COMMISSION OF THE EUROPEAN COMMUNITIES

Radioactive effluents from nuclear power stations in the Community

DISCHARGE DATA
RADIOLOGICAL ASPECTS

APRIL 1974

DIRECTORATE-GENERAL FOR SOCIAL AFFAIRS
Directorate for Health Protection

COMMISSION OF THE EUROPEAN COMMUNITIES

Radioactive effluents from nuclear power stations in the Community

DISCHARGE DATA
RADIOLOGICAL ASPECTS

APRIL 1974

DIRECTORATE-GENERAL FOR SOCIAL AFFAIRS

Directorate for Health Protection

V/1973/74-E

SUMMARY

This report summarizes for 1969, 1970, 1971 and 1972 the activities of gaseous and liquid waste discharged from nuclear power stations in the Community of Six and those run by the Central Electricity Generating Board in Great Britain.

It also gives the typical composition of radionuclides in the noble gases discharged by the various power stations. In the case of liquid effluents, in addition to listing the radionuclides identified in 1972, the report indicates the methods of activity assessment used and also the fraction of the maximum permissible concentration for drinking water reached in the receiving watercourse, as an annual average.

On the basis of the discharges made, maximum exposure around the sites is estimated and compared with the dose limits fixed by radiological protection standards and with the natural level of radiation.

Finally, the ratio of activity discharged (noble gases, liquid effluents excluding tritium) to the energy produced is given for each power station.

*

*   *

Address for correspondence :

Commission of the European Communities
Directorate-General for Social Affairs
Directorate of Health Protection - DG V/F/2

Centre Louvigny

LUXEMBOURG (Grand-Duché)

PREFACE

In this document, the second of its kind, the Directorate of Health Protection is providing an overall survey of the discharges of radioactive effluents from nuclear power stations in the Community and an analysis of the possible consequences for the areas around each site. The favourable reception given to the first report, published in November 1972, by the circles directly concerned and also by a wider public, has encouraged us to repeat this attempt.

We should like to thank all those who have helped us with advice and suggestions for improving the presentation of this document. In particular, we would thank the competent authorities who provided us with data on radioactive waste discharges, thus making this inventory more complete than the previous one.

Because the information did not always conform to a sufficiently uniform pattern, it was not possible to make the comparative examination which we should like to have made. Further efforts are therefore necessary in order to achieve better harmonization of the measurement results and make them fully comparable. But even so, there has been definite progress since the last publication, and we hope that this document will interest all those concerned with radiological protection.

Dr. P. RECHT

CONTENTS

Pages

SUMMARY I

PREFACE II

INTRODUCTION 1

I. RADIOACTIVE EFFLUENTS

1) General 3

2) Gaseous radioactive effluents 4

a) Noble gases 4

b) Aerosols and iodine 5

3) Liquid radioactive effluents 6

II. RADIOLOGICAL ASPECTS

1) Gaseous effluents 9

2) Liquid effluents 11

3) Assessment of exposures resulting from effluent releases 13

REFERENCES 17

TABLES

I. General characteritics of the nuclear power stations

II. Annual discharges of gaseous radioactive waste (noble gases)

III. Typical radionuclide composition [%] of the noble gases

IV. Annual discharge of radioactive aerosols

V. Annual discharge of iodine-131 into the atmosphere

VI. Annual discharge of liquid radioactive effluents (exclusive of tritium)

VII. Methods of determining gross radioactivity (exclusive of tritium) discharged in liquid effluents

VIII. Radionuclides identified in liquid effluents in 1972 (as a percentage of the total discharge) (exclusive of tritium)

IX. Annual tritium discharge in liquid effluents

X. Maximum exposure from gaseous effluents in 1972 (noble gases and iodine-131) 0.5 and 5 km from the point of discharge

XI. Average activity concentration (exclusive of tritium) added to the receiving watercourse

XII. Average tritium concentration added to the receiving watercourse

XIII. Radioactive waste discharge and electrical energy produced

INTRODUCTION

The first report on the discharge of radioactive effluents from nuclear power stations in the Community, published in November 1972, related to the years 1969, 1970 and 1971 (1)*. It was based on disparate data from a variety of literature sources and had certain weaknesses. In order to improve future issues of the report, a group of experts from the various Member States was consulted in June 1973 and suggested the following improvements :

- to include effluents from all nuclear power stations, including pilote plants;
- to indicate the typical radionuclide composition of the effluents from each power station in order to allow a better assessment of radiological consequences;
- to mention the detection methods used to determine the gross activity in the effluents in order to permit comparison of the discharges from different power stations, and
- to use appropriate atmospheric dilution factors and iodine transfer factors in dose calculations around power stations from gaseous effluents (noble gases, aerosols and iodine).

In this second report, which covers the years 1969 to 1972, an attempt has been made to implement these suggestions where the necessary information was available.

Although the United Kingdom was not a member of the European Community during the period under consideration, it was felt that data on the power stations run by the Central Electricity Generating Board (C.E.G.B.) should be included.

---

* References : see page 17

I. RADIOACTIVE EFFLUENTS

1) General

This report contains data on the discharge of radioactive effluents into the atmosphere and into water bodies by nuclear power stations in the Community during the years 1969 to 1972. In the case of gaseous effluents a distinction is made between noble gases, aerosols and iodine-131 and in the case of liquid effluents between total activity (excluding tritium) and tritium.

In contrast to the first report, the tables merely show the authorized discharge limits and the actual discharge levels, without comparing the two sets of figures. As the limits were not always derived in accordance with the same criteria, they cannot form a real basis for comparison.

The following notes will be of assistance for interpretation of the tables presented :

- the report contains brief comments on each table; the relevant bibliographical references are listed;
- in all the tables the power stations are classified by country. Where several power stations are located on the same site (Chinon, St-Laurent-des-Eaux, ...), the discharges have been presented as coming from a single source;
- blanks appear in the tables when the relevant information was unobtainable;
- a dash "-" has been used to indicate zero or negligible values;
- the abbreviation MPCP, which appears in several places, denotes "Maximum Permissible Concentration for members of the Public"; the MPCP corresponds to one tenth of the MPC for occupationally exposed personnel;

- certain figures relating to discharge values have been corrected since publication of the first issue.

The first table gives the main characteristics (2) (3) of the nuclear power stations in operation in the Community during the period covered by the report. Table XIII shows, inter alia, the gross electricity output of each of these power stations.

The data used in the other tables were for the most part derived from the following references :

- power stations in Germany, references (4) (5)
- power stations in France, references (6) (7) (8) (9) (10)
- power stations in Italy, references (11) (12) (13)
- power stations in the Netherlands, references (14) (15) (16)
- power station in Belgium, reference (17)
- power stations in the United Kingdom, reference (18)

Where other sources have been used, they are mentioned in the text.

2) Gaseous radioactive effluents

a) Noble gases

Table II gives the activities of noble gases discharged by the power stations and the annual discharge limits. In general the activities released in 1972 are of the same order of magnitude of those of the preceding years. The discharge of noble gases by the KWL power station at Lingen has, however, been reduced considerably since 1971, that is since the delay system on the discharge circuit was brought into operation.

The radionuclide composition of the noble gases depends on the type of reactor and on the gas treatment before discharge. In order to assess external irradiation in the vicinity of a power station, it is necessary to know what radionuclides are discharged; Table III therefore gives the typical radionuclide composition in the gaseous effluents from the various power stations. It will be noted that gas-cooled power stations discharge mainly argon-41, while the more recent of the water-cooled power stations discharge virtually only Xe-133. The effluents from gas-cooled power stations contain only very small amounts of fission gases, since in these power stations faulty fuel elements are immediately removed from the reactor.

Argon-41 activities released by the CEGB power stations are not stated in Table II, since argon-41 is not routinely measured at these plants. Occasional measurements have shown that annual discharges for the Bradwell, Hinkley Point and Trawsfynydd power stations are approximately 40,000, 200,000 and 130,000 Ci respectively (18). The main source of this activity is the air-cooling system of the biological shield of the reactor. In the newer power stations Oldbury and Wylfa, the shield is cooled by water, which eliminates this source of release (19).

b) Aerosols and iodine

It may be seen from Tables IV and V that discharges of radioactive aerosols and iodine-131 were very low in 1972, as in earlier years. Moreover, the values indicated in the tables are often above the true levels since the activity concentration in the air before discharge is in most cases close to the detection threshold of the detectors.

Tables IV and V also give the discharge limits for aerosols and iodine-131 respectively. The authorizations for the discharge of gaseous effluents from the CEGB power stations place no limit on the quantities but require that the best practicable means, be used to minimise the amount of radioactivity to be discharged (18).

3) Liquid radioactive effluents

Table VI shows the annual liquid radioactive waste discharges (exclusive of tritium), together with the annual discharge limits. For practically all the power stations, the 1972 figures are similar to those for preceding years. It will be noted that the activities released by the oldest CEGB power stations, Bradwell and Hinkley Point "A", are considerably higher than those from other power stations. The main reason for this is corrosion of the fuel element cladding following prolonged storage in the storage pool for irradiated fuel elements, which increases the release of long-living fission products, in particular Cs-137. In newer power stations, such as Wylfa, used fuel is kept in a dry store, which greatly reduces the activity released (19).

The discharge limits for liquid effluents at the various power stations, shown in Table VI, were determined on the basis of differing criteria; in some cases they are based on the MPC in drinking water, in others on the radioecological capacity of the receiving water body or on the principle of "as low as practicable" release. This explains the differences in the discharge limits for power stations of the same type and comparable output.

Table VII shows the methods of gross activity assessment in water applied at the various power stations : in some cases gamma activity is measured, in some beta activity and in others alpha and beta or alpha, beta and gamma activity; also the reference nuclides vary greatly. All these factors make it difficult to compare activities discharged by the different power stations.

In order to assess the radiological consequences of the discharge, it is important to know the radionuclide composition of the liquid waste; Table VIII gives the radionuclides identified in liquid effluents from various power stations in 1972.

Table IX gives discharge values of tritium in liquid effluents. PWR reactors release the highest tritium activities; the nuclide originates mainly in the primary water of these reactors and is formed by neutron activation of anticorrosion and reactivity control additives.

The major source of tritium in gas-cooled reactors is fission and the (n,α) reaction with lithium, which is present as an impurity in the graphite and the Magnox cladding. A fraction of this tritium is released in the primary gas, from which it is continuously extracted and then discharged with the liquid effluents (19).

The comment made earlier on the different criteria used to establish limits for liquid waste discharges applies equally to tritium.

II. RADIOLOGICAL ASPECTS

As in the first issue (1972), an attempt will be made here to assess the maximum exposure of the population living in the vicinity of the nuclear power stations as a result of the activities released with the liquid and gaseous effluents during 1972.

It must be remembered, however, that these assessments are often based on very approximate hypotheses, so that the values obtained are merely an indication of the maximum exposure around a site.

1) Gaseous effluents

The main ways of exposure of man to ionising radiation emitted by gaseous effluents are :

- external (beta and gamma) irradiation by the cloud of radioactive gases (submersion);
- internal irradiation by inhalation of radioactive aerosols and iodine;
- internal irradiation by the ingestion of contaminated foods, for example milk contaminated with iodine-131 (grass-cow-milk pathway).

The doses from these exposure paths were calculated for each site at two places situated beneath the prevailing wind 0.5 km and 5 km from the point of discharge respectively. The first of these places roughly corresponds to the point where the highest average annual activity concentration is found, that is, generally in the immediate vicinity of the site boundary, where people seldom reside; the second place, at a distance of 5 km, corresponds approximately to the distance at which the group of dwellings or milk production centre nearest to the discharge point of a nuclear installation is to be found.

The dose calculations presented below differ from those of the first report in two ways :

- for exposure due to external irradiation, account has been taken of the typical radionuclide composition, shown in Table III, of the noble gases for each power station;

- the atmospheric dilution factors valid for a given site have been used if available. In the absence of precise information in this respect, dilution factors were based on a frequency distribution of the atmospheric diffusion categories typical for several Western European countries (20).

a) External irradiation

The whole-body dose from gamma rays and the skin dose from beta-gamma rays were assessed. The dose factors are taken from reference (21). The results of this calculation are given in Table X. Except for the area around some older power stations or those of a special type, the external whole-body and skin doses 500 m from the power station due to the discharge of gaseous effluents are less than 5 mrem/year and even less than 0.5 mrem/year in the case of more recent power stations.

b) Internal irradiation by inhalation of aerosols and iodine

As the amount of aerosols and iodine in gaseous waste is extremely low, assessment has been restricted to the dose resulting from the maximum discharge of these substances in 1972, that is 0.21 Ci for aerosols by the AVR plant and 0.19 Ci for iodine-131 by the KRB plant.

When assessing exposure from the inhalation of aerosols, it was assumed that a concentration of 10^{-9}Ci/m^3 *) in air results in an annual dose of 5 rem. Maximum exposure in 1972 due to the inhalation of aerosols was 0.03 mrem at 0.5 km from the point of discharge at AVR

*) That is the MPC for continuous occupational exposure of any mixture of beta-gamma emitters from which Sr-90, I-129, Pb-210, Ac-227, Ra-228, Pa-230, Pu-241, Am-242m, Bk-249, Cf-253, Cf-254, Es-255 and Fm-256 can be excluded.

and 0.007 mrem at 5 km; the maximum dose to the thyroid of a child from the inhalation of iodine-131 0.4 mrem at 0.5 km and 0.09 mrem at 5 km from KRB.

c) Internal irradiation caused by the ingestion of contaminated foods

An assessment was made of the dose to the thyroid of an infant due to I-131 ingestion by the grass-cow-milk pathway. The results of this calculation are also shown in Table X. The consumption of milk produced 500 m from the point of discharge would give rise to maximum annual doses generally lower than 5 mrem. At a distance of 5 km from the power stations, the dose generally remains below 1 mrem.

2) Liquid effluents

As in the case of gaseous effluents, there are several ways in which man can be exposed to liquid effluents : by internal irradiation following ingestion of contaminated water or food and by external irradiation; exposure by internal irradiation is usually the more common and this is therefore the type mainly considered below.

Tables XI and XII give the increase in activity concentration (gross activity exclusive of tritium and tritium alone respectively) resulting from the above given releases in the receiving water bodies. To obtain some idea of the health implications of this increased concentration, reference is made to the MPCP in drinking water, not forgetting that the drinking of water is only one of the possible ways in which man can be exposed. In Table XI the reference value taken was the MPCP of any mixture of radionuclides exclusive of Ra-226 and Ra-228 in drinking water. It can be seen that the added concentration in the water body often remains less than or approximately equal to 1 % of the MPCP. The highest value were those reached by the SENA and Garigliano power stations, which in 1971 amounted to 9.5 % and 5.5 % of the said MPCP respectively and even 20 % for SENA if the presence of the gamma emitters Mn-54 and Co-58 in the effluents is taken into account.

None the less, if the radionuclide composition of the effluents is considered, it is found that the sum of the ratios of the average concentration C_i in the river at the $MPCP_i$ for each nuclide i, $\sum_i \frac{C_i}{MPCP_i}$, is less than 0.01.

Table XII, which relates to tritium discharges, similarly shows that the added concentration in the receiving water bodies always remains lower than 0.02 % of the MPCP of tritium.

It can thus be inferred from the above what would be the exposure of a hypothetical person assumed to be drinking only water contaminated at the concentration level determined by the discharge of liquid effluents from a nuclear power station, that is, a person consuming water direct from the receiving water body without any filtration or purification. At the highest concentration recorded in a river (SENA/Meuse) during the reference period (9.5 pCi/l), and taking account of the nuclide composition in the effluents, the annual dose would be less than 1 % of the dose limits to members of the public.

As regards <u>other possible ways of exposure</u>, reference is made to the analyses carried out by the Fisheries Radiobiological Laboratory (FRL) (22) in Great Britain, which monitors the aquatic environment around British nuclear power stations. It may be seen from Table VI that the activities released into surface waters by the oldest CEGB power stations are considerably higher than those from most of the water-cooled power stations. The FRL has carried out research into exposure paths and critical groups in the vicinity of various power stations operated by the CEGB. In the area around 3 power stations only, Bradwell, Hinkley Point and Trawsfynydd, did the dose to the critical population group exceed in 1971 0.1 % of the dose limit for members of the public.

At Bradwell, where liquid waste is discharged into the Blackwater estuary, the critical material is oyster flesh, the critical nuclides are Zn-65 and Ag-110m, and the critical population group oyster fishermen and their families. The maximum dose to a member of the public in 1971 is estimated at 0.2 % of the dose limit.

At Hinkley Point, which discharges into the Severn Estuary, the critical pathways are the consumption of fish and shrimps by local fishermen and their families and external exposure of local fishermen from use of the foreshore; the critical nuclides are Cs-134 and Cs-137. In 1971, the most highly exposed individuals received only a fraction of 1 % of the dose limit.

Trawsfynydd is the sole British power station which discharges low-level radioactive waste into fresh water, that is into a mountain lake. The critical pathway in this case is the consumption of trout, contaminated with Cs-134 and Cs-137, by local fishermen and their families. In 1971 the dose may have reached a few per cent of the dose limit.

It may be concluded from the above that, in general, the annual dose to the most exposed members of the public from liquid radioactive discharges by nuclear power stations in the Community is less than 1 % of the dose limits; in some exceptional cases it may reach a few per cent of these limits.

3) Assessment of exposures resulting from effluent releases

To assess the relative importance of exposure of the public to radioactive effluents from nuclear power stations, adequate criteria must be adduced for comparison. Reference is therefore made below to the radiological protection standards in force and to natural radiation exposure.

a) Radiological protection standards (23)

The dose limits for individual members of the public are :

0.5 rem/year to the whole body;
3 rem/year to the bone and skin;
1.5 rem/year to the other organs.

When a comparison is made between the doses due to radioactive effluents listed in Table X and the above-mentioned dose limits, it is found that :

- doses to the whole body and the skin from gases discharged by the nuclear power stations are generally less than 1 % and 0.2 % of the corresponding dose limits and in the case of the newer power stations lower than 0.1 % and 0.02 % of these limits

- doses resulting from the inhalation of aerosols and iodine are less than 0.03 % of the dose limits

- doses to the thyroid of an infant consuming milk produced near the power stations are less than 0.3 % of the dose limits

- doses to critical groups of the population exposed to discharges of liquid radioactive waste are generally lower than 1 % of the dose limits; in some exceptional cases, it may reach a few per cent of these limits.

b) Natural radiation exposure

According to UNSCEAR (24), the average annual gonadal dose to man from natural radiation is 93 mrad/year which corresponds to a dose equivalent of approximately 100 mrem/year. This dose may be broken down as follows :

	[mrad/y]
- cosmic rays, ionizing component	28
- cosmic rays, neutron component	0.35
- terrestrial radiation (including air)	44
- internal irradiation from potassium-40	19
carbon-14	0.7
polonium-210	0.6
other nuclides	0.45
	$\sum \sim 93$

At ground level, therefore, the most important source of natural radiation is that of terrestrial origin, which varies considerably, depending on the geological nature of the sub-oil. In Community countries, the dose from this source varies between 50 and 500 mrem/year. It should be added that the dose to man from natural radiation also depends on the construction materials used for his dwelling and on his living habits.

Comparison with the values given earlier for maximum whole-body exposure resulting from the discharge of radioactive substances from nuclear power stations shows that the latter exposure generally amounts to less than 5 % of man's average exposure from natural sources, that is to a value which is within the margin of regional fluctuations of the natural radiation background.

*

* *

Enlarging the scope of the report, Table XIII shows the relationship between the activity released and the energy produced by each power station. On the basis of this relationship it is possible to establish an index which may be used to study the environmental implications of increased energy production.

With respect to gaseous effluents, only noble-gases discharges have been considered here, since these are the main constituents. Table XIII brings to light the following facts :

- the average activity discharged per unit of energy produced is 60 Ci/GWh. For newer power stations, however, this value is considerably lower, in the region of a few Ci/GWh;

- the wide scatter of the discharge values reflects the variety of reactor types and the disparities in their levels of technological development.

With respect to liquid effluents, it is found that :

- the activity discharged per unit of energy produced is on average about 15 mCi/GWh;

- the scatter of the discharge values, which ranges over several orders of magnitude, is not basically attributable to the type of reactor, but rather to the method of treating the waste before discharge.

REFERENCES

(1) "Radioactive effluents from Nuclear Power Stations in the Community, discharge data; Radiological aspects"
Commission of the European Communities, Directorate General for Social Affairs, Directorate of Health Protection, November 1972.

(2) "Energy Statistics", 1960-1961
Statistical Office of the European Communities, 1972.

(3) "Energy Statistics - United Kingdom, Ireland, Denmark, 1969, 1970, 1971"
Statistical Office of the European Communities, 1972, No. 4.

(4) "Zusammenstellung über die Ableitungen radioaktiver Stoffe bei Kernkraftwerken in der Bundesrepublik Deutschland"
Bundesministerium des Innern, 4 June 1974.

(5) "Radiological Surveillance of the Environment of the Nuclear Power Stations at Kahl, Gundremmingen, Lingen and Obrigheim"
R. Bödege, N. Eickelpasch, A. Gran, W. Stephan
IAEA - SM - 180, Warsaw, November 1973.

(6) "Rejets d'effluents de centrales nucléaires et surveillance de l'environnement", J.J. Martin and P. Beau,
VIe Congrès International de la Société Française de Radioprotection, Bordeaux, 1972 (Exposé VI-SFRP/45).

(7) "Compte rendu annuel des contrôles effectués dans les centrales nucléaires et alentour - Année 1969"
EDF, Direction Production et Transport/Département de Radioprotection (May 1970).

(8) "Compte rendu annuel des contrôles effectués dans les centrales nucléaires et alentour - Année 1970"
EDF, Direction Production et Transport/Département de Radioprotection.

(9) "Compte rendu annuel des contrôles effectués dans les centrales nucléaires et alentour - Année 1971"
EDF, Département de Radioprotection/Direction Production et Transport (April 1972).

(10) "Rapport d'Activité 1972", Annexe IX-B, Prévention des Nuisances d'Exploitation
EDF, Direction de la Production et du Transport, Service de la Production Thermique (July 1973).

(11) "Radiation Protection Experience in Italian Nuclear Power Plants"
M. Cometto et al.
A/CONF. 49/P/191, (1971).

(12) Private Communication from Mr. O. Ilari, C.N.E.N., Italy (Nov. 1972).

(13) "Scarichi radioattivi delle Centrali Nucleari italiane per il 1972"
Comitato Nazionale per l'Energia Nucleare, 16 August and 30 November 1973.

(14) "50 MWe Kernenergiecentrale Dodewaard", Jaarverslag 1970, EUR 4717 n (1971).

(15) Private Communication from Mr. C.J. van Daatselaar, Ministerie van Sociale Zaken, Netherlands (Nov. 1972).

(16) Private Communication from Mr. C.J. van Daatselaar, Ministerie van Sociale Zaken, Netherlands (June 1973, January 1974).

(17) Data provided by the C.E.N., Mol (Nov. 1972, August 1973, September 1973).

(18) Data provided by the C.E.G.B. (October 1973).

(19) "Radioactive Wastes from the Nuclear Power Programme up to the year 2000" ANS Report n° 53, 1973.

(20) "Site Selection for Nuclear Power Plants; Guides for Estimation of Consequences due to the Release of Contaminated Air and Water during normal Operation", H. Bresser et al.,
Proc. of Symp. on the Containment and Sitting of Nuclear Power Plants, IAEA, p. 753-771, (STI/PUB/154), Vienna, 1967.

(21) "Numerical Guides for Design Objectives and limiting Conditions for Operation to meet the Criterion "As low as practicable" for radioactive Material in Light-water-cooled nuclear Power Reactor Effluents"
WASH 1258, July 1973.

(22) "Radioactivity in Surface and Coastal Waters of the British Isles, 1971"
N.T. Mitchell, Technical Report FRL9, July 1973.

(23) "Directives issued by the Council setting the Basic Safety Standards for Protection of the Health of the general Public and Workers against ionizing Radiation", Official Gazette no 11 of 20-2-1959.
Amendments : Official Gazette no 57 of 9-7-1962
Official Gazette no 216 of 26-11-1966.

(24) "Ionizing Radiation : Levels and Effects" UNSCEAR Report, Vol. I "Levels", Annex A, New York, 1972.

TABLE I

GENERAL CHARACTERISTICS OF THE NUCLEAR POWER STATIONS

Facility/Location	Type of reactor (a)	Power level thermal [MWth]	net [MWe]	First link-up with grid	Water body receiving the liquid effluents
GERMANY					
VAK, Kahl (Bavaria)	BWR	60	15	17.06.1961	Main
AVR, Jülich (North-Rhine Westphalia)	GCR	46	13	17.12.1967	Rur
KRB, Gundremmingen (Bavaria)	BWR	801	237	12.11.1966	Danube
MZFR, Karlsruhe (Baden-Wurtemberg)	HWR	200	51	09.03.1966	Rhin
KWL, Lingen (Lower Saxony)	BWR	520	174b)	20.05.1968	Ems
KWO, Obrigheim (Baden-Wurtemberg)	PWR	1 050	328	29.10.1968	Neckar
KWW, Würgassen (North-Rhine Westphalia)	BWR	1 912	640	18.12.1971	Weser
KKS, Stade (Lower Saxony)	PWR	1 900	630	29.01.1972	Elbe
BELGIUM					
BR-3, Mol (Antwerp)	PWR	40	10	28.10.1962	Molse Nete
FRANCE					
EDF-1, Chinon (Indre-et-Loire)	GCR	300	70	14.06.1963	Loire
EDF-2, Chinon (Indre-et-Loire)	GCR	848	200	24.02.1965	Loire
EDF-3, Chinon (Indre-et-Loire)	GCR	1 560	480	04.08.1966	Loire
SENA, Chooz (Ardennes)	PWR	905	270	03.04.1967	Meuse
EL-4, Monts d'Arrée (Finistère)	HWR	240	70	09.07.1967	Ellez
SL-1, St-Laurent-des-Eaux (Loir-et-Cher)	GCR	1 652	480	14.03.1969	Loire
SL-2, St-Laurent-des-Eaux (Loir-et-Cher)	GCR	1 700	515	09.08.1971	Loire
BUGEY, St-Vulbas (Ain)	GCR	1 950	540	15.04.1972	Rhône

TABLE I (continued)

Facility/Location	Type of reactor (a)	Power level thermal [MWth]	net [MWe]	First link-up with grid	Water body receiving the liquid effluents
ITALY					
LATINA, Latina (Latina)	GCR	575	153	12.05.1963	Thyrrhenian Sea
GARIGLIANO, Sessa (Caserta)	BWR	506	152	23.01.1964	Garigliano
TRINO VERCELLESE, Trino Vercellese (Vercelli)	PWR	825	247	22.10.1964	Po
NETHERLANDS					
DODEWAARD, Dodewaard (Gelderland)	BWR	163	52	25.10.1968	Waal
GREAT BRITAIN C.E.G.B. (c)					
BERKELEY, Gloucestershire (England)	GCR	2 x 620	276	06.1962	Severn Estuary
BRADWELL, Essex (England)	GCR	2 x 481	250	06.1962	Blackwater Estuary
HINKLEY POINT "A", Somerset (England)	GCR	2 x 900	460	02.1965	Severn Estuary
TRAWSFYNYDD, Merionetshire (Wales)	GCR	2 x 850	390	01.1965	Lake Trawsfynydd
DUNGENESS "A", Kent (Wales)	GCR	2 x 840	410	09.1965	English Channel
SIZEWELL, Suffolk (England)	GCR	2 x 1010	420	01.1966	North Sea
OLDBURY, Gloucestershire (England)	GCR	730 + 660	400	11.1967	Severn Estuary
WYLFA, Anglesey (Wales)	GCR	2 x 1500	645	12.1971	Irish Sea

a) Type of reactor :

BWR : Boiling Water Reactor
PWR : Pressurized Water Reactor
GCR : Gas-cooled reactor
HWR : Heavy Water Reactor

b) Plus 87.5 MWe by conventional superheating

c) Central Electricity Generating Board (C.E.G.B.)

TABLE II

ANNUAL DISCHARGES OF GASEOUS RADIOACTIVE WASTE (NOBLE GASES)

Country	Facility	Discharge limit [Ci/year]	Activity released (Ci/year)			
			1969	1970	1971	1972
GERMANY	VAK	8.8×10^4	1 750	3 340	2 455	-
	AVR	51.6	18	32	27	30
	KRB	1.9×10^6	11 400	7 350	6 780	11 105
	MZFR a)	3×10^3			526	955
	KWL	3.1×10^6	166 000	114 000	9 000	5 300b)
	KWO	8×10^4	5 560	7 700	1 456	3 202
	KWW	3.2×10^4	-	-	-	594
	KKS	6.1×10^4	-	-	3	2 445
BELGIUM	BR 3			26 680 c)	-	252
FRANCE	Chinon	4×10^5 d)	12 300	8 085	4 225	11 515
	SENA	2.5×10^6 d)	-	3	4 500	31 342
	EL-4	4×10^5 d)	46	72	53 810	144 450f)
	St-Laurent-des-Eaux	4×10^5 d)	1 900	305	3 425	3 863
	Bugey	4×10^5 d)	-	-	-	841
ITALY	Latina	5×10^5 e)	1 500	2 500	2 470	3 660
	Garigliano	3×10^6 e)	140 000	275 000	640 000	290 000
	Trino	5×10^4	-	19	585	1 031
NETHERLANDS	Dodewaard	3×10^5	-	~ 3 000	~ 3 000	8 400
GREAT BRITAIN	CEGB Power Stations : gaseous activity not measured routinely (g)					

a) In addition MZFR discharged the following amounts of tritium into the atmosphere : in 1969 : 1,300 Ci; in 1970 : 1,190 Ci; in 1971 : 1,130 Ci; in 1972 : 542 Ci; the discharge limit is 4,000 Ci/year.

b) Shut-down of the power station for 8 months.

c) Exceptional discharge due to reactor operating experimentally with faulty fuel elements.

d) At this discharge level, assuming an atmospheric dilution factor of 1.5×10^{-5} s/m^3 and a probability of 20 % that the wind is blowing in one direction, the maximum concentration in air at ground level is equal to the MPCP in air.

e) The discharge limits for the Latina and Garigliano power stations correspond to the MPCP in air at ground level. They are being replaced, however, by "discharge formulae" based on analyses of critical groups of the population and on the actual waste discharge needs of the power stations.

TABLE II (continued)

f) In addition, EL 4 discharged 83 Ci of tritium into the atmosphere.

g) In the CEGB power stations, gas activity (A-41) is not systematically measured. Occasional measurements have shown that at the Bradwell, Hinkley Point and Trawsfynydd power stations the annual discharges are approximately 40,000 Ci, 200,000 Ci and 130,000 Ci respectively.

TABLEAU III

TYPICAL RADIONUCLIDE COMPOSITION [%] OF THE NOBLE GASES (1)

<table>
<tr><th>Country/Facility</th><th>A-41</th><th>Kr-85m</th><th>Kr-87</th><th>Kr-88</th><th>Xe-133</th><th>Xe-135</th><th>Xe-138</th></tr>
<tr><td><u>Germany</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>VAK</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>AVR</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>KRB</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>MZFR</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>KWL</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>KWO</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>KWW</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>KKS</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td><u>Belgium</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>BR 3</td><td colspan="4">← 20 →</td><td>50</td><td>30</td><td></td></tr>
<tr><td><u>France</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Chinon</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>SENA</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>EL-4</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>St-Laurent-des-Eaux</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bugey</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td><u>Italy</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Latina</td><td>99</td><td></td><td></td><td></td><td colspan="2">← 1 →</td><td></td></tr>
<tr><td>Garigliano</td><td></td><td>6</td><td>15</td><td>18</td><td>6</td><td>19</td><td>25</td></tr>
<tr><td>Trino</td><td></td><td></td><td></td><td></td><td>99.8</td><td>0.2</td><td></td></tr>
<tr><td><u>Netherlands</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Dodewaard</td><td></td><td></td><td></td><td></td><td>x</td><td></td><td></td></tr>
<tr><td><u>Great Britain</u></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>C.E.G.B. Power Stations</td><td>x</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

1) A cross indicates the predominant nuclide

TABLE IV

ANNUAL DISCHARGE OF RADIOACTIVE AEROSOLS

Country	Facility	Discharge limit [Ci/year]	Activity released (Ci/year) 1969	1970	1971	1972
GERMANY	VAK	88	8.8×10^{-2}	0.13	6.8×10^{-2}	-
	AVR				0.152	0.21
	KRB	2 850	7.6×10^{-3}	7.5×10^{-2}	5.0×10^{-2}	1.4×10^{-2}
	MZFR				$< 1.2 \times 10^{-3}$	1.2×10^{-3}
	KWL	15 800	0.25	0.67		$< 1.4 \times 10^{-2}$
	KWO	(a)	$< 3 \times 10^{-2}$	$< 5 \times 10^{-2}$	5.8×10^{-2}	1.7×10^{-2}
	KWW	10.5	-	-	-	6.5×10^{-3}
	KKS	17.5	-	-	-	1.2×10^{-2}
BELGIUM	BR 3		-	-	-	-
FRANCE	Chinon	1×10^{3} b)	$< 1 \times 10^{-2}$	$< 1 \times 10^{-2}$	18×10^{-3}	7.5×10^{-2}
	SENA	1×10^{3} b)	-	-	-	5×10^{-4}
	EL-4	1×10^{3} b)	$< 2 \times 10^{-3}$		7.3×10^{-2}	6.2×10^{-3}
	St-Laurent-des-Eaux	1×10^{3} b)	< 1	$< 1 \times 10^{-2}$	4.7×10^{-2}	7×10^{-3}
	Bugey	1×10^{3} b)	-	-	-	4×10^{-4}
ITALY	Latina	5×10^{2} c)	-	-	-	-
	Garigliano	3×10^{3} c)	6.3×10^{-2} d)	6.3×10^{-2} d)	6.3×10^{-2} d)	6×10^{-2}
	Trino	0.2	-	$< 1.2 \times 10^{-4}$	$< 1.4 \times 10^{-4}$	1×10^{-5}
NETHERLANDS	Dodewaard	(a)		2×10^{-2}	4×10^{-2}	2×10^{-2}
GREAT BRITAIN	Berkeley	(e)	6.6×10^{-3}	5.7×10^{-3}	5.2×10^{-3}	5.7×10^{-3}
	Bradwell	(e)	3.7×10^{-3}	5.6×10^{-3}	3.2×10^{-3}	3.0×10^{-3}
	Hinkley Point "A"	(e)	2.8×10^{-2}	1.7×10^{-2}	1.3×10^{-2}	4.3×10^{-2}
	Trawsfynydd	(e)	2.2×10^{-2}	2.0×10^{-2}	2.6×10^{-2}	3.4×10^{-2}
	Dungeness "A"	(e)	1.55×10^{-1}	1.25×10^{-1}	1.12×10^{-1}	9.4×10^{-2}
	Sizewell	(e)	1.6×10^{-2}	1.3×10^{-2}	1.1×10^{-2}	8.4×10^{-3}
	Oldbury	(e)	9.1×10^{-3}	2.0×10^{-2}	5.6×10^{-3}	3.2×10^{-2} f)
	Wylfa	(e)	-	-	-	3.2×10^{-3} g)

a) No limit laid down in the operating licence.

b) At this level, assuming an atmospheric dilution factor of 1.5×10^{-5} s/m^3 and a probability of 20 % that the wind is blowing in one direction, the concentration at ground level is equal to the MPCP in air (10^{-9}Ci/m^3).

TABLE IV (continued)

c) For Latina and Garigliano these limits correspond to the MPCP in the air at ground level. They are being replaced, however, by "discharge formulae" based on analyses of critical groups of the population and on the actual waste discharge needs of the power stations.

d) Average value for the years 1969, 1970, 1971.

e) Authorizations for discharge of radioactive gases and aerosols from C.E.G.B. power stations place no limit on the quantities but require that the best practicable means be used to minimize the amount of radioactivity to be discharged.

f) In addition, Oldbury discharged 0.3 Ci of S-35 in 1972.

g) In addition, Wylfa discharged 5.6×10^{-2} Ci of S-35 and 194 Ci of H-3 in 1972.

TABLE V

ANNUAL DISCHARGE OF IODINE-131 INTO THE ATMOSPHERE

Country	Facility	Discharge limit [Ci/year]	Activity released [Ci/year] 1969	1970	1971	1972
GERMANY	VAK	0.61	7×10^{-3}	0.6	2.9×10^{-3}	-
	AVR					
	KRB	22	0.36	0.2	0.35	0.19
	MZFR				-	-
	KWL	16		0.26	0.38	0.15
	KWO	15 a)	6.3×10^{-2}	4.4×10^{-2}	1.5×10^{-2}	6.2×10^{-3}
	KWW		-	-	-	-
	KKS	0.21	-	-	-	4.0×10^{-2}
BELGIUM	BR 3		1×10^{-4}	6.3×10^{-2}	$< 2 \times 10^{-5}$	$< 1 \times 10^{-3}$
FRANCE	Chinon	1.5 b)				2.7×10^{-2}
	SENA	1.5 b)				2.3×10^{-2}
	EL-4	1.5 b)				
	St-Laurent-des-Eaux	1.5 b)				6.5×10^{-2}
	Bugey	1.5 b)				1×10^{-4}
ITALY	Latina	3×10^{3} c)	-	-	-	-
	Garigliano	1×10^{4} c)	-	6×10^{-2}	0.13	6×10^{-2}
	Trino	5×10^{-2}	-	$< 5.9 \times 10^{-4}$	1×10^{-3}	1×10^{-6}
NETHERLANDS	Dodewaard			6.3×10^{-3}	6.3×10^{-3}	6×10^{-3}
GREAT BRITAIN	CEGB power stations d)	e)				

a) During the grazing period, the discharge of iodine-131 is limited to 2.5 mCi per week and 1 mCi per day.

b) Annual permissible discharge based on the milk consumption exposure path.

c) For Latina and Garigliano the limits correspond to the MPCP in the air at ground level. They are being replaced, however, by "discharge formulae" based on analyses of critical groups of the population and on the actual waste discharge needs of the power stations.

d) The discharges of iodine-131 by British power stations are stated to be negligible.

e) Authorizations for the discharge of iodine from the C.E.G.B. power stations place no limit on the quantities, but require that the best practicable means be used to minimize the amount of iodine to be discharged.

TABLE VI

ANNUAL DISCHARGE OF LIQUID RADIOACTIVE EFFLUENTS (EXCLUSIVE OF TRITIUM)

Country	Facility	Discharge limit [Ci/year]	Activity released [Ci/year] 1969	1970	1971	1972
GERMANY	VAK a)	0.6	6×10^{-3}	6.4×10^{-2}	6.0×10^{-2}	2.3×10^{-2}
	AVR b)					9.7×10^{-2}
	KRB	14.4	1.65	1.52	1.89	1.54
	MZFR c)					
	KWL	5.4	0.65	0.60	0.38	0.11
	KWO		10.5	3	4.4	3.33
	KWW	17	-	-	-	1.8
	KKS	5	-	-	-	0.63
BELGIUM	BR 3 d)					
FRANCE	Chinon	900 e)	7.44	2.25	2.0	3.0
	SENA	100 e)	3.8	6.4	34.4	12.4
	EL-4	4 e)	2.7×10^{-2}	6×10^{-3}	0.1	0.22
	St-Laurent-des-Eaux	800 e)	2.71	0.77	2.25	9.4
	Bugey	680 e)	-	-	-	3.9×10^{-2}
ITALY	Latina	1.6×10^{3} f)	29.6	10.2	1.5	16.5
	Garigliano	5×10^{3} f)	9	11.9	19.1	14.4
	Trino	21	3.09	2.96	19.07	6.0
NETHERLANDS	Dodewaard	2.6	0.5	2.33	1.6	2.03
GREAT BRITAIN	Berkeley	200 g)	55.1	23.2	15.0	23.3
	Bradwell	200 g)	113	129	82.9	118.9
	Hinkley Point "A"	200 g)	194	128	161	147.4
	Trawsfynydd	40 g)	10.8	13.5	22.8	31.4
	Dungeness "A"	200 g)	181	83.7	29.4	29.0
	Sizewell	200 g)	9.91	23.4	12.6	14.6
	Oldbury	100 g)	2.32	7.74	2.54	5.2
	Wylfa	65 g)	-	6.32h)	0.31	0.30

a) Including effluents from the experimental power station HDR-Grosswelzheim.

b) The liquid waste from AVR is transferred to the decontamination plant at Jülich Nuclear Centre (KFA), which discharged 0.41 Ci to the Rur in 1972, of which 9.7×10^{-2} Ci originated from AVR.

TABLE VI (continued)

c) Liquid waste from MZFR is transferred to the decontamination plant at Karlsruhe Nuclear Centre (GfK), which discharges into the Rhine.

d) Liquid waste from BR-3 is transferred to the decontamination plant of Mol Nuclear Centre (C.E.N.), which discharges into the Molse Nete.

e) Values inferred from a MPCP in drinking water of 10^{-7} Ci/m^3 (any mixture of alpha, beta, gamma emitters from which Ra-226 and Ra-228 can be excluded) and the annual flow of water body; at SENA a discharge formula is applied.

f) Discharge limits for the Latina and Garigliano power stations correspond respectively to 1/3 and the MPCP in drinking water, measured in the cooling water discharge channels. These limits are being replaced, however, by "discharge formulae" based on analyses of critical groups of the population and on the actual waste discharge needs of the power stations.

g) The discharge limits are laid down according to the waste discharge needs of each power station, but within the maximum permissible discharge limit as estimated by the "critical path" approach.

h) Mainly Br-82 used in radioactive tracer tests.

TABLE VII

METHODS OF DETERMINING GROSS RADIOACTIVITY (EXCLUSIVE OF TRITIUM) DISCHARGED IN LIQUID EFFLUENTS

Country/Facility	Activity measured	Method of assessment	Reference nuclide
GERMANY			
VAK	Gamma	Gamma spectrometry with NaI(Tl)	Cs-137
AVR	Beta	Methane proportional counting	
KRB	Gamma in 1972 : beta	Gamma spectrometry with NaI(Tl)	Cs-137
KWL	Gamma	Gamma spectrometry with NaI(Tl)	Cs-137
KWO	Gamma	Gamma spectrometry with NaI(Tl)	Cs-137
KWW	Gamma	Gamma spectrometry with NaI(Tl)	Cs-137
KKS	Gamma	Gamma spectrometry with NaI(Tl)	Cs-137
FRANCE	Beta	Proportional counting	Sr-90 Y-90
ITALY			
Latina	Alpha Beta Gamma	Alpha spectrometry End window GM counting or plastifluor scintillation counting Gamma spectrometry with Ge(Li) and NaI(Tl)	
Garigliano	Gamma	Gamma spectrometry with Ge(Li) and NaI(Tl)	
Trino	Gamma	Gamma spectrometry with Ge(Li) and NaI(Tl)	
NETHERLANDS			
Dodewaard	Beta	GM counting	
GREAT BRITAIN			
Berkeley	Alpha + beta	Windowless gas flow GM counting	Cs-137
Bradwell	Alpha + beta	Windowless gas flow GM counting	Cl-36
Hinkley Point "A"	Alpha + beta	Windowless gas flow GM counting	Cl-36
Trawsfynydd	Alpha + beta	Windowless gas flow GM counting	Cs-137
Dungeness "A"	Alpha + beta	GEL scintillation counting	S-35
Sizewell	Alpha + beta	Liquid scintillation counting	C-14
Oldbury	Alpha Hard beta (Emax > 170 KeV) Soft beta (Emax < 170 KeV)	Scintillation counting Windowless gas flow GM counting Liquid scintillation counting	U-nat. C-14
Wylfa	Alpha + beta	Liquid scintillation counting	C-14

TABLE VIII

RADIONUCLIDES IDENTIFIED IN LIQUID EFFLUENTS IN 1972 (AS A PERCENTAGE OF THE TOTAL DISCHARGE) (EXCLUSIVE OF TRITIUM) a)

Nuclide	GERMANY b)					
	VAK	KRB	KWO	KWL	KWW	KKS
Cr-51			5.72	0.55		1.38
Mn-54	0.05	0.68	2.22		5.03	0.98
Fe-59						0.25
Co-57	0.02		0.02			0.01
Co-58	0.01	2.73	24.45		79.08	25.20
Co-60	6.97	2.15	20.76	24.58	13.17	1.25
Sr-89	13.39	58.94	0.09	0.79	0.73	0.18
Sr-90	46.41	5.46	0.03	0.39	0.03	0.01
Zr-95				0.62		
Nb-95	0.08	0.14	0.03	1.51		0.03
Ag-110m		0.68				0.21
Sb-124		0.08	1.50	0.44		9.17
Sb-125	0.13	0.01				
I-131	0.23	9.05	2.64	11.28		47.89
Cs-134	0.57	7.05	14.55	15.95		2.07
Cs-137	29.16	12.39	27.75	33.54		7.07
La-140		0.15	0.24			
Ce-141		0.08		3.77	1.34	
Ce-144	2.98	0.41		6.58	0.62	4.40

a) A dash "-" in the table corresponds to non-detectable activity

b) Results of measurements by the "Institut für Wasser-, Boden-, und Lufthygiene" of the Bundesgesundheitsamt, Berlin.

Table VIII (continued 1)

Nuclide	FRANCE					ITALY		
	Chinon	SENA	EL-4	St-Laurent	Bugey	Latina	Garigliano	Trino
P-32						1.15		
S-35						1.70		
Ca-45						0.43		
Mn-54		0.33						
Co-58		0.58					6.51	3.19 d)
Co-60		14.56				0.12 c)	21.0	7.71
Sr-89							4.97	
Sr-90		1.27				3.47	0.69	
Zr-95-Nb-95		0.19						
I-131		21.87					2.38	58.7
Cs-134		30.83				31.0	20.3	13.9
Cs-137		30.16				62.1	44.1	16.4
Total alpha		0.006						

c) Co-60 + Fe-59

d) Co-58 + Mn-54

TABLE VIII (continued 2)

Nuclide	GREAT BRITAIN						
	Berkeley	Bradwell	Hinkley	Trawsfynydd	Dungeness	Sizewell	Oldbury
P-32	0.8	0.5	< 0.1	0.3	0.2	2.0	< 0.1
S-35	20.0	[illegible]	0.2	7.8	23.2	26.0	29.8
Ca-45	1.6	0.2	< 0.1	0.1	1.0	6.6	1.2
Fe-55	0.2	0.1	0.8	0.2	1.9	1.0	0.1
Co-58	< 0.1	0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1
Co-60	0.1	0.3	0.1	< 0.1	0.1	0.1	< 0.1
Sr-89	5.0	< 0.1	4.3	0.6	1.2	2.1	2.4
Sr-90	6.1	16.1	18.5	3.7	4.3	5.8	10.1
Y-90	6.1	16.1	18.5	3.7	4.3	5.8	10.1
Ru-106	0.8	4.6	6.2	2.6	0.3	0.1	< 0.1
Rh-106	0.8	4.6	6.2	2.6	0.3	0.1	< 0.1
Sb-125	0.6	6.1	8.9	47.7	0.8	0.5	0.5
Ce-144	1.2	4.3	5.7	0.9	0.3	0.2	0.1
Cs-134	8.6	6.3	2.4	3.0	10.2	6.4	6.6
Cs-137	44	25.1	13.6	12.4	49.3	40.7	38.1
Pr-144	1.2	4.3	5.7	0.9	0.3	0.2	< 0.1
Pm-147	1.6	1.8	6.3	0.5	0.5	0.4	0.3
Total alpha	0.1	0.3	0.2	< 0.1	< 0.1	< 0.1	< 0.1

TABLE IX

ANNUAL TRITIUM DISCHARGE IN LIQUID EFFLUENTS

Country	Facility	Discharge limit [Ci/year]	Activity released [Ci/year] 1969	1970	1971	1972
GERMANY	VAK a)	480 b)			1.43	3.45
	AVR c)					42.46
	KRB	432 b)	17.8		45.60	90.23
	MZFR d)					
	KWL		26	31.7		23.7
	KWO		328		311.1	319.77
	KWW	300	-	-	-	4.59
	KKS	1 600	-	-	-	101.4
BELGIUM	BR-3 e)					
FRANCE	Chinon					
	SENA			340	706	1 762
	EL-4	1.5×10^5 f)				5
	St-Laurent-des-Eaux					
	Bugey		-	-	-	
ITALY	Latina	2.5×10^5 g)	25.2	16.7	13	16.9
	Garigliano	5×10^5 g)	7.0	5.0	5.0	3.0
	Trino	5×10^3	-	135	1 117	1 078
NETHERLANDS	Dodewaard			2.37		2.5
GREAT BRITAIN	Berkeley	1 500	60.5	60.1	43.1	44.2
	Bradwell	1 500	183	95.3	102	251.
	Hinkley Point "A"	2 000	35.3	18.6	24.9	38.6
	Trawsfynydd	2 000	233	67.7	41.9	46.0
	Dungeness "A"	2 000	72.2	18.6	35.5	28.9
	Sizewell	3 000	9.56	20.9	77.0	53.2
	Oldbury	2 000	16.4	17.3	64.4	15.0
	Wylfa	4 000	-	0.551	30.2	82.7

a) Including effluent from the experimental power station HDR-Grosswelzheim

b) Figure derived from the monthly limit

c) Liquid waste from AVR is transferred to the decontamination plant of Jülich nuclear centre (KFA), which discharged 50.23 Ci of H-3 in 1972, of which 42.46 originated from AVR.

TABLE IX (continued)

d) Liquid waste from MZFR is transferred to the decontamination plant of Karlsruhe Nuclear Centre (GfK).

e) Liquid waste from BR-3 is transferred to the decontamination plant of Mol Nuclear Centre (C.E.N.).

f) Value inferred from the MCP in drinking water of 3×10^{-3} Ci/m^3 and from the annual flow of the watercourse.

g) The discharge limits for the Latina and Garigliano power stations correspond respectively to 1/3 and to the MPCP in drinking water, measured in the cooling water discharge channel. These limits are being replaced, however, by "discharge formulae" based on analyses of critical groups of the population and on the actual waste discharge needs of the power stations.

TABLE X

MAXIMUM EXPOSURE FROM GASEOUS EFFLUENTS IN 1972 (NOBLE GASES AND IODINE-131) 0.5 AND 5 KM FROM THE POINT OF DISCHARGE

Country Facility	Average annual atmospheric dilution factor [s/m³] at 0.5 km	Average annual atmospheric dilution factor [s/m³] at 5 km	Dose [mrem] at 0.5 km: Whole body (a)	Dose at 0.5 km: Skin (b)	Dose at 0.5 km: Thyroid (c)	Dose at 5 km: Whole body (a)	Dose at 5 km: Skin (b)	Dose at 5 km: Thyroid (c)
GERMANY								
VAK	$1x10^{-6}$	$2x10^{-7}$						-
AVR	$1x10^{-6}$	$2x10^{-7}$	$9.1x10^{-3}$	$1.3x10^{-2}$		$1.8x10^{-3}$	$2.7x10^{-3}$	
KRB	$2x10^{-7}$	$5x10^{-8}$	$1.5x10^{-2}$	$4.2x10^{-2}$	6	$3.9x10^{-3}$	$1.0x10^{-2}$	1.5
MZFR	$2.3x10^{-7}$	$6x10^{-8}$	$1.5x10^{-3}$	$4.2x10^{-2}$		$4.0x10^{-4}$	$1.1x10^{-3}$	-
KWL	$9.5x10^{-8}$	$2.6x10^{-8}$	$3.5x10^{-3}$	$9.7x10^{-3}$	2.3	$9.6x10^{-4}$	$2.7x10^{-3}$	0.6
KWO	$7x10^{-7}$	$1.3x10^{-7}$	$1.5x10^{-2}$	$4.3x10^{-2}$	0.7	$2.8x10^{-3}$	$7.9x10^{-3}$	0.1
KWW	$5x10^{-7}$	$1.2x10^{-7}$	$2.0x10^{-3}$	$5.7x10^{-3}$		$5.0x10^{-4}$	$1.4x10^{-3}$	-
KKS	$4x10^{-7}$	$9x10^{-8}$	$6.8x10^{-3}$	$1.9x10^{-2}$	2.5	$1.5x10^{-3}$	$4.2x10^{-3}$	0.6
BELGIUM								
BR-3	$7.8x10^{-7}$ d)	$7.3x10^{-8}$ a)	$2x10^{-2}$	$3.9x10^{-2}$	0.1	$1.9x10^{-3}$	$3.6x10^{-3}$	$1x10^{-2}$
FRANCE								
Chinon	$1x10^{-6}$	$2x10^{-7}$	3.6	5.2	4.3	0.7	1.0	0.8
SENA	$6x10^{-6}$	$4x10^{-7}$	1.3	3.6	22	$8.5x10^{-2}$	0.23	1.5
EL-4	$5x10^{-7}$	$1x10^{-7}$	22	32		4.4	6.4	
St-Laurent-des-Eaux	$4x10^{-7}$	$9x10^{-8}$	0.47	0.69	4.1	0.10	0.15	0.9
Bugey	$3x10^{-7}$	$8x10^{-8}$	$7.7x10^{-2}$	0.11	$4.8x10^{-3}$	$2.0x10^{-2}$	$2.9x10^{-2}$	$1.3x10^{-3}$
ITALY								
Latina	$4.6x10^{-7}$ d)	$8x10^{-8}$ d)	0.51	0.74	-	$8.9x10^{-2}$	0.13	-
Garigliano	$5.1x10^{-7}$ d)	$8x10^{-8}$ d)	33.5	54	4.9	5.3	8.4	0.8
Trino	$4.85x10^{-7}$ d)	$1.8x10^{-7}$ d)	$3.5x10^{-3}$	$9.7x10^{-3}$	$8.2x10^{-5}$	$1.3x10^{-3}$	$3.6x10^{-3}$	$2.9x10^{-5}$
NETHERLANDS								
Dodewaard	$6.1x10^{-8}$	$3.6x10^{-8}$	$3.5x10^{-3}$	$9.7x10^{-3}$	$5.8x10^{-2}$	$2.1x10^{-3}$	$5.8x10^{-3}$	$3.4x10^{-2}$

a) From external gamma irradiation

b) From external beta + gamma irradiation

c) Dose to the thyroid of an infant consuming milk produced at this point

d) Experimental value

TABLE XI

AVERAGE ACTIVITY CONCENTRATION (EXCLUSIVE OF TRITIUM) ADDED TO THE RECEIVING WATERCOURSE

Country	Facility	Receiving watercourse	Average flow rate [m^3/s]	Added activity concentration a) 1969 [Ci/m^3]	1969 [% MPCP]	1970 [Ci/m^3]	1970 [% MPCP]	1971 [Ci/m^3]	1971 [% MPCP]	1972 [Ci/m^3]	1972 [% MPCP]
GERMANY	VAK	Main	150	1.3×10^{-12}	1.3×10^{-3}	1.5×10^{-11}	1.5×10^{-2}	1.3×10^{-11}	1.3×10^{-2}	4.9×10^{-12}	4.9×10^{-3}
	AVR	Rur	16							1.9×10^{-10}	0.19
	KRB	Danube	147	3.6×10^{-10}	0.36	3.3×10^{-10}	0.33	4.1×10^{-10}	0.41	3.3×10^{-10}	0.33
	KWL	Ems	38	5.4×10^{-10}	0.54	5×10^{-10}	0.5	2.5×10^{-10}	0.25	9.2×10^{-11}	9.2×10^{-2}
	KWO	Neckar	124	2.7×10^{-9}	2.7	8×10^{-10}	0.8	1.2×10^{-9}	1.2	8.5×10^{-10}	0.85
	KWW	Weser	129	-	-	-	-	-	-	4.4×10^{-10}	0.44
	KKS	Elbe	480	-	-	-	-	-	-	4.2×10^{-11}	4.2×10^{-2}
FRANCE	Chinon	Loire	500	5.7×10^{-10}	0.57	1.4×10^{-10}	0.14	1.3×10^{-10}	0.13	1.9×10^{-10}	0.19
	SENA	Meuse	116	1×10^{-9}	1	1.8×10^{-9}	1.8	9.5×10^{-9}	9.5	3.4×10^{-9}	3.4
	EL-4	Ellez	2	4.3×10^{-10}	0.43	9.6×10^{-11}	9.6×10^{-2}	1.6×10^{-9}	1.6	3.5×10^{-9}	3.5
	St-Laurent-des-Eaux	Loire	357	2.4×10^{-10}	0.24	7×10^{-11}	7×10^{-2}	2×10^{-10}	0.2	8.4×10^{-10}	0.84
	Bugey	Rhone	500	-	-	-				2.5×10^{-12}	2.5×10^{-3}
ITALY	Latina	Tyrrhenian Sea									
	Garigliano	Garigliano b)		2.4×10^{-9}	2.4	2.8×10^{-9}	2.8	5.5×10^{-9}	5.5	3.7×10^{-9}	3.7
	Trino	Po c)		4.7×10^{-10}	0.47	8.4×10^{-10}	0.84	3.4×10^{-9}	3.4	5.2×10^{-10}	0.52
NETHERLANDS	Dodewaard	Waal	1 300	1.4×10^{-11}	1.4×10^{-2}	5.7×10^{-11}	5.7×10^{-2}	3.9×10^{-11}	3.9×10^{-2}	5.0×10^{-11}	5.0×10^{-2}

a) Average activity concentration due to liquid radioactive effluents from the power station in question, at the place of discharge after uniform dilution in the watercourse, expressed in (Ci/m^3) and as a percentage of the MPCP of any mixture of radionuclides (excluding Ra-226 and Ra-228) in drinking water (10^{-7} Ci/m^3).

b) Average flow rate in 1969 : 120 m^3/s, in 1970 : 134 m^3/s, in 1971 : 110 m^3/s, in 1972 : 125 m^3/s.

c) Average flow rate in 1969 : 203 m^3/s, in 1970 : 112 m^3/s, in 1971 : 175 m^3/s, in 1972 : 363 m^3/s.

TABLE XII

AVERAGE TRITIUM CONCENTRATION ADDED TO THE RECEIVING WATERCOURSE

Country	Facility	Receiving watercourse Average flow rate $[m^3/s]$		Added activity concentration a) 1969 $[Ci/m^3]$	1969 [% MPCP]	1970 $[Ci/m^3]$	1970 [% MPCP]	1971 $[Ci/m^3]$	1971 [% MPCP]	1972 $[Ci/m^3]$	1972 [% MPCP]
GERMANY	VAK	Main	150					$3x10^{-10}$	$1x10^{-5}$	$7.3x10^{-10}$	$2.4x10^{-5}$
	AVR	Rur	16							$8.4x10^{-8}$	$2.8x10^{-3}$
	KRB	Danube	147	3.[illegible]x10^{-9}	$1.3x10^{-4}$			$6.2x10^{-9}$	$2.1x10^{-4}$	$1.9x10^{-8}$	$6.3x10^{-4}$
	KWL	Ems	38	$2.2x10^{-8}$	$7.4x10^{-4}$	$2.7x10^{-8}$	$9x10^{-4}$				
	KWO	Neckar	124	$8.4x10^{-8}$	$2.8x10^{-3}$					$8.2x10^{-8}$	$2.7x10^{-3}$
	KWW	Weser	129	-	-	-	-	-	-	$9.3x10^{-10}$	$3.1x10^{-5}$
	KKS	Elbe	480	-	-	-	-	-	-	$6.7x10^{-9}$	$2.2x10^{-4}$
FRANCE	Chinon	Loire	500								
	SENA	Meuse	116			$9.3x10^{-8}$	$3.1x10^{-3}$	$2.1x10^{-7}$	$7x10^{-3}$	$4.8x10^{-7}$	$1.6x10^{-2}$
	EL-4	Ellez	2							$7.9x10^{-8}$	$2.6x10^{-3}$
	St-Laurent-des-Eaux	Loire	357								
	Bugey	Rhone	500								
ITALY	Latina	Thyrrhenian Sea									
	Garigliano	Garigliano b)		$1.9x10^{-9}$	$6.3x10^{-5}$	$1.2x10^{-9}$	$4x10^{-5}$	$1.5x10^{-9}$	$5x10^{-5}$	$7.6x10^{-10}$	$2.5x10^{-5}$
	Trino	Po c)		-	-	$3.8x10^{-8}$	$1.3x10^{-3}$	$2x10^{-7}$	$7x10^{-3}$	$9.4x10^{-8}$	$3.1x10^{-3}$
NETHERLANDS	Dodewaard	Waal	1 300			$5.8x10^{-11}$	$1.9x10^{-6}$			$6.1x10^{-11}$	$2.0x10^{-6}$

a) Average concentration due to tritium discharge from the power station at the place of release after uniform dilution in the watercourse, expressed in (Ci/m^3) and as a percentage of the MPCP in drinking water $(3 \times 10^{-3}\ Ci/m^3)$.

b) Average flow rate in 1969 : 120 m^3/s, in 1970 : 134 m^3/s, in 1971 : 110 m^3/s, in 1972 : 125 m^3/s.

c) Average flow rate in 1969 : 203 m^3/s, in 1970 : 112 m^3/s, in 1971 : 175 m^3/s, in 1972 : 363 m^3/s.

TABLE XIII

RADIOACTIVE WASTE DISCHARGE AND ELECTRICAL ENERGY PRODUCED

Country	Facility	Gross electricity production		Ratio of activity released to energy produced	
				Gaseous waste (noble gases)	Liquid waste (excluding tritium)
		Year	[GWh]	[Ci/GWh]	[mCi/GWh]
GERMANY	VAK	1969	90	20	0.07
		1970	116	29	0.55
		1971	115	22	0.52
		1972	-		
	AVR	1969	73	0.25	
		1970	95	0.34	
		1971	98	0.28	
		1972	99	0.30	1.0
	KRB	1969	1 260	9.0	1.3
		1970	1 844	4.0	0.8
		1971	1 991	3.3	0.9
		1972	1 820	6.1	0.8
	MZFR	1971	334	1.57	
		1972	435	2.20	
	KWL	1969	1 351	123	0.5
		1970	1 008	113	0.6
		1971	1 011	8.9	0.3
		1972	530	10	0.2
	KWO	1969	1 990	2.8	5.3
		1970	2 533	3.0	1.2
		1971	2 257	0.7	2.0
		1972	2 402	1.3	1.4
	KWW	1972	573	1.1	3.1
	KKS	1972	3 280	0.75	0.2
BELGIUM	BR-3	1969	22		
		1970	57	468	
		1971	-	-	
		1972	11	23	

TABLE XIII (continued 1)

Country	Facility	Gross electricity production		Ratio of activity released to energy produced	
				Gaseous waste (noble gases)	Liquid waste (excluding tritium)
		Year	[GWh]	[Ci/GWh]	[mCi/GWh]
FRANCE	Chinon	1969	3 164	4.0	2.3
		1970	3 611	2.2	0.62
		1971	3 408	1.2	0.59
		1972	4 351	2.6	0.69
	St-Laurent-des-Eaux	1969	1 120	1.7	2.4
		1970	138	1.8	4.5
		1971	3 156	1.1	0.71
		1972	5 765	0.7	1.6
	SENA	1969	-		
		1970	1 313	2.3×10^{-3}	4.9
		1971	1 930	2.3	18
		1972	2 140	14.5	5.8
	EL-4	1969	-		
		1970	-		
		1971	176	300	0.57
		1972	513	280	0.43
	Bugey	1972	1 139	0.7	0.03
ITALY	Latina	1969	497	3.0	60
		1970	1 191	2.1	8.5
		1971	1 845	1.3	0.8
		1972	1 204	3.0	14
	Garigliano	1969	1 182	119	7.6
		1970	742	370	16
		1971	1 164	550	16
		1972	426	665	33
	Trino	1969	-		
		1970	1 243	1.5×10^{-2}	2.4
		1971	1 356	0.4	14
		1972	1 986	0.5	3.0
NETHERLANDS	Dodewaard	1969	315		1.6
		1970	368	8.1	6.4
		1971	405	7.4	4.0
		1972	326	25.8	6.2

TABLE XIII (continued 2)

Country	Facility	Gross electricity production Year	[GWh]	Ratio of activity released to energy produced: Gaseous waste (noble gases) [Ci/GWh]	Liquid waste (excluding tritium) [mCi/GWh]
GREAT BRITAIN a)	Berkeley	1969	2 522		22
		1970	2 581		9.0
		1971	2 525		5.9
		1972	2 318		10.0
	Bradwell	1969	2 382		47
		1970	1 871		69
		1971	1 809		44
		1972	2 123		56
	Trawsfynydd	1969	3 172		3.4
		1970	3 339		4.0
		1971	3 468		6.5
		1972	2 802		11
	Hinkley Point "A"	1969	3 615		54
		1970	1 481		86
		1971	771		208
		1972	3 530		42
	Dungeness "A"	1969	3 679		49
		1970	3 221		26
		1971	3 449		8.5
		1972	3 351		8.7
	Sizewell	1969	3 401		2.9
		1970	3 710		6.3
		1971	3 973		3.2
		1972	3 236		4.5
	Oldbury	1969	2 563		0.9
		1970	2 792		2.8
		1971	3 186		0.8
		1972	2 754		1.9
	Wylfa	1969	-		
		1970 b)	90		70
		1971	3 050		0.1
		1972	2 948		0.1

a) The values quoted are given per financial year.

b) Discharge relatively high owing to use of Br-82 as tracer.