator of nuclear power stations in Italy, has set for the installations which it operates at present, operational limits equal to 75% of the authorized limits. If these operational limits are exceeded, the staff of the installation must make a thorough investigation to determine the causes.

f) Controls exercised to ensure compliance with the authorization

Controls to determine that the authorized limits are being observed are carried out at various levels.

- The operator is required to monitor the activity and the nature of the effluent by continuous measurements and laboratory analysis; all terms in the discharge formulae must always be checked. The monitoring equipment, the way in which it is used and calibrated and the frequency of sampling and measurement are subject to advance approval and are regularly checked thereafter.

- The operator is also required to record all measurements made, both by continuous monitoring and in laboratory analyses. Each year he must draw up a report on the discharges, the measurements taken and the results of environmental monitoring. This report must be submitted to the regulatory body (CNEN).

  If the derived operational limits are exceeded, the operator must inform the regulatory body immediately (see (g) below).

- The regulatory body carries out regular inspections of nuclear installations. During these inspections discharges are verified and a check is made that the regulations are being observed.

- As an additional and independent check on discharges and their impact on the environment and the health of the population, the regulatory body also carries out radiological campaigns around each installation every 2-3 years.

g) Procedures and/or actions following a breach of the authorization

With the exception of the circumstances mentioned in (e) above (permitted "exceptional discharges") and accidental discharges, all cases where the authorized limits are exceeded must by law be reported to the Ministry of Industry by the regulatory body. The Ministry can suspend the operating licence for six months or, in extreme cases, withdraw it completely. Legal penalties of imprisonment and fines are laid down for those who infringe the technical regulations establishing discharge limits.

2.8. Luxembourg

Since the Luxembourg Government has decided to apply the statutory regulations and other standards in force in the Federal Republic of Germany (FRG), the philosophy and methods of fixing operational limits will be the same as in the FRG. (See section 2.5)

2.9. Netherlands

a) Methods of deriving operational limits

Discharge limits for a particular plant are based on a case-by-case analysis of the true discharge needs.

In his application for a licence to operate a nuclear power plant the applicant must propose to the authorities maximum discharge values and must demonstrate that these values observe the "as low as readily achievable" principle . (See Table 1.2)

He must also submit an assessment of the possible radiological consequences of these proposed discharge limits, taking into account meteorological, ecological and demographic conditions, in which it is shown that certain radiological limits are not exceeded, (see Table 1.1.), and considering possible changes in these conditions over the life of the plant.

The data are jointly evaluated by the Reactor Safety Commission (technical aspects) and the Health Council (radiological aspects).

On the basis of the recommendations of these Commissions the licence is drawn up thus establishing the discharge limits.

b) Revision of limits

The Ministers who grant the licence (14) are empowered, with due regard to the procedures stipulated by the Nuclear Energy Act, to revise the discharge limits at all times. These revisions may be result from e.g. new regulations, operating experience, monitoring results or backfitting for older installations.

In general, any proposed revision of the discharge limits will also be evaluated by the Reactor Safety Commission and the Health Council.

c) Units used to express operational limits

The discharge limits are expressed in Ci/a.

For gaseous effluents, specific limits exist for

- noble gases
- iodine-131
- halogens other than I-131
- aerosols
- tritium (for the Borssele plant only).

For liquid effluents there is a gross activity and a concentration limit in respect of beta activity (excluding tritium); for tritium there is only a concentration limit.

d) Limitations on short-term releases

For gaseous effluents, the daily release may be allowed to reach 10 times the daily average as derived from the annual limit; however, the actual daily releases averaged over 5 consecutive days may not exceed 5 times the permitted daily average thus derived.

For liquid effluents, a limit for any period of 28 consecutive days has been fixed in respect of Borssele as regards beta activity excluding tritium; additionally concentration limits have been fixed for condenser coolant outfalls in general.

e) Flexibility permitted in relation to the discharge limits

No flexibility is permitted in relation to discharge limits; discharge limits are set in such a way that they are not exceeded in the case of minor operational disturbances.

f) Controls exercised to ensure compliance with the authorization

Monitoring and control at the plant

Gaseous effluents which are discharged continuously are measured or sampled continuously. Calibration of the monitoring equipment is perfcrmed under supervision of the competent authorities.

Before each liquid effluent discharge is executed a sample is taken and measured for total beta activity.

Inspection and control carried out by the authorities

There are 3 types of inspection:

- Regular inspection of the recorded gaseous releases.
- Regular (monthly) administrative surveillance of reported gaseous and liquid releases.
- Measurement of isotopic composition and total activity of specially prepared samples taken from liquid discharges.

For the future it is also envisaged that weekly reporting and standardised measuring techniques and reporting forms will be introduced.

g) Procedures and/or actions following a breach of the authorization

If a discharge limit is exceeded, actions are initiated in accordance with the Nuclear Power Stations Alarm Regulation Decree (30). If the discharge has exceeded or is likely to exceed the discharge limit, this must be reported by the nuclear power plant operator to the authorities. If the discharge limit is expected to be exceeded by more than a factor of 10, the authorities will automatically initiate certain protective measures, which will depend on the actual and expected discharges. (A general guide is given in the emergency regulations for Borssele and Dodewaard. Decree of 1st July,1976) These measures are implemented by a number of specialised groups composed of personnel from the authorities.

2.10. United Kingdom

a) Methods of deriving operational limits

As stated in Section 1.3.9 authorizations for discharging radioactive waste from a nuclear installation (containing limits for liquid discharges and possibly supplemented by de-facto limits in letters-of-intent in the case of discharges to atmosphere) are granted on a case-by-case basis taking into account the true discharge needs of the plant and ensuring compliance with the ICRP recommendations.

Gaseous effluents

An operator wishing to discharge gaseous waste from a nuclear installation has to apply to the competent government departments for authorization. He submits, therefore, to the technical inspectorates concerned detailed plant design proposals and estimated emission data.

These inspectorates make a careful assessment and consider the consequences of the limiting discharges as proposed by the operator in terms of dose to humans taking into account possible changes in ecological and other conditions.

If such doses are deemed acceptable, authorizations are granted by the responsibile government departments, though not until after consultation with local authorities and others in the area concerned. However, as stated in Section 1.3.9, authorizations for gaseous emissions from nuclear installations do not per se include specific limits for the nuclides discharged.

Liquid effluents

The formal procedure leading up to an authorization for liquid waste discharge follows a similar pattern to that for gaseous wastes. The operator is required to justify the proposed discharge of liquid effluent, wherein some reasonable margin is allowed for operational flexibility and inaccuracies in forecasting the amount of waste arising, treatment plant performance, etc..

The technical inspectorates concerned make an assessment of the "radiological capacity of the environment" (see definition in Section 1.3.6) and compare the proposed discharges against this value.

Authorizations usually include numerical discharge limits, although the operator is still under an obligation to minimise discharges and avoid unnecessary disposals. The authorized limits are usually only a small fraction of the radiological capacity of the environment.

b) Revision of limits

The regulatory authorities can decide at any time to amend the imposed discharge limits.

c) Units used to express operational limits

Gaseous effluents

Where letters of intent have been issued specific nuclides considered to be of special significance are stated, but in general, due to the insignificance of the discharges, gross activity (Ci/a) is regarded as acceptable provided spot checks are made to identify the composition of the release.

Liquid effluents

Limits are normally expressed in terms of gross activity (Ci/a) but additionally may contain references to specific nuclides either because they are of special importance (e.g. Zn-65 or Cs-137) or conversely when large curie quantities are of exceptionally little significance (e.g. tritium).

d) Limitations on short-term releases

Gaseous effluents

For trivial discharges, e.g. particulate material, no restriction has proved necessary. Where letters of intent incorporating references to specific nuclides are concerned the maximum

daily release rate has been expressed as a multiple (x4) of the permitted daily average (i.e. the DWL *). Such releases may not continue for more than 4 consecutive days. For the relatively large releases of A-41 from the earlier Magnox stations the release rate is directly related to power output and the level at full power is thus intrinsically fixed.

Liquid effluents.

Operators are encouraged to discharge at a reasonably uniform rate by the use of "rolling" 12 monthly averages and the stipulation included to date that over any 3 month period no discharge may exceed 1/3 of the annual limit.

e) Flexibility permitted in relation to discharge limits

No flexibility is permitted in relation to the discharge limits set by the authorities, but minor operational malfunctions are allowed for in the values authorised.

f) Controls exercised to ensure compliance with the authorization

The policy of the authorising authorities is to require that the necessary monitoring to assess the level of radioactivity in the effluents and the effect of such effluents on the environment, is undertaken principally by the station operators. The information provided by such monitoring can then be used to demonstrate compliance with ICRP recommendations regarding exposure of members of the general public.

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*) The DWL (Derived Working Limit) for a stack discharge for a given nuclide is here defined as the discharge rate per day which if continued indefinitely would yield the ICRP annual dose limit to the hypothetically most exposed member of the public outside the site perimeter. For some nuclides where the modelling is incomplete and the persistence of the practice can be estimated only approximately the term "DWL" is not strictly applicable although there will be practical uses for a figure which relates the daily discharge rate to a particular route of exposure.

Additional independent checks are undertaken by the authorities particularly in the marine environment.

Station operators are regularly visited by inspectors employed by these authorities and the following topics are among those which receive their attention:

- monitoring of radioactivity in effluents including sampling arrangements, counting, calibration, composition and record keeping.
- environmental monitoring, particularly of those materials associated with the transfer of radionuclides in key human food chains.
- utilisation of best practicable means to reduce radioactive discharges to atmosphere to a minimum including such aspects as design, maintenance and testing of air cleaning and discharge apparatus.

The plant operator has to communicate the activity discharged to the authorities at monthly intervals.

g) Procedures and/or actions following a breach of the authorization

Matters considered to constitute a breach of the authorisations issued to a station operator are drawn to his attention formally by letter by the authorising department or departments. Such matters would almost certainly be concerned with shortcomings in the implementation of the "best practicable means" principle. Under Section 13 of the 1960 Radioactive Substances Act provision is made both for the imposition of fines and imprisonment. The ultimate sanction would be to withdraw the authorization to discharge radioactive waste, thus in effect closing down operations.

2.11. Switzerland

a) Methods of deriving operational limits

The operator of a nuclear power plant proposes to the authorizing bodies annual discharge limits for liquid and gaseous effluents.

He submits at the same time an assessment of the environmental radiological consequences of these proposed maximum discharges in which he has firstly to demonstrate that certain recommended dose limits (see Table 1.1 and Ref. 18) are not exceeded taking into account possible future changes in environmental conditions (i.e. population growth, use of river water, etc.). The dose evaluation should be based on realistic assumptions and dose models.

Secondly he must justify that these discharges are kept so far below the values derived from the recommended dose limits that on the basis of a cost-benefit analysis a further reduction of the discharges would not be justified.

The authorities, after assessing the analyses submitted, fix the discharge limits. It is explicitly stated that the plant operator may make full use of these authorized limits.

b) Revision of limits

Limits given in the guidelines of the Federal Commission of Safety of Nuclear Installation (18), i.e. the whole body dose limit for the critical groups and the discharge limits, can be changed at any time. The reason for a change could be operating experience and/or monitoring results from the environment.

c) Units used to express operational limits

Limits for gaseous effluents are expressed in curies-equivalent, valid for a mixture of nuclides with a radiotoxicity such that its maximum permissible concentration (MPC) in air for occupationally exposed persons is 1×10^{-5} Ci/m^3 (corresponding to Xe-133 and cited in Ref 17).* There are separate limits for discharges to atmosphere of I-131 and particulates.

The limits for liquid effluents (excluding tritium) are expressed in curies-equivalent, valid for a mixture of nuclides with a radiotoxicity such that its MPC in drinking water for occupationally exposed persons is 1×10^{-4} Ci/m^3.* There is a separate limit for tritium.

d) Limitations on short-term releases

The discharge of radioactive gaseous effluents must take place in such a way that :

- the hourly discharge never exceeds 9 times the permitted hourly average as derived from the annual limit.
- the total discharge per calendar quarter does not exceed half the annual limit.

The discharge of liquid effluents must be controlled so that :

- the specific activity in the discharge line from the water treatment plant never exceeds 20 times the corresponding drinking-water MPC value for occupational exposure
- the increase in specific activity of the receiving waterbody, after mixing, never exceeds 0.3 % of the aforesaid MPC.

e) Flexibility permitted in relation to discharge limits

The discharge limits given in the licence are fixed values.There is no flexibility.

---

*) If the radiotoxicity of the radioactive gases or liquids discharged is in practice subtantially different from the reference value, this must be taken into account.

f) Controls exercised to ensure compliance with the authorization

The operator is required to ensure that the discharge limits are observed by means of:

- continuous monitoring of all discharges (at source) and regular detailed analyses of representative effluent samples;
- radioactivity measurements in the environment, e.g. analysis of aerosols and water samples;
- continuous dose measurements at selected points in the surrounding area.

The authorities confirm that the discharge limits are observed by means of:

- their own random sampling of discharges at source;
- dose rate and dose measurements in the surrounding area taken with transportable ionization chambers (field measurements);
- an environmental monitoring programme including analysis of samples of air, water, rain, aerosols, milk, grass, fish, aquatic plants and sediments.

The type and number of measurements to be made by the operator are laid down by the authorities. The operator is responsible for selecting and calibrating the measuring equipment.

The accuracy of the operators' equipment is checked by taking comparative measurements.

Every three months the operator has to report the activity discharged in the liquid and gaseous effluent, giving a breakdown of the nuclides, and the results of the measurements taken in the surrounding area.

g) Procedures and/or actions following a breach of the authorization

A report must be immediately submitted to the competent authorities should the discharge limits laid down in the

authorization be exceeded. The report must contain an estimate of the dose to the affected population groups and describe the measures which will be taken to keep future discharges within the permissible limits. The competent authorities decide on the measures to be taken in cases where the discharge limits have been exceeded and where it is assumed that the dose to members of the affected population groups has risen above 10 mrem.

2.12. United States

a) Methods of deriving operational limits

10 CFR 50 Part (19) requires that each operating license issued by the NRC contain technical specifications that set forth the limits, operating conditions, and other requirements imposed upon facility operation for the protection of the health and safety of the public.

There are two types of technical specifications:

- safety technical specifications;
- environmental technical specifications.

The latter include limits and conditions for the controlled release of radioactive materials in liquid and gaseous effluents. These limits are based on a radioecological assessment of the environment to ensure that these releases respect the NRC radiological limits given in Table 1.1.

b) Revision of limits

Limits can be revised at any time on the basis of new regulations, operating experience or monitoring results. The procedure is for NRC to simply amend the license. If necessary to satisfy the regulations, backfitting can be required, but is not usual.

c) Units used to express operation limits

The technical specifications mentioned above contain discharge limits, expressed in Ci/a, for gaseous and liquid effluents, and additionally limits for specific radionuclides, e.g. I-131.

d) Limitations on short-term releases

The technical specifications accompanying the operating license, also contain short-term limitations to effluent discharges such as instantaneous release limits and calendar quarter limits. For liquid waste also instantaneous concentration limits on radioactive materials released are imposed.

e) Flexibility permitted in relation to discharge limits

Flexibility is permitted in discharge limits under unusual operating conditions.

f) Controls exercised to ensure compliance with the authorization

Monitoring of the releases is the responsibility of the licensee; the technical specifications outline the monitoring procedures. The releases are reported to the NRC twice-yearly in semi-annual operating reports. NRC does, however, periodically check the monitoring program and reported releases.

g) Procedures and/or actions following a breach of the authorization

Violations of the technical specifications are reported to the NRC, which has the authority to impose monetary fines, or shutdown the reactor. Most minor violations are handled by a licensee commitment to resolve the situation so that a similar occurrence is not expected in the future.

2.13. Discussion

From the answers of the different delegations to the points treated above, an overall conception is obtained of the ways in which operational discharge limits are generally derived, expressed and applied, as summarised below.

I. In most countries, the plant operator proposes discharge limits to the authorities, who fix the maximum discharge values, after:

- assessing the potential environmental radiological impact implied by the proposed values and deciding whether the resulting doses would be acceptable (either being below a specific radiological limit applicable to effluent releases, such as given in Table 1.1., or being considered to represent an acceptable fraction of the dose limits as fixed in the Euratom Basic Standards or recommended by ICRP.);
- checking that these values, on the basis of the best current technology, correspond to "as low as readily achievable" values, specified for nuclear power stations in some countries as overall annual discharge limits.(See Table 1.2)

II. These discharge limits can be amended by the authorities, in most countries at any time and in others after some years of operation (2 or 3 years).

III. All but two countries express the annual discharge limits in curies. Belgium (for liquids only) and Switzerland have to date used curies-equivalent where the curie-equivalent is a measure of radiotoxicity.

For nuclear power stations, specific limits are usually fixed :

for gaseous effluent:
- noble gases
- aerosols (in several countries for nuclides with $T_{\frac{1}{2}} \geqslant 8d$)
- iodine-131 (sometimes limits for iodines in general or for halogens in general)

for liquid effluent: - gross activity, excluding tritium
- tritium alone

Some countries set - other specific limits, such as tritium in gaseous effluent or noble gases in liquid effluents
- limits for specific nuclides of special importance in the exposure pathway to man (e.g. Zn-65 or Cs-137 in liquid effluents).

IV. All countries impose limitations on short-term releases, in order to avoid that the exposure, calculated on the basis of long-term dispersion factors, is exceeded as a result of short-term influences.

However, no uniformity exists in this field as regards the time-scales used and large differences appear between plants in the same country even. For nuclear power stations short-term restrictions on activity discharges or activity concentrations in effluent may concern hourly, 1-day, 4-day, 5-day, weekly, monthly and/or quarterly periods.

V. In most countries yearly discharge limits must be complied with under all circumstances, as these limits generally already take into account minor operationnal disturbances; a few countries allow certain limits to be exceeded subject to certain conditions.

VI. To ensure compliance with the discharge authorization conditions, the following system of control and inspection is usually applied:

- all effluents are monitored before discharge;
- monitoring of continuous discharges is carried out by the plant operator, according to methods and procedures imposed or agreed on by the authorizing bodies; calibration of instruments is often done by recognized laboratories;
- for discontinuous releases, the decision to discharge is taken by the plant operator after provisional

assessment of the effluent; representative samples of liquid effluents are sent to a government appointed laboratory for checking;

- independent checks at the site on sampling, measurement and records are undertaken periodically by the inspection bodies of the authorities;
- records of activity releases and radionuclide composition are sent periodically by the plant operator to the authorities;
- each plant has a system of environmental monitoring, backed up by a survey by or on behalf of the authorities.

VII. In case of breach of the authorized limits, the authorities have to be informed immediately. Following investigation, further measures will depend on the severity of the breach. The law usually provides for the imposition of fines and/or imprisonment and, where necessary, the closing down of the installation.

3. Conclusions

In accordance with the recommendations of ICRP, all countries considered above apply the "as low as readily achievable" principle. To this end some countries incorporate in legislation, directives, recommendations or guidelines environmental radiological limits, far below the ICRP Dose Limits to be associated specifically with radioactive discharges whereas others have incorporated limits on the maximum permitted activity in discharges. Some countries have not explicitly stated such generally applicable limits for effluent control.

However, for fixing discharge limits to individual nuclear installations a case-by-case analysis is always carried out. The above mentioned generally applicable limits serve then as maxima within which the operational limits have to be fixed, taking into account the best current technology for the type of plant in question.

Although no radiological limits applied specifically to effluent control in the different countries exceed 10 % of the ICRP Dose Limits · they vary over an order of magnitude. Any attempt to compare the relative severity of these different values can however lead to misunderstandings if no account is taken of corresponding differences in the range of conditions to which the values are intended to apply.

A better approach to grasping what constitutes the best current practice in discharge control would appear to be comparison of operational limits applied to the same type of nuclear installations. This is particularly true for nuclear power stations equipped with light water reactors of which a significant number of stations is already in operation or planned. Moreover, operational limits can respond to improvements in technology more easily than limits laid down in formal legislation.

Table 2 compares the annual discharge limits for recent nuclear power plants equipped with PWRs and BWRs.

It appears that the limits per GWe for a given reactor type differ by less than a factor of 2.5 for noble gas and iodine-131 discharges to atmosphere, and less than 3.5 for liquid effluent (excluding tritium) to rivers (exceptionally a factor of 8 is found if discharges to estuaries are included). These ranges compare very favourable with the order of magnitude range encountered in generally applicable radiological effluent limits. On the other hand for tritium in liquid effluent the range exceeds an order of magnitude.

Finally it can be concluded that, although considerable differences appear in the generally applicable limits applied today in the Member States and some other countries to effluent control from nuclear installations, a growing uniformity can however be observed in respect of:

- the quantities cited in the operational limits;
- the ways in which these limits are derived, expressed and implemented.

One field, however, in which the variations still present may lead to complications, and in which, therefore, further harmonization should be positively encouraged, is limitations on discharge to international waterways which by their very nature tend to have a restrictive environmental capacity.

In the absence of such harmonization, variations from one country to another in respect of the same waterway could lead to difficulties albeit of an economic, psychological and/or political rather than a radiological nature.

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ANNEXE

MEETING ON DISCHARGE LIMITS OF RADIOACTIVE EFFLUENTS FROM NUCLEAR INSTALLATIONS

Brussels, 20th - 21st April 1977

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TABLE 1

GENERALLY APPLICABLE EFFLUENT CONTROL LIMITS

Table 1.1 : Radiological Limits (For countries marked *, see also Table 1.3)

COUNTRY	STATUS OF LIMITS (Legislation, recommendations etc.)	LIMITS	APPLICABILITY				NOTES
			Who are limits designed for?	At what location?	Fuel cycle step involved	Discharge from single unit, site, etc?	
Belgium	The future practice will be in general to apply the USNRC rules for effluents from LWRs – See "USA" below						
Denmark* (also Finland, Iceland, Norway, Sweden)	Recommendations [Ref. 3]	10 % of ICRP annual dose limits (1)	Critical group	–	Power stations	Site	(1) Limits at which continued operation must be reconsidered. Design basis value lower (to be established)
France	See Table 1.2 for releases from LWRs. Case by case approach used for other installations						
F.R. Germany *	Legislation [Ref. 11]	30 mrem/a whole body from gas. effluents 30 mrem/a whole body from liq. effluents 90 mrem/a thyroid from liq. and gas. effluents	Member of the critical group	Position of maximum possible exposure	All installations	All installations contributing to exposure	
Ireland	No limits at present – Expect to adopt general numerical limits in near future						
Italy	No specific limits (see para. 1.3.6) at present – Expect to adopt general design guide lines in future						
Luxembourg	Limits specified above for F.R. Germany are applied						
Netherlands	Recommendations (1) [Ref. 15]	30 mrem/a any organ	Most exposed individual	Site vicinity	All installations	Site	(1) Recommendations of the Health Council
	Recommendations (2) [Ref. 15b]	Gases: 5 mrem/a – whole body – gonads – haemopoetic organs; 15 mrem/a – other organs Liquids: 5 mrem/a – any organ	Most exposed individual	Site vicinity	Power stations	Single unit of 1,000 MW_e	(2) Recommendations of the Reactor Safety Commission

TABLE 1 (continued)

Table 1.1 : Radiological Limits (continued)

COUNTRY		STATUS OF LIMITS [Legislation, recommendations etc.]	LIMITS	APPLICABILITY: Who are limits designed for?	APPLICABILITY: At what location?	APPLICABILITY: Fuel cycle step involved	APPLICABILITY: Discharge from single unit, site, etc.	NOTES
United Kingdom		No generally applicable effluent control limits - Case by case approach used (see para. 1.3.9.)						
Switzerland		Legislation	Only concentration limits (see Table 1.2)					
		Guidelines [Ref. 18]	20 mrem/a weighted whole body dose	Critical group		Power stations	Site	
U.S.A.*	10 CFR 50 - Appendix I	Design guidelines for licensing purposes (1) [Ref. 19]	Liquids 3 mrem/a whole body; 10 mrem/a any organ Gases 5 mrem(2)/a whole body; 15 mrem(2)/a skin Iodine and particulates 15 mrem/a any organ	Most exposed individual	Any unrestricted area	LWRs	Single unit	(1) For action levels see para. 1.3.11 (2) Limits also quoted in "rads in air" at most exposed position (3) Further reductions to population within 50 miles must be considered on cost-benefit basis
			Additionally See note (3)	Surrounding population	Within 50 miles			
	EPA Standards	Legislation [Ref. 21]	25 mrem/a whole body; 75 mrem/a thyroid; 25 mrem/a other organs } See notes (1)&(3)	Most exposed individual	Any unrestricted area	All installations(2) in uranium fuel cycle	Site	(1) Effective date 1979 (1980 for milling) (2) Excludes mining, transport, waste disposal sites. Reactor operation limited to LWRs (3) Radon and daughters excepted

TABLE 1 (continued))

Table 1.2 : Radioactivity Limits

COUNTRY	STATUS OF LIMITS (Legislation, recommendations etc.)	LIMITS	APPLICABILITY				NOTES
			Who are limits designed for?	At what location?	Fuel cycle step involved	Discharge from single unit, site, etc?	
France	**Legislation** [Refs. 4,5,7,8,9,10]	The limits, fixed case by case, may not exceed the following values: Atmospheric Overall annual: 5 Ci halogens & aerosols 80,000 Ci rare gases Average weekly (2) : 20,000 pCi/m^3 gases - total γ 0.2 pCi/m^3 aerosols - total β --- Liquids Overall annual (2)(6) : 2,000 Ci tritium 40 Ci others Daily: Rivers (3)(4)(5) : 2,000 pCi/l tritium 20 pCi/l others Sea channel (by pipe) or within 500 m of sea discharge point (5): 20,000 pCi/l tritium 200 pCi/l others	-	-	Power stations operating LWRs	Single unit of 3,000 MW$_{th}$(1)	(1) In other cases, limits will take account of actual capacities (2) Close to ground after dispersion; >1,000 m from stack --- (1) As (1) above (2) K-40 and radium excluded (3) For up to 30 days limited to 10 times the average concentration derived from the annual discharge limits (4) Discharges into same river basin limited to quarterly average: 40,000 pCi/l tritium 100 pCi/l others (5) After dilution (6) No releases of radium-226 or radium-228 permitted
F.R. Germany	**Directive** [Ref. 29]	Liquids Average annual 1,000-2,000 Ci tritium 3-5 Ci others	-	-	Power stations operating LWRs	Single unit of 1,000 MW$_e$	
Netherlands	**Recommendations** [Ref. 15b]	Gases Overall annual 25,000 Ci rare gases 0.25 Ci I-131 1 Ci other halogens Liquids Overall annual 10 Ci excl. tritium	-	-	Power stations	Single unit of 1,000 MW$_e$(1)	(1) Pro rata for other capacities
Switzerland	**Legislation** [Ref. 17]	Atmospheric $\frac{1}{300}$ x MPC$_a$(1) Liquid $\frac{1}{300}$ x MPC$_w$(1) } See note (2)	-	Position of maximum exposure	All installations	Site	(1) Concentrations specified [Ref. 17] for 40 h week (2) Where more than one nuclide present, quantities to be reduced accordingly

T A B L E 1 (continued)

Table 1.3 : Limits to Control Exposure of World Population

COUNTRY	STATUS OF LIMITS (Legislation, recommendations etc.)	LIMITS	APPLICABILITY				NOTES
			Who are limits designed for?	At what location?	Fuel cycle step involved	Discharge from single unit, site, etc?	
Nordic Countries	Recommendations [Ref. 3]	0.5(1)(2) man rem/a global collective dose per MW_e	-	-	Power stations	Total installed power	(1) dose commitment, integrated over 500 years (2) 1 man rem/a for whole fuel cycle
F.R. Germany	Recommendations [Ref. 12]	10^6 Ci/a(1) krypton-85	-	-	Fuel reprocessing	Total release	(1) Figure specified for design purposes
U.S.A.	Legislation [Ref. 21]	50,000 Ci/GW_ea krypton-85(2) 5 mCi/GW_ea iodine-129(2) 0.5 mCi/GW_ea transuranics(1)(3)	-	-	-	Site	(1) Effective date 1979 (2) Effective date 1983 (3) Alpha emitters, $T_{1/2}$ >1 a

TABLE 2

Annual discharge limits of radioactive effluents from power stations operating LWR s

(listed according to the date of first grid connection)

Country	Power station	Net electrical output [MWe]	First grid connection	Gaseous effluents					Liquid effluents			
				Noble gases		I-131		Aerosols	Total activity excluding tritium		Tritium	
				[Ci/a]	[Ci/a GWe]	[mCi/a]	[mCi/a GWe]	[Ci/a]	[Ci/a]	[Ci/a GWe]	[Ci/a]	[Ci/a GWe]
Pressurised Water Reactors												
Netherlands	Borssele	450	1973	12 000	26 700	240	533	1	15	33	1)	-
Belgium	Doel 1+2	2 x 392.5	1974/1975	40 000	51 000	200	255	2	24 2)	31	3 580	4 560
F.R. Germany	Biblis A+B	1 146 and 1 240	1974/1976	90 000	37 700	700	293	3.25 5)	10	4.2	1 600	670
Belgium	Tihange I	870	1975	40 000	46 000	200	230	2	8 2)	9.2	4 000	4 600
F.R. Germany	Neckarwestheim I	805	1976	25 000	31 000	250	310	0.5 5)	3)		500	620
France	Fessenheim	2 x 890	1977/1978	40 000	22 500	6)		6)	25	14	2 000	1 120
Switzerland	Goesgen 2)	920	1978	30 000	32 600	200	217	5	5	5.4	2 000	2 170
Boiling Water Reactors												
F.R. Germany	Würgassen	640	1971	31 540	49 300	263	411	10.5	6.7	10.5	300	470
F.R. Germany	Brunsbüttel	770	1975	70 000	90 900	260	338	17.5	5	6.5	1 000	1 300
Italy	Caorso	840	1977	50 000 7)	59 500	8)		0.08 7)	5 4)	6	5 000 4)	5 950
F.R. Germany	Isar	870	1977	90 000	103 400	500	575	1.5 5)	5	5.7	500	575

1) No annual limit fixed, only a concentration limit (10^{-5} Ci/m^3) on cooling water discharges.

2) Limits expressed in curies-equivalent (Ci-eq) (see 2.2 and 2.11)

3) Provisional value

4) Limits are expressed in discharge formulae. The stated value assumes its presence alone

5) Aerosols with $T^1/2 > 8d$

6) Annual limit of 3 Ci halogens and aerosols

7) Limits are expressed in discharge formulae, which take into account the height of release.
The value given in the table assumes release from the highest point only.

8) Annual limit of 1 Ci halogens; see also Foot-note 7)