COMMISSION OF THE EUROPEAN COMMUNITIES

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REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT

The Chernobyl Nuclear Power Plant Accident and its Consequences in the Framework of the European Community

- October 1986 -

COM. 607

PREAMBLE

In its Framework Communication[1] on the consequences of the Chernobyl accident, the Commission reviewed the policy implications of those events and declared its intentions with respect to necessary actions to be taken. Since the communication a number of the actions foreseen have already been taken (e.g. the publication of the Commission's proposals for development of measures for application of Chapter III of the Euratom Treaty (COM (86) 434)); other actions are in course of preparation.

The foregoing activities and communications relate to policy questions and initiatives. Hitherto, the Commission has not published any general description of the events before and after the accident, which constitute the background against which actions in the Community framework are set. This communication fulfils that purpose. Its nature is purely descriptive, intended to provide the reader with a general orientation. The document does not have any policy implications - these being reserved to the other communications foreshadowed in the Framework Communication.

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(1) COM (86) 327 final

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1. INTRODUCTION

On 26 April 1986 a major accident in the No. 4 Unit at the Chernobyl nuclear power plant set in train a sequence of damaging events whose impact, although most severe in the Soviet Union, extended throughout Europe and beyond. Initially, information on all of the multitudinous events precipitated by the accident was limited, particularly as regards conditions and activities in the region surrounding the damaged reactor. Because of this lack of public information, the Commission was requested to prepare a report on the various events related to the accident which have relevance to the interests of the Community and its citizens. This report has been prepared in response to that request. Information sufficient to allow a balanced report to be made did not become available to the Commission until the major information release made by the Soviet delegation to the IAEA post accident review meeting, 25-29 August.

The report gives summary accounts of the principal events in the accident and post-accident periods, both in the Soviet Union and in the Community. The time period reported, from the time of the accident until late September is divided between the period of tactical response to the accident induced events and the later period of strategic actions intended to reduce future accident probability and improve the Community's capability to deal speedily and effectively with the consequences of any nuclear accident which might take place. Some discussion of issues for the future is included.

The report concentrates upon events and actions directly related to the Chernobyl accident and its effects. It covers only part of the range of issues raised in the Commission's Framework Communication(1).

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(1) COM (86) 327 final - referred to here and hereafter as "the Framework Communication".

2. THE NUCLEAR CONTEXT

2.1. The Status of Nuclear Energy in the USSR and Eastern Europe

At present, the installed nuclear capacity in the USSR has reached 30 GWe. Nuclear power plants produce close to 15% of the total electricity requirement. A further capacity of 29 GWe is reported to be under construction. Most of the plants are located in the European region of the USSR, which has only very limited fossil fuel resources and where the cost of transporting fossil materials from Siberia and the Asian territories is felt to be prohibitive.

The Soviet nuclear programme is mainly based on two reactor types : graphite-moderated boiling water cooled reactors (RBMKs), such as Chernobyl, and pressurised light-water moderated and cooled reactors (VVERs). RBMK reactors have not been exported by the USSR.

According to the Soviet Union's energy programme, nuclear power should cover most of the economy's increased requirements; maximum possible use of nuclear fuel for centralising heating and industrial heat is planned. It is expected that nuclear power will be developed extremely rapidly in the European part of the country and in the Urals. The nuclear power plants being built in USSR are based on the VVER 1000 (PWR, 1000 MWe), RBMK (including increased power versions), fast breeder reactors and possibly HTGR types.

The COMECON countries, with the exception of Rumania which ordered two reactors from Canada, have signed a multilateral specialisation and co-production agreement with the USSR for the mutual supply of nuclear power plant equipment.

Nuclear reactors are operating at present in Bulgaria, Czechoslovakia, the German Democratic Republic and Hungary. The total capacity amounts to 6,7 GWe. A further capacity of 8,2 GWe is reported to be under construction, with Poland and Rumania joining the countries already mentioned. With the exception of Rumania, these nuclear programmes are all based on the Soviet VVER reactor type.

2.2. The Status of Nuclear Energy in the European Community

Although the position in the different Member States varies considerably, nuclear energy is used for electricity production on a large scale in the European Community.

Belgium, the Federal Republic of Germany, Spain, France, Italy, the Netherlands and the United Kingdom rely in varying degrees on nuclear energy. Denmark, Greece, Ireland, Luxembourg and Portugal do not.

The most common reactor type is the light water reactor (pressurised or boiling). Gas graphite reactors and fast breeder reactors are used to a lesser extent.

The contribution of nuclear energy has grown impressively since the first oil price shock in 1973, when nuclear power plants accounted for only 5 per cent of net electricity production. By 1986, the nuclear share will have multiplied by a factor of 7 to account for 35 per cent of electricity, or more than 13 per cent of total energy consumption. Nuclear capacity currently amounts to 73 GWe, more than twice that currently operational in the USSR and provides the energy equivalent of more than 100 million tonnes of oil per year.

Further nuclear installations with a total capacity of 30 GWe are under construction.

It is expected that nuclear energy will contribute 40% to electricity generation by 1990. Taking account of the substantial part played by nuclear power on the Community's energy supply, the Council agreed in its Resolution of 16 September 1986 (2) that, on the basis of the highest standards of safety, appropriate measures must ensure that all aspects of planning, construction and operation of nuclear installations fulfil optimal safety conditions.

2.3. The Status of Nuclear Energy in Other European Countries

With particular regard to Western European countries outside the Community, there is a considerable use of nuclear energy in Switzerland, Sweden and Finland.

In Switzerland, five nuclear power stations are in operation; the total installed nuclear capacity reaches 2,900 MWe.

In Sweden, the nuclear programme has been statutorily restricted in scope, but it is very substantial: 12 reactors currently provide an installed capacity of 9450 MWe, some 60% of total generating capacity. The decision has been taken to phase out the use of nuclear power by 2010.

Finland has four nuclear power plants at its disposal, with a total capacity of 2200 MWe.

Norway and Austria, on the contrary, do not use nuclear energy.

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(2) Doc 7466/86 ENER 38 of 12 September 1986

3. THE EVENTS OF THE ACCIDENT AND ITS IMMEDIATE CONSEQUENCES

3.1. The Soviet Report on the Chernobyl Accident

This is a summary of the conference document submitted by the Soviet delegation to the IAEA post-accident review meeting 25-29 August and based upon material assembled by the Soviet Government Commission on the causes of the accident at the fourth unit of the Chernobyl Nuclear Power Plant and on its consequences. Comments and interpretations by the Commission services have been reduced to the minimum required for clarity.

a) Events Leading to the Accident

The accident took place on 26 April 1986 at 1.23 a.m. prior to shutdown of the unit for planned maintenance, during the execution of a test. There was a sudden power surge in the reactor due to introduction of excess reactivity, leading to the destruction of the reactor and part of the building in which it was housed and to the release into the atmosphere of part of the radioactive fission products which had accumulated in the core.

The Chernobyl Nuclear Power Plant (NPP) consists of four operating units and two units in construction. Each unit is equipped with a reactor type RBMK 1000, having a thermal power output of about 3200 MW; the corresponding electric power is 1000 MW. The RBMK 1000's main features are : core composed of vertical channels containing the fuel rods cooled by boiling light-water, graphite moderator between the channels, forced circulation coolant loop, steam generated directly and fed to the two 500 MWe turbogenerators.

Confinement of radioactive emission in accidents involving loss of integrity of components of the coolant circulation loop is provided by locating most of these components in reinforced over-pressure resistant compartments of the main reactor building.

Over the period 1973 to 1985, 14 RBMK-1000 reactors were put in operation, with a power generating capacity of 13,000 MWe (out of a total of nuclear generating capacity in USSR of 30,000 MWe).

The fourth unit of the Chernobyl NPP went into operation in December 1983. At the fuel burn-up conditions existing when the accident occurred, the void coefficient of the reactor core was positive (i.e. an increase of the steam content in the water flowing through the channels causes a simultaneous increase of the neutron flux and, as a consequence, of the energy produced in the fuel); this physical characteristic, very important from the standpoint of reactor control and safety, had a leading role in the accident dynamics[3].

The aim of the planned test was to verify the possibility of utilising the electric energy produced by a turbogenerator during its run-down, following its cut-off from the steam supply, to sustain temporarily the unit's essential electrical loads up to the start up

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(3) The RBMK is not the only important type of reactor with a positive void coefficient; however it is the only such reactor type designed to have a boiling coolant.

of the emergency diesel generators. Similar tests had already been carried out at the Chernobyl plant. The working programme to perform this test had not been properly prepared and had not received the requisite approval; safety aspects had not received the necessary attention. The operating staff were not adequately prepared for the test and had not been made aware of the possible dangers. Moreover the staff departed from the programme during execution of the test and thereby created the conditions for the accident.

b) Main Steps of the Accidental Sequence

- On 25 April at 0100 hours, commencement of decreasing the reactor power, to prepare the unit for the tests and the planned shut-down.

- At 1400 hours, when the reactor thermal power was 1600 MW, one turbogenerator having been stopped, the emergency core cooling system (ECCS) was switched off, in accordance with the test programme. However, the preparation of the unit for the test was suspended until 2310 hours because of a request from the competent electricity supply grid control office for continuation of electrical power supply from Chernobyl no. 4. The unit continued operation with the ECCS isolated, in violation of the operating rules.

- At 2310 hours, the power decrease was resumed, to meet the reference value for the test, i.e. a thermal power of 700-1000 MW.

- On 26 April, at 0028 hours, the operator having switched off the local power control system, had difficulty in controlling reactor thermal power, which dropped below 30 MW. Only at 0100 hours could the reactor be brought to 200 MW; a further increase towards the level specified for the test was hindered by the smallness of the excess reactivity of the core, due to the continuing "poisoning" of the core consequent upon the previous drop of the power to very low levels. The excess reactivity at this moment was substantially below the level specified in operating regulations; even so, it was decided to continue the test, in violation of the requirements both of the test programme and of the operating rules.

- At 0103 and 0107 hours, two additional circulation pumps of the main coolant loop were switched on, according to the test programme. As the power level was substantially lower than that planned, the resulting coolant flow was excessive; in consequence some important thermohydraulic parameters (steam pressure and water level in the separator) changed to levels at which automatic shutdown (scram) of the reactor normally occurs. To prevent the reactor scram (and interruption of the test) the staff blocked this automatic emergency protection. At the same time core poisoning was progressing and the reactivity continued to drop slowly.

- At 01.22.30 the available excess reactivity had decreased to a level requiring immediate reactor shut-down. Nevertheless the next stage of the test was started.

- 01.23.04 Shut-off of the steam supply to the second turbogenerator with the reactor operating at 200 MW. The staff had blocked the automatic scram which normally results from the switching-off of both turbogenerators; their intention was to maintain the reactor at power so that it would be possible to repeat the test if the first attempt proved unsuccessful. This meant a further departure from the test schedule.

  The coolant flow started to reduce slowly, following the decrease of speed of the 4 circulation pumps (out of a total of 8 operating pumps) which were supplied from the turbogenerator which was running down.

- 01.23.31 The flow decrease caused an increase of coolant temperature leading to increased boiling and steam voids with a consequent increase of reactivity which the automatic regulation was incapable of compensating; the reactor power began to rise slowly.

- 01.23.40 The shift head gave the order to press the scram button, which would send all the safety and control rods into the core. The rods began to enter but, after a few seconds, a number of shocks were felt and the operator saw that the absorber rods had halted without fully reaching the lower stops. He then cut off the current to the sleeves of the servo drives so that the rods would fall into the core under their own weight.

- 01.24 Approximately, according to observers outside unit 4, two successive explosions occurred. Burning lumps of material shot in to the air above the reactor, some of which fell into the roof of the machine room and started a fire.

c) Soviet Analysis of the Accident Sequence

An analysis of the accident was performed using complex mathematical models. Very little measured data is available relating to the final moments leading up to the core disruption. As regards the final few seconds, the appearance of high power and short period alarms showed that the insertion of the safety rods and the insertion of the control rods (which were at that moment almost fully extracted due to the low excess reactivity and, as a consequence, ineffective at the beginning of their movement) were inadequate to neutralise the power surge caused by the progressive increase of the steam voids in the channels. The continuous reactivity increase, a consequence of the continuing growth of steam voids, caused a further excursion, fuel fragmentation, leading to a vapour explosion which destroyed the channels. Further explosions, destroyed the reactor and part of the building and released radioactive fission products to the environment.

d) Measures taken after the Accident

- Fighting the fire: fires had broken out in over 30 places as a result of the explosions of the reactor which had ejected fragments of its core, heated to high temperature. The fires on the roof of the reactor section had been overcome by 0210 hours. All fires were out at 0500 hours.

- Limiting the Consequences of the Accident

  . The damaged reactor was covered by about 5.000 t of material (boron compounds, dolomite, lead, sand, clay dropped from helicopters); this layer covering the reactor strongly absorbed aerosol particles, ensured shutdown of the reactor and reduced gamma radiation.

  . to reduce the fuel temperature and reduce oxygen concentration (to stop graphite burning) nitrogen was pumped under pressure into the space beneath the reactor vault; by 6 May, a stable convective flow of air through the core into the open atmosphere had been established.

  . as a precaution against the remote risk of a penetration of the fuel (if melted) through the lower reactor structure, a concrete slab was constructed beneath the foundations of the building.

  . Since the end of May, a significant degree of stabilisation has taken place concerning the temperatures in the reactor vault and reactor core, the uptake of radioactivity from the unit into the atmosphere and the exposure dose rate in the areas around the reactor. The protective slab beneath the unit is intact and the fuel is mostly (96%) localised within the reactor vault.

- Unit 3, technically linked with the damaged unit 4, suffered practically no damage from the explosion and was shut down at 0500 hours on 26 April, more than 3 1/2 hours after the accident. Units 1 and 2 were shut down early on 27 April.

  After decontamination of the site and the entombment of the unit 4, it is intended that units 1 and 2 should resume operation again before the end of 1986. (Unit 1 resumed operation end September.)

- Decontamination of the site is being carried out by decontaminating buildings surfaces, removal of 5-10 cm layer of soil, covering with concrete, coating of the non-concrete areas with film-forming compounds, etc.

- Entombment of the fourth unit is intended to ensure a normal radiation situation in the surrounding area and in the atmosphere and preclude escape of radioactivity into the environment. (Construction of the entombment structure is virtually complete.)

- In June, the construction of a complex of hydraulic engineering structures began with a view to protect the ground water and the surface water in the nuclear power plant area from contamination.

e) Environmental Contamination

The evolution of released airborne radionuclides was followed from 26 April onward, by systematic analysis of aerosol and fall-out samples and by aerial gamma survey of the plant area.

A total release of about 50 MCi corrected to equivalent value on 6 May and excluding noble gases was estimated to have occurred. From the radiochemical composition of the released nuclides it appears that approximately 3.5% of the core inventory of fission products was released, as fine fuel particles; about one half of it was redeposited on the surroundings of the plant. Volatile fission products were released in higher quantities (iodine 20%, cesium 10-13%, noble gases 100%).

Significant release continued for about ten days, being highest at the beginning and the end of the period. This variation was largely a result of the accident containment measures described at 3.1.d) above.

A site and regional monitoring program was set up, including radioecological and biomedical analyses, to assess the radiological exposure of plant personnel and population and to recommend protection measures. Monitoring included levels of gamma radiation in contaminated areas, concentration of biologically significant radionuclides in air, water, soil, vegetation and food products, and internal contamination of people.

The water bodies were also monitored. Iodine-131 reached 1000 Bq/l in the Kiev water reservoir on May 3. Total radioisotope concentration in the reservoir was about 4 Bq/l on 10-12 June.

f) Health Effects upon Plant Personnel and the General Population in the Soviet Union

About 200 persons at the Chernobyl plant received whole body gamma irradiation and/or suffered burns due to beta rays and to steam and fire. These persons were rapidly transported to specialised hospitals and cared for by an experienced medical team. The combination of bone marrow damage with the extensive burns presented difficult problems of management. Altogether 31 persons died from the acute sequels of the accident (Table 1). A substantial percentage of those would probably have died in any case from the extensive skin burns due to radiation and heat. Treatment of the general radiation syndrome was primarily conventional, i.e. maintenance in ad-hoc aseptic units, preventive administration of antibiotics to reduce bacterial contamination of the intestine and to treat infections, blood platelet transfusions to avoid bleeding. Bone marrow transplantation was not very useful in these cases. Burns were treated by local and generalised treatment.

TABLE 1 : NUMBER OF VICTIMS TREATED AND DOSES

Degree of Severity	Dose Range Gy	Number at Kiev	Number at Moscow	Deceased
I	1- 2	14	31	0
II	2- 4	10	43	1 (not from radiation?)
III	4- 6	2	21	7 (6 with heavy skin injury)
IV	6-16	2	20	21 (burns 40-60% of body surface)
TOTAL :		143		29 (+2 dying immediately)

Countermeasures in the population in the 30km zone most heavily exposed to fallout were considered soon after the accident: stable iodine tablets were distributed among workers and residents around Chernobyl and successfully reduced uptake of radioactive iodine by the thyroid. When it became clear that the population in the 30km zone around the plant might receive doses of the order of several hundred mSv, about 135,000 persons, many of them children, were evacuated. This was carried out rapidly and efficiently, and nobody outside the plant thus suffered from acute radiation syndrome. The collective dose received by the population in the 30km zone is estimated at 16,000 manSv. Based on the UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) total risk estimate of 0.01 extra cancers per Sv, the Soviet authorities estimated the relative increase in cancer incidence at about 0.6%.

Doses to the Soviet population decreased with distance from the plant and depended on local meteorological conditions. The collective dose commitment from external exposure as a consequence of the Chernobyl accident to 75 million inhabitants of the European part of the Soviet Union is estimated at 90,000 manSv for the first year and 290,000 manSv for the subsequent 50 years. The collective dose commitment from intake of radionuclides, largely a result of caesium radionuclides in food, was pessimistically evaluated at about 2.000.000 manSv but, according to other calculations and preliminary measurements of radioactive body burdens, may be as much as a factor of ten lower.

3.2. Events in the Framework of the European Community

During the period which followed the Chernobyl event, numerous actions to monitor conditions and protect citizens from the effects of contamination were undertaken by national authorities. The Commission does not dispose of complete information on these actions which, nevertheless, represent the major part of the immediate response to the post-accident situation. The ensuing description is confined to those events which took place within the framework of the European Community.

In structuring the presentation, a question arises as to the distinction which should be made between the immediate consequences and longer term events and actions. For convenience, Community events up to the date on which the Commission adopted its Framework Communication are treated as part of the immediate sequence of events; subsequent events are reported in Section 4.2 "Measures in the framework of the European Community".

3.2.1. Chronology

The following is a simple chronology of main events :

26 April: Accident at the Chernobyl nuclear power plant.

28 April: 10.00 hrs. First radioactive fallout is detected on Community territory at Risö, Denmark.

29 April: Commission requests Member States to provide information on radioactivity levels in their territories pursuant to Articles 35 and 36 of the Euratom Treaty.

2 May: First results on contamination both of food and of environment become available via the rapid alert system for food.

6 May: Commission proposes a Council Regulation to temporarily suspend imports of certain agricultural products (foodstuffs) from some Eastern European countries.

Commission adopts Recommendation No. 86/156/EEC on limits of contamination of certain agricultural products (foodstuffs) for the internal market and on reciprocal recognition of controls by Member States.

7 May: Commission adopts Decision No 86/157/EEC temporarily suspending the imports of some livestock and fresh meat from certain Eastern European countries.

12 May: Council adopts Regulation No 1388/86 suspending imports of certain agricultural products (foodstuffs) from certain Eastern European countries until 31 May 1986.

20 May: Report is transmitted from the Commission to the Council as required by Article 5 of Council Regulation No 1388/86 on the development of the situation.

22 May: Commission proposes a Council Regulation to fix limits of caesium contamination in food imports from all countries.

30 May: Council adopts Regulation (EEC) No 1707/86 on conditions governing imports of agricultural products and processed foods originating in all third countries. The Regulation fixes limits for caesium radioisotopes and expires on 30 September 1986.

5 June: Commission adopts Regulation (EEC) No 1762/86 laying down detailed rules for the application of Council Regulation (EEC) No 1707/86 on the imports of agricultural products and processed foods.

12 June: Commission transmits to the Council a Framework Communication on the consequences of the Chernobyl accident.

3.2.2. Problems of Radiation Fallout from Chernobyl within the Community

With the detection of increased radioactivity levels in air in Sweden, and later in the Community, national authorities in Member States began an extensive monitoring of the environment. Rainfalls over significant parts of the Community during the passage of the radioactive plume (27 April - 12 May) led to significant, but uneven, deposition of radiologically important nuclides, notably iodine and caesium.

Recognising the potential danger and in accordance with Articles 35 and 36 of the Euratom Treaty, the Commission requested on 29 April, 1986, from Member States the regular communication of monitoring data on radioactivity in air, water, soil and foodstuffs. Information on contamination was exchanged on a daily basis between national competent authorities. It soon became apparent that air and surface water radioactivity was not such as to cause concern. Attention was focussed instead on the contamination of agricultural products used for human consumption which became the major exposure pathway.

Because they became a major preoccupation for the Community, administrative problems and measures relating to contamination of foodstuffs are described separately in section 3.2.2.1 below.

The major release of activity from Chernobyl lasted for about 10 days, i.e. from 26 April to 5 May. During this period the meteorological conditions over Europe changed considerably and as a consequence the dispersion of radioactive material across Europe was widespread but very uneven; in particular the pattern of radionuclide deposition on the ground was greatly affected by the occurrence of localised rainfalls.

The release of 26 April reached Scandinavia on the 27th and 28th, that of 27 April spread further southwards passing through the Federal Republic of Germany and France before turning northeastwards to Belgium, the Netherlands, the UK and Ireland. The releases of 29 and 30 April travelled to the South-East to Northern Italy before moving northwards. On 1 and 2 May the radioactive plume carried towards Greece. The releases of 3 and 4 May passed towards the North-West and had no immediate impact on Member States: however, subsequent releases on 5 May travelled towards the South-West reaching Italy and Northern Greece between 9 and 11 May.

Levels of surface contamination in Member States by the most important radionuclides, namely iodine-131 and caesium 134/137, as reported to the Commission by national administrations following the accident are illustrated in Figures 1 and 2.

The resulting radiation exposure has been calculated[4] for the following pathways:

- external radiation from the cloud and deposited material;
- internal irradiation from inhalation of airborne material during the passage of the cloud
- internal irradiation from ingestion of contaminated foodstuffs.

The latter pathway is the most important.

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(4) Dose assessment carried out for the Commission by the National Radiological Protection Board, UK.

Doses have been estimated for three representative age-groups, namely the 1 year-old infant, the 10 year-old child and the adult. The effects on exposure of countermeasures taken by the authorities were taken into account; however, the reduction in dose achieved by precautionary measures taken by individual members of the public as a reaction to the contamination resulting from Chernobyl is difficult to quantify and was therefore neglected. Table 2 gives the individual effective doses received in the first year for each of the three age categories considered. Table 3 gives the effective dose received over a lifetime in each Member State for the average adult. The average lifetime dose ranges from 0.3 µsv to 610 µsv. It is of interest to compare the above doses with that received from natural background radiation, which on average over a lifetime amounts to some 130 mSv (see Table 4).

The collective effective dose equivalent commitment to the Community population, which is a measure of the potential health impact of the exposure, amounts to about 85,000 man-Sv.

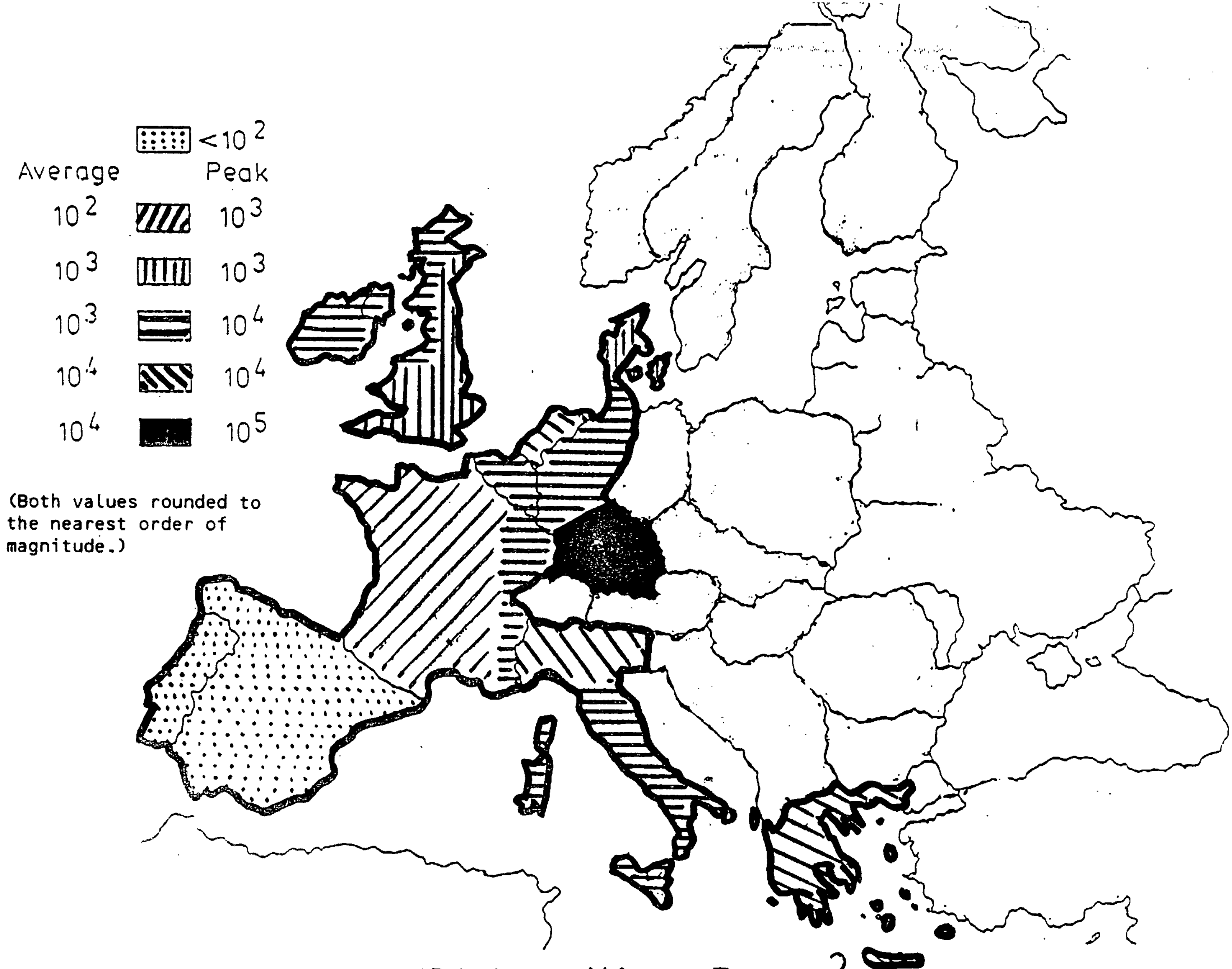

FIGURE 1 Iodine-131 deposition, Bq·m^{-2}

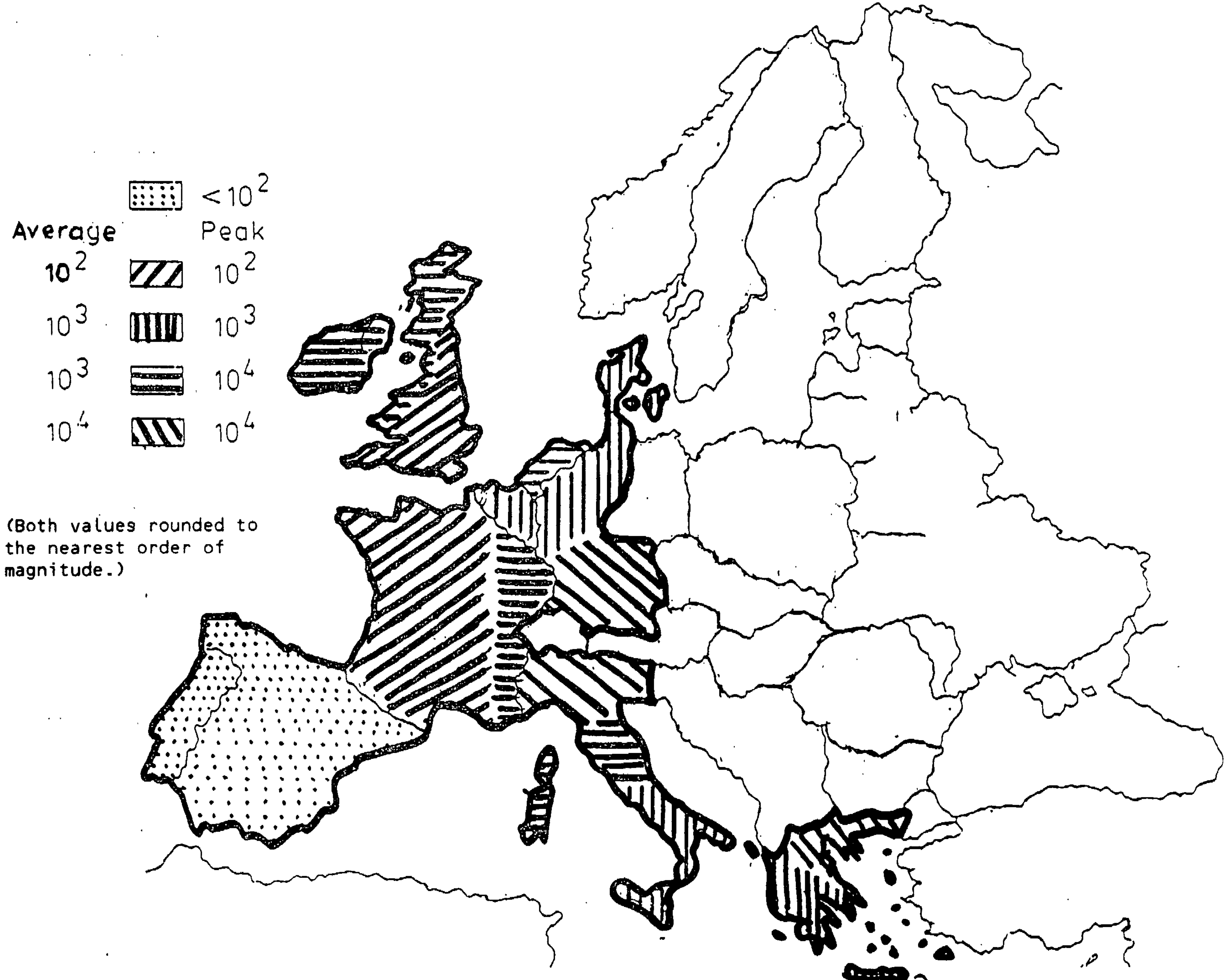

FIGURE 2. Total caesium deposition, $Bq \cdot m^{-2}$

TABLE 2

Average Individual Effective Dose Equivalents in First Year (μSv)

	Infant	Child	Adult
Belgium	110	61	52
Denmark	110	76	63
France	81	55	51
Germany	230	200	190
Greece	420	420	370
Ireland	130	100	100
Italy	160	180	210
Luxembourg	120	78	62
Netherlands	89	78	69
Portugal	0.4	0.3	0.2
Spain	2.7	1.6	1
United Kingdom	56	38	35

TABLE 3

Average Adult Effective Dose Equivalent Commitments (μSv)
(Integration over 50 years)

Belgium	92
Denmark	100
France	88
Germany	410
Greece	610
Ireland	170
Italy	370
Luxembourg	100
Netherlands	110
Portugal	0.3
Spain	1.2
United Kingdom	49

TABLE 4

Annual effective dose equivalents in the Community from various sources of exposure

Source of exposure		Effective dose equivalent (μSv)	
		In a year	Over a lifetime
Natural		1000 - 2000	70,000 - 140,000
Medical		300 - 500	21,000 - 35,000
Chernobyl	first year	0.2 - 370	
	adult		0.3 - 610

3.2.2.1. Administrative Problems of Food Contamination

The radioactivity which was deposited in varying amounts over the surface of Europe contaminated a wide range of agricultural products. Plants were contaminated by direct deposits of radionuclides upon their surface. Animal products - dairy produce, meat, etc. - were contaminated through animal consumption of contaminated grass, etc. Contaminated agricultural products which are used for human consumption become vehicles for exposure of man to radioactivity. In view of the potential danger in this situation the Community system for rapid alert in cases of food contamination was put into effect on 2 May, 1986 and data on food contamination were exchanged on a daily basis between control authorities. Concern over foodstuffs from contaminated areas, and especially imports from the Soviet Union and other affected Eastern European countries, led to the imposition by national authorities of restrictions on internal trade and on imports.

The national experts on food contamination met on 5 May together with experts in trade and in radiation protection and on the basis of this consultation the Commission:

- adopted a Recommendation calling on Member States to set certain maximum levels for radioactivity in milk, in milk products, and in fruit and vegetables;

- decided, subject to approval of the Standing Veterinary Committee, to ban the importation of meat and live animals from certain Eastern European countries and the Soviet Union;

- proposed a Council Regulation to ban imports of fruit and vegetables, milk and milk products, game and fresh water fish from Eastern European countries and the Soviet Union.

The objective of these actions was to allow Member States to remove restrictions which had been imposed on internal trade and to take common measures on imports while protecting the health of the population. The Commission Decision on meat and live animals was taken on May 7, covering imports of more than 70% of fresh food and live animal imports from the countries concerned. On May 12 the Council adopted a Regulation suspending imports of other foodstuffs. At the same time, the Member States agreed not to impose on imports from within the Community stricter radioactivity levels than those pertaining to home products. Both the Commission Decision and Council Regulation were to run until the end of May.

Subsequently, the alert system continued to operate and a number of meetings of experts were held to update the situation. The Group of Experts set up under Article 31 of the Euratom Treaty to advise the Commission on radiation protection standards, provided a provisional opinion on the derived reference level of caesium in major foodstuffs in international trade. These consultations were the basis for the provisional regulation adopted by the Council on 30 May to replace the import ban fixing the maximum levels of caesium 134 and 137 contamination in foodstuffs.

4. RESPONSES TO CHERNOBYL

4.1. Soviet National Measures

4.1.1. Energy Supply Policy

It is the Soviet view that the Chernobyl event is altogether exceptional and that continuation of the policy to expand nuclear power is not in question. Consistent with this view, the Soviet authorities have already resumed operation of Unit 1 at Chernobyl, are preparing Unit 2 to resume operation and will be attempting to recommission Chernobyl Unit 3 once entombment of Unit 4 has been completed.

4.1.2. Organisational Measures

It is the Soviet view that the nuclear safety standards in force in USSR are comparable with those in force abroad, appear to be adequate and do not require revision. However, they recognise that a more careful verification of their implementation in practice is necessary (training and retraining of operating staff, more careful quality assurance audits at the design and construction phases, etc.). An All-Union Ministry of Nuclear Power has been established and a number of senior officials have been replaced. A whole range of measures to improve State monitoring of nuclear safety is also to be carried out.

4.1.3. Technical Measures

The Soviet authorities have announced that a number of material and procedural changes which will increase the safety of operation of RBMK reactors are being implemented. The main actions are:

- improvement of instrumentation and control equipment;
- revision and stricter enforcement of administrative procedures;
- limitation of possible withdrawal of control rods from the core such that the minimum penetration is 1.2 metres below the top of the core;
- change of the reactor operating rules to forbid operation with available reactivity control less than 70-80 equivalent control rods (compared with the previous limit of 30).

These actions can be implemented without backfitting which would require extended shutdown of the plant.

In the longer term, it is planned to increase the level of enrichment used in the reactor and to insert neutron absorbers in the core - measures which are intended to eliminate the present positive void coefficient of reactivity.

After the accident, the status of theoretical and experimental research on nuclear safety in the USSR has been reviewed. Analyses of all possible transients and accident regimes, including conditions not anticipated at the design stage, are in progress. More extensive use will be made of quantitative probabilistic analysis of safety. (It may be noted that the unstable characteristics of the RBMK reactor, to which the short-term remedial measures listed above are addressed, were known to the Soviet designers in 1974 and were described in the open literature in 1979. As regards this problem, safety analysis could not add appreciably to answers of the potential hazard.)

4.2 Measures in the Framework of the European Community

Experience of the immediate post-accident events has shown the need for some improvements in existing procedures and facilities for alleviating and reducing the health effects and stresses on the population both in the Community framework and in individual member states. A variety of measures are being or will be taken to respond to these needs - some in the Community framework, some in the national setting.

In the Framework Communication, the Commission has proposed a programme of actions and studies lying in five main areas :

- Health protection
- Safety of nuclear installations and their operation
- Emergency procedures
- Actions in conjunction with third countries
- Community research

a) Health Protection

The Chernobyl events focused attention upon three main requirements for health protection for which provisions in the Community need to be reviewed. These requirements are :

(i) for measuring, assessing and reporting radioactivity to which citizens may be exposed in accident and post-accident situations; and, in particular, for monitoring radioactive contamination and regulating trade in food;

(ii) for medical treatment of persons suffering immediate medical effects of accidental radioactive release;

(iii) for decontamination of living and working areas affected by post-accident contamination.

The Commission has undertaken recently an examination of current Community instruments and measures relevant to radiological protection. This was in part prompted by incidents and accidents that occurred over the last few years, but mainly brought about by events following the Chernobyl accident. As announced in its Framework Communication, the Commission has concluded that existing measures for the application of Chapter III are in need of review.

The experience gained and the lessons learnt from this review are reflected in the Commission Communication to the Council COM (86) 434 (The development of Community measures for the application of Chapter III of the Euratom Treaty - "Health and Safety"). In that document, the principle lines of action relevant to the accident and post-accident situations, such as Chernobyl, are:

- application of effective and uniform radiation safety standards: the assimilation of the Euratom basic standards into national law should be accelerated: the Commission will use every endeavour to this end.

- establishment of a rapid information system for timely reporting of levels of radioactivity in the event of radiologically important incidents inside or outside the Community: The Commission is preparing proposals.

- establishment of suitable arrangements for provision of mutual assistance in the event of nuclear accidents: the Commission intends to make proposals.

The arrangements already in place at the time of Chernobyl for monitoring and regulating trade in edible goods, notably agricultural products, have been widely acknowledged to be inadequate to face such an abnormal situation. In recognition of this, the Commission is deeply engaged in consideration of various possible improvements. To clarify the scientific elements of the problem, the group of experts, constituted under Article 31 of the EURATOM Treaty, has developed guidance on the derived reference levels of contamination of food: at the same time, the Commission has sought the views of an ad-hoc committee of experts on current implementation of basic safety standards and derived reference levels. These elements will be combined with considerations of administrative aspects in the Commission preparation of draft regulations which it will be putting forward before the end of 1986.

The existing food regulations referred to in Section 3.2.2.1 have been extended until 28 February 1987. Monthly reports are being made to the Commission by the Member States on their import controls and these are distributed to all control services in the Community.

As regards provision of medical treatment for victims of nuclear accidents, the principal responsibilities reside with the governments of those Member States which conduct nuclear operations. The Community, through the Radiation Protection Research Programme (5), contributes to

(5) OJ No L83, 25.3.85, p23

the common stock of medical knowledge available to guide physicians and surgeons in the treatment of accident victims. A review of topics and priorities within the existing programme has been carried out in light of the Chernobyl experience and desirable changes have been identified. This review has been discussed with the appropriate CGC and with the EURATOM Scientific and Technical Committee. The Commission is currently examining the extent to which these changes should be translated into proposals for revision of the current research programme.

As regards provisions for decontamination of areas which might be affected if a severe accident were to occur within the Community, responsibility lies with national governments. Some themes in the radiation protection[6] and the decommissioning[7] research programmes are yielding useful contributions to the common stock of knowledge of methods and problems.

b) Safety of Nuclear Installations and their Operation

The Commission and Member States participated in the post-accident review meeting in Vienna 25/29 August 1986 and in the ensuing special session of the IAEA General Conference. The information exchanged and the policy considerations illuminated in those discussions are ingredients of the Commission consideration of future actions in the field of safety of nuclear installations. As announced in the Framework Communication, the Commission will report on the Council resolution of 22 July 1975 relative to the technological problems of nuclear safety.

The Commission is also giving consideration to the following problems :

- whether provisions of the EURATOM basic standards which cover industrial preventive measures are correctly applied and sufficient for the protection and information of the public;

- the question of whether emission standards based on the concept of the best available technology not involving excessive costs should be applied to nuclear installations;

and will come forward with a communication or communications in due course.

The Commission also intends to make proposals before the end of 1986 on the following:

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(6) O.J. No. L83, 25.3.85, p23
(7) O.J. No. L36, 08.2.84, p23

- implementation of a mandatory system of incident reporting;
- legislation concerning transport of dangerous materials, including uniform standards of training for transport workers.

c) Emergency Procedures/Plans

The Commission will explore with national authorities possible further needs for Community provisions in the field of mutual assistance and other common elements of emergency management, taking into account the situation created by the adoption of the IAEA convention on mutual assistance (see Section 5.2).

d) International Actions

The principal international actions to respond to the Chernobyl event are pursued in the framework of the IAEA and are described more fully in Section 5. In addition, the Commission is preparing a proposal for Community adhesion to the London Convention on the prevention of marine pollution by dumping of wastes and other matter. This proposal will be put forward before the end of 1986.

e) Research

Both the Commission's own reflections and the report of the IAEA post-accident review meeting point to the need for an adaptation of the Community research programmes in the fields pertinent to the safety and health effects of nuclear operations. Analysis of the implications of the Chernobyl event is in progress with the intention of drawing up specific proposals by end 1986. Among the areas of research which are under examination are modelling of human behaviour, techniques and applications of probabilistic reliability analysis, severe accident phenomena, techniques and systems for accident management, design concepts for benign reactors, modelling and analysis of long range transport of radioactivity, techniques for post-exposures dosimetry, and study of the immediate and late radiological consequences of Chernobyl.

5. INTERNATIONAL ACTIONS IN THE IAEA FRAMEWORK

5.1 General

Very soon after the Chernobyl accident, the IAEA became the principal forum in dealing with international aspects. In early May the Western Economic Summit took place. It discussed Chernobyl and issued a declaration welcoming the work of the IAEA and urging it to improve international cooperation on the safety of nuclear installations, the handling of nuclear accidents and their consequences and the provision of mutual emergency assistance.

Subsequently, at a special Governing Board meeting of the IAEA on 21 May it was decided to :

(a) hold within three months - a meeting of experts to examine in detail the cause and the sequence of events during the Chernobyl accident;

(b) convene an expert group with the aim of transforming the existing IAEA guidelines on rapid information exchange and mutual emergency assistance into binding international conventions;

(c) established an expert working group to consider additional measures to improve cooperation in the field of nuclear safety, including ways and means of further refining nuclear safety standards;

(d) hold an intergovernmental conference in order to consider the full range of nuclear safety issues.

Three out of four of these activities have already taken place with Community participation. Experts, meeting between 21 July and 15 August, succeeded in establishing draft texts for the two conventions (rapid information exchange and mutual emergency assistance). The post accident review meeting took place in Vienna from 25-29 August. The outcomes of both of these expert meetings were discussed at the special session at ministerial level of the IAEA General Conference in Vienna from 24-26 September.

For some time the Commission and the IAEA have been developing broad cooperations in the fields of nuclear safeguards and nuclear research and training, the latter particularly in the areas of waste management, safety, fusion, transport, etc.

The Commission formally takes part in the IAEA General Conference and thus is naturally associated with IAEA actions following Chernobyl. It intends to take an active part in the forthcoming IAEA activities on nuclear safety.

5.2. The Conventions on Early Notification of a Nuclear Accident and on Assistance in the Case of a Nuclear Accident or Radiological Emergency

The convention on early notification relates to accidents having actual or potential trans-boundary effects and arising from nuclear operations. State parties undertake to provide prompt notification to the IAEA and to other state parties regarding any accident which has affected or may affect those state parties: this latter notification may be direct or via the IAEA. Other state parties, not affected by the accident, may request to receive the notified information from the IAEA. Each notification is to include details of accident location, radiation release, meteorological information, monitoring information relative to trans-boundary effects, etc., and is to be updated at appropriate intervals. Each state party is to designate its relevant authorities and points of contact.

The convention on assistance provides a framework for the organisation and provision of assistance by state parties and/or the IAEA to any requesting state party, in the event of a nuclear accident or radiological emergency, whether or not the incident has occurred on the territory of the requesting state party. Each assisting state party may, at its discretion, offer its assistance on the basis of full, partial or null riembursement. Each state party is to designate its competent authorities and points of contact.

5.3. The Results of the IAEA Special General Conference

At the special General Conference 24-26 September the above-mentioned conventions on notification and on assistance were adopted. All Member States of the Community have signed the former; all but one have signed the latter. The Conference also adopted a resolution on nuclear safety, recognising that nuclear energy will continue to be an important energy source for economic and social development. All countries, including those who have rejected the use of nuclear power, upheld this resolution.

The special General Conference also took note of the post accident review report prepared by the International Nuclear Safety Advisory Group (INSAG) on the basis of the presentation and discussion which took place during the 25-29 August meeting, supplemented by subsequent debate and expert analysis. The INSAG report, while drawing attention to some remaining areas of uncertainty, largely confirms the validity of the Soviet account of the accident sequences and presents views agreed between INSAG members and Soviet experts on the probable mechanisms of some previously unexplained elements of the original Soviet description of the accident sequence. In the light of the discussions which took place in the post accident review meeting and of further expert analysis, the INSAG report includes a series of observations and recommendations relating to a number of reactor safety and radiation protection topics. These observations and recommendations are to be taken into account by the IAEA Board of Governors in the future development of the IAEA programme of work. Many of the topics have counterparts in the nuclear and health protection activities pursued at Community level and the Commission intends to promote the closest possible cooperation with activities on those topics which may be instituted by the IAEA.

6. ISSUES FOR THE FUTURE

The effects of the Chernobyl accident still persist and many actions which have been launched in consequence are in progress. This report surveys events over the first five months after the accident and, within this time frame, only those aspects directly related to the accident event. Many conclusions have been suggested regarding the various technical and administrative questions encountered but in most cases such conclusions are premature in relation to the necessary supporting analyses.

In the following, an attempt is made of listing the issues which deserve special attention for the future, taking into account in particular the international nature of nuclear safety and the unique potential of the European Community to contribute to this international analysis. The achievement of the best possible approaches to safe design, construction and operation of nuclear installations, the provision of the essential assurances to the public of the adequacy of nuclear safety, the monitoring of the effects of any major nuclear accident and the efficient management of measures needed to deal with large scale incidents such as Chernobyl are all matters in which the ingredient of international cooperation is indispensable. This is again a field in which the European Community has a unique potential to contribute.

a) What Was the Cause of the Accident?

The prime cause of the accident was a combination of violations of instructions and operating rules committed by the staff of the unit, compounded by specific features of behaviour of RBMK reactors. The result was a fast reactivity excursion culminating in an extremely rapid power surge and a major core disruptive accident.

The reactor and associated plant behaved in an entirely predictable manner during the run-up to the test and no new unknown phenomena occurred before or after the accident. The unfavourable characteristics of thr RBMK reactors in respect of dynamic instability were known to the designers in 1974 and were published in 1977. Explanations for the unorthodox behaviour of the operators and for the ease with which so many essential reactor protection circuits could be interfered with or disabled at the one time are still lacking.

In the relatively older philosophy of the RBMK reactor safety protection system, more reliance is placed on proper operator action than on automatic safety circuits. Thus the fast reactivity excursion was not automatically terminated immediately.

b) Have Steps Been Taken to Prevent its Repetition?

As described in Section 4.1.3., the Soviet authorities are introducing a number of modifications to reinforce the level of safety of existing and future RBMK reactors.

It was stated by the Soviet representatives that further measures are being studied, e.g. the provision of fast-acting shutdown devices.

There is, as yet, no evidence of a move to implement the "defence in depth" philosophy of modern nuclear reactor safety design which requires that manual actions of operators are overruled by the automatic safety systems when the safety of the plant is seriously threatened.

Taken together with the altogether singular character of the events leading to the Chernobyl accident, the measures being implemented will make it extremely unlikely that there will be a repetition of the accident.

c) Could Such an Accident Occur in the Community?

Insofar as there are no nuclear power plants in the Community displaying the unfavourable stability characteristics of the RBMK reactors and insofar as criteria for segregation of safety functions and safety circuits are entirely different in the Community, such an accident cannot be considered as a precursor or as a warning of specific relevance to the Community. However, the Chernobyl accident has re-emphasised some of the lessons of the Three Mile Island accident, i.e. the importance of the human factor and man-machine interface, the value of properly conceived and built containment and the need to consider a very wide range of conceivable events when evaluating design safety and possible accident consequences.

Serious reactor accidents in the Community, or indeed elsewhere, are not impossible by definition. Their probability of occurrence is, however, very low. Very great attention is given to reducing this probability to extremely low levels and to ensuring that the consequences of such an event are at a minimum. As regards the human factor, operator training in all Community countries is long and rigorous. In addition, system design includes automatic negation of operator actions which could threaten reactor safety.

d) Is There Scope for Improving Current Levels of Assurance of Safety of Nuclear Installations?

There are four broad categories of actions which could improve the assurance of safety of nuclear installations:

(i) exchanging information and making intercomparisons between countries concerning the safety philosophies and approaches and safety criteria and guidelines for the design and licensing of nuclear installations. The resulting process of analysis and the diversity of scrutiny of the various approaches tends to ensure that potentially severe sequences of events have not been overlooked. Each party can learn from the other and the countries with the smaller or incipient nuclear programmes can benefit from the strength of knowledge and experience of the others.

(ii) The present population of reactors in the world comprises reactors of different design, sizes and operational experience[8]. Periodical safety reviews on individual reactors or classes thereof

(8) It is to be noted that major nuclear accidents (Windscale, Three Mile Island, Chernobyl) have befallen comparatively new reactors.

should be conducted using the most up-to-date methodologies, including Probabilistic Safety Assessment, in order to check their safety performance, to identify the possible needs for backfitting and to help taking decisions about withdrawal from service. A major advantage in performing Probabilistic Safety Assessments lies in the opportunity that these exercises offer to identify potentially dangerous sequences of events so far overlooked and weak points of the design.

The use of Probabilistic Safety Assessment should be encouraged. Its benefit could be enhanced by exchanging information upon the methodologies and the results of the safety reviews.

(iii) The human factor, both in the phase of design and construction and in the phase of operation of nuclear installations plays a major role in achieving safety. Expert teams of scientists and engineers have been created and maintained by the utilities, the reactor constructors, the licensing authorities and the research organisations to support the steadily expanding nuclear programmes over the last 25 years. These human resources, together with the laboratories and facilities for safety research are the foundations upon which continuing safe performance of nuclear installations is built. These assets must be preserved and, where necessary, upgraded.

Although the world collectively possesses the capability to maintain the necessary high standards and the human resources to pursue the safe exploitation of nuclear energy for peaceful purposes, the distribution of these assets is not uniform among all countries. Technological exchanges across regions should therefore be encouraged in the field of safety of nuclear installation in the interest of the international community.

(iv) As was vividly illustrated by the events of Chernobyl, interferences both with the normal pattern of operation of a nuclear plant and with the engineering elements of a plant safety systems can have seriously adverse effects. The designs of plant operational procedures and of plant safety systems should be such that interferences with the normal operating modes are extremely difficult to achieve.

e) Is Medical Knowledge Adequate for Provision of Immediate Medical Care?

Clinicians and scientists in the Community have the experience and facilities to diagnose and treat victims of radiation accidents according to the best available state of art, and the management and treatment of several accident victims has been handled efficiently in Europe in the past. An important aspect in the treatment of such persons is the close cooperation between specialists from different disciplines. The careful study of the Chernobyl victims and the follow-up of these lessons will certainly improve further diagnostics and treatment methods for victims of radiation accidents. An effort must be made to maintain such competence into the future.

Dealing with a large number of victims may present problems for which plans should be made in advance. Recommended treatment schedules taking into account the Chernobyl experience should be developed, clinical teams should be selected and trained, and structures for a rapid and efficient management of patients should be foreseen. Particular attention should be paid to the optimal treatment of persons suffering from both radiation and conventional burns in addition to radiation.

Some additional efforts might also be devoted to improving decision criteria for bone marrow transplantation and to techniques for the removal of incorporated radionuclides from the body.

f) <u>What Lessons Can Be Learned Regarding Protection of the Public near the Site of a Nuclear Accident?</u>

Detailed plans for local emergency countermeasures after nuclear accidents must be well prepared and up-to-date having regard to the possible gravity of a situation and to the problems arising near national and Community frontiers. The Soviet experience clearly illustrated the benefit of strong central control of the numerous coordinated measures which may be necessary. The Commission had previously organised a review of transfrontier emergency planning and has now embarked on a process of consultation of national authorities on the problems of emergency management in the light of the Chernobyl events.

In view of the major social and economic upheaval experienced by the citizens of the Chernobyl region, it may be that the risks and benefits of grave countermeasures which might be needed after a nuclear (and other serious) accident need to be studied in the light of the Chernobyl experience taking into account the specific social and administrative structures in Member States of the Community.

g) <u>What are Likely to be the Long Term Effects on the Health of Community Citizens?</u>

With increasing distance from the accident site, exposure of persons and contamination levels diminished, and there were certainly no acute health effects to persons in the European Community. In order to reduce possible long-term health effects in the Community, only a limited range of countermeasures was required in Member States of the Community.

The long-term health impact from the Chernobyl accident in terms of cancer and genetic damage is very small compared to that arising from other sources and, in particular, from natural radiation. The studies referred to in 3.2.2. yield an estimate of about 1000 potential additional deaths from cancer over the next 70 years, which is to be compared with a total of about 60 million fatal cancers from all other causes over the same period. Further refinements of this estimate will be obtained from future assessments using better databases. On present dose estimates, it would appear that epidemiological investigations designed to detect any relative increase in malignant and genetic disease due to Chernobyl, would be impracticable to undertake in the scale and extent required to yield statisitically reliable results.

g) How was the Dispersion of Radioactive Material in the Community Assessed?

A widespread and rather heterogeneous contamination of the territory of the Community occurred as a consequence of the radioactivity released from Chernobyl. The Member States deployed their existing infrastructures to measure environmental contamination, to assess doses to the population and to take appropriate countermeasures. Existing techniques and facilities permitted a rough estimate of the environmental impact. Based upon this experimental data, available real time assessment methods were successfully applied in the Member States and proved to be valuable for immediate emergency management and for forecasting deposition patterns. More emphasis needs to be given to local and regional aspects in such models.

Existing models for atmospheric dispersion are now being validated and embodied into a probabilistic risk assessment structure to serve as an essential input for predicting consequences of accidental releases. Improvement is needed, in particular, with respect to a more rapid verification and utilisation of measurement data in such models as well as the consideration of local and regional meteorological conditions. Ongoing research, e.g. in the project "Methods for Assessing the Radiological Impact of Accidents" (MARIA) will take into account the experience of Chernobyl and render the models more comprehensive and more rapid for both Community-scale and local-scale accident situations and will attempt to help decision-making on countermeasures by introducing some representation of the possible health, social and economic consequences.

h) What Lessons can be Learned About Food-chain Transfer

Transfer of radioactivity into the human food chain occurs most rapidly for iodine 131 via a contamination of vegetables and milk. Later, the long-lived caesium isotopes in meat, dairy products, vegetables and grains become the limiting factor and contribute most to the long-term dose. Models available for calculating these transfer processes have been shown, in general, to be valid in the Chernobyl situation although a few unforeseen effects were noted in environmental or food transfer. The role of natural ecosystems such as forests as storage sites of radioactivity is a significant feature of the Chernobyl situation: the phenomena and mechanisms involved have not been adequately considered in the past. The influence of processing and cooking and the application of these procedures for reducing radioactivity in food require more attention. The large amount of measurement data collected in the course of monitoring and regulating food quality requires better processes of verification and harmonisation in the future.